|CURIEUX|

ACADEMIC JOURNAL

June Issue

Issue 39

Editing Staff

Chief-In-Editor

Caroline Xue

George Hasnah

Chief of Operations

Anshal Vyas

Assisting Editors

Olivia Li

Luzia Thomas

Madalyn Ramirez

Shefali Awasthi

Soumya Rai

Sarah Strick

Table Of Contents

The Geopolitics of Space with Special Emphasis on the Second Space Race By Nandini Tewari

Abstract

The First Space Race shaped the way space technology and advancements are viewed, a rivalry between world powers which fueled the scientific community and sped the pace at which discoveries were made. Back in the 20th century, this friction existed between the United States of America and the Union of Soviet Socialist Republics, but currently in the 21st century, the emergence of a new struggle is observed. The People's Republic of China, an ascending force, is visibly making long-term plans to analyze and colonize the lunar surface with research bases. Its opposition, the United States of America, is crafting an alternate story with its crewed missions and gateway models. Unlike the 1950s, the scuffle is not just to reach the Moon, it is to stay there. The aim of this study is to analyze the geopolitics of the Moon with regards to the "Second Space Race" between the U.S. and China, understand the goals of both the nations, gauge the severity of this competition, and realize the impact of it on the current age. The approach to conduct the study was taken as examining several other research papers, probing government websites and released statements and finally putting the pieces together to comprehend the situation at present. The findings of the study were that both the nations are working towards the same ultimate goal, both of them have substantially different strategies, with the U.S. using manned operations to establish supremacy, and China utilizing its robots, machinery and artificial intelligence to make its mark. The only question remaining is, who will win this time?

Introduction

With the commencement of the Space Age in the late 1950s, multinational collaboration has played a key role in space policy and strategy (Peter). Owing to outer space's strategic and economic significance, various national and international bodies have consistently attempted to pursue space activities considering both military and security factors (Nucera). The break of the Cold War and the division of social, political and economic world affairs into two blocs, the United States and the Union of Soviet Socialist Republics gave rise to the conventionally recognised 'First Space Race.' The battle to achieve the ultimate high ground, while noted no end goal at the beginning, ceased, as stated by popular belief, with the achievement of the Moon landing by NASA's Apollo 11 on the 20th of July, 1969. With the conclusion of the Cold War, the proliferation of national space agencies was observed, such as a Chinese Space Station founded in 1993 and the disintegration of the USSR in itself giving rise to three space agencies: Kazakhstan in 1991, Ukraine in 1992 and Russia in 1992 (Peter). The establishment of state-controlled space agencies is an ongoing process, with nations instituting space administrative centers even in the 21st century. But the First Space Race set the tone for any astro political contest thereafter, therefore inducing a newly-established 'Second Space Race' between the United States of America and the People's Republic of China.

The existence of the 'Second Space Race' is a topic of debate, since many space policymakers and policy intellects argue that there is no new space race since the United States of America won the only possible space race with Apollo 11, and others argue that the rivalry between China and the United States of America cannot epitomize the intense clash between the Soviet Union and the United States of America during the 'First Space Race', and hence is not deserving of the 'Space Race' title (Hickman). But regardless of these pieces of discussion, enough evidence is available for analysis that points towards a possible Second Space Race. China, looking into the NASA dialogue, has also stepped foot into manned spaceflight for the same reasons as American manned missions, for "enhancing international prestige and enhancing science and technology (Seedhouse)." China's efforts to match the efforts of the United States of America to militarize space can be observed with the launch of China's 'Anti-Satellite' (ASAT), which matches the USA's feat of destroying a deteriorated satellite of its own in orbit. And finally, with the independent launch of Taikonauts into space, China became the third country, after the Soviet Union and the US, to do so. While the events of the Soviet and American launches were noted as important milestones in the history of space technology and politics, the launch of China into this arena may just be marked as the origin of the 'Second Space Race' (Seedhouse).

With the focus of the 'Second Space Race' being the Moon, public statements by the Chinese and American space policy decision-makers supporting their struggle against the other nation add to the argument supporting the Second Space Race's initiation (Hickman). The Moon serves as a site of both strategic importance for national militarization and security, as well as an accepted body by the general public, in spite of their academic qualifications and economic backgrounds, since the only visible celestial body via the naked eye is also the most understood and welcomed by the masses. Hence, both nations have planned in their books different moon missions to further exploit the satellite and use it for scientific and strategic advancements. NASA following its Apollo legacy plans on the establishment of "a Lunar Gateway as an orbital platform in lunar orbit to develop and explore the moon." CNSA plans on similar lines of lunar projects, the establishment of "a scientific research station at the south pole of the Moon (Hickman)." Unanimously agreed space policies include The Outer Space Treaty signed in 1967, governing and monitoring the peaceful utilization of outer space. While the OST doesn't prevent nations from building non-military structures on the lunar surface or suspending peaceful structures into the lunar orbit, this fabrication of celestial bodies, mainly driven by competition to attain the high ground, may lead to hostile military actions in the coming future, with growing competitive spirits and advanced developments in space technology.

The motive of this review paper is to explore the pioneering of schemes on the Moon to achieve the paramount coign of vantage by the states of the United States of America and the People's Republic of China.

Discussion

The discussion section of this review paper aims to form an academic comparison between the Projects and Missions centered around the Moon undertaken by The United States

of America and The People's Republic of China, additionally also analyzing the advancements of a few other space-faring nations.

The Moon, as discussed earlier, is a critical celestial body in terms of geopolitics and space exploration for both nations. Via this analysis, we shall shed light on both the countries' advancements in the field of Lunar Programs over the past five decades. An effort towards identifying both their experimental and research objectives, similarities in strategies and differences in missions shall be made.

1.   USA's Lunar Projects

1.1 The Apollo Mission

John F. Kennedy, on May 25, 1961, said, "No single space project will be more impressive to mankind, or more important in the long-range exploration of space; and none will be so difficult or expensive to achieve." At the program's budgetary peak in 1965, approximately 400,000 skilled people worked on the project, all of them eager to make the first lunar landing a reality (Jolliff and Robinson). The Apollo Missions was a series of manned and unmanned lunar missions executed by the National Aeronautics and Space Administration (NASA) and the United States of America. Making its mark on the books of history, the Apollo Missions were successful in putting the first man on the surface of the Moon while accomplishing multiple other milestones in its series of 14 missions. But the initial Apollo 11 operation went beyond achieving feats in scientific exploration. It played a pivotal role in the First Space Race between the United States of America (USA) and the then Union of Soviet Socialists Republics (USSR), fetching the win for the USA. Apollo was a start to realizing the immense potential of mankind and a comprehension of the possibility of life beyond the exosphere.

The Apollo Program was the third human spaceflight program conducted by the United States and the National Aeronautics and Space Administration (NASA) successfully planted 11 spacecraft and enabled 12 astronauts to walk on the surface of the Moon. At the time of Apollo 11, NASA was divided into three major accounts, each appropriated separately: Research and Development (R&D), which funded program activities; Construction of Facilities (CoF), which supported the design, construction, and equipping of government facilities; and Administrative Operations (AO), later renamed Research and Program Management (R&PM), which provided staff salaries, travel, and other overhead costs. The Apollo Mission was majorly funded by the R&D Department (Dreier).

The primary aim of the Apollo program was to achieve the remarkable feat of landing humans on the Moon and safely returning them to Earth. The secondary aim, which over time became the focus of all the Apollo Missions, was to learn more about the Lunar surface and atmosphere, comprehend the composition of elements and matter on another celestial body and contribute to the discussion of life beyond Earth. The Apollo program was broken down into a series of missions, with Apollo 11 becoming the most famous. On July 20, 1969, Neil Armstrong and Buzz Aldrin became the first humans to step foot on the lunar surface.

Armstrong's glorious "That's one small step for man, one giant leap for mankind" is one phrase which still echoes in the realm of space exploration.

The scientific findings from the various Apollo Missions have greatly contributed to our understanding of other celestial bodies, but especially the Moon. The results of tests conducted on the extra-terrestrial matter brought back to Earth and the experiments carried out on the lunar surface itself have cleared the fog to a significant extent, with the analyses growing exponentially with each mission.

Astronauts Armstrong and Aldrin returned 20 kg of lunar material for the first Apollo 11 mission. Additionally, they deployed several experiments on the surface. The first one, a solar cell-powered seismometer, provided scientists on Earth with information on man-made and natural seismic events. Secondly, a laser reflector, made using an array of very precise corner reflectors to allow laser beams from the Earth to be reelected to measure the Earth-Moon distance with extreme precision was also deployed. Finally, the solar wind composition collector, entailing an aluminum foil piece being exposed to the Sun while the astronauts are on the lunar surface, and then being analyzed for trapped lighter elements of the solar wind upon return was also conducted. Comparatively, Apollo 12 deployed a much more complicated science station powered by a nuclear generator, with the instruments including a seismometer, a magnetometer, a solar wind spectrometer, an atmosphere detector and an ion detector.

Well-trained astronauts made geologic observations and collected samples of rock and regolith, the impact-generated layer of debris that composes the lunar surface (Jolliff and Robinson). This allowed to unveil the history of the Moon: the original crust, made of anorthosite, formed 4.5–4.1 Ga through plagioclase crystallization and flotation from a magma ocean; impacts formed large basins until 3.8 Ga; most of these basins were filled by basalts, erupted as a consequence of secondary melting of deeper portions of the crystallized magma ocean; this volcanic activity occurred until 3 Ga, followed by other sporadic events (Longobardo). Despite the fact that the geological sample collection is five decades old, these materials are still being used to test key lunar and comparative planetary science questions (Pernet-Fisher et al.).

1.2 The Role in the Second Space Race

NASA Administrator James Webb's fundamental part the effort addressed a legitimate concern that the scientific and technological advancements for which NASA had been created not be eclipsed by the political necessities of international rivalries, and conveyed the concern of the agency's technical and scientific community to Jerome Wiesner on 2 May 1961, noting that "the most careful consideration must be given to the scientific and technological components of the total program and how to present the picture to the world and to our own nation of a program that has real value and validity and from which solid additions to knowledge can be made, even if every one of the specific so-called 'spectacular' flights or events are done after they have been accomplished by the Russians"(*Apollo: A Retrospective Analysis*).

The significance of the Apollo Missions goes beyond mankind's technological and scientific advancements. Their launch was highly connected to the political games played by

countries in the 20th Century. The Space Race between the then Union of Soviet Socialist Republics (U.S.S.R.) and the United States of America (U.S.A.), launched by the infamous Cold War, started as a nuclear arms and technological superiority race and eventually took its course in space exploration. It all began on the 2nd of August 1955, when the USSR responded to the USA's statement of planning the launch of the first artificial satellite by announcing a launch of their own. These opposing statements themselves ignited the fire of rivalry, which eventually translated into an essential factor of the Cold War. Two years after the announcements, on 4th October 1957, the USSR launched the first-ever satellite into a low-earth orbit called Sputnik 1. This lift-off was not just a sign of human competence, but also one of the technological prowess of the USSR. Just a month later, the USSR also took the plaque of sending the first nation to send a living being into the Earth's orbit when they launched Laika, a dog into space via their second satellite, Sputnik 2. The USA was falling behind. To create a space for their nation in the global space technology arena, launched Explorer 1, its first satellite to reach orbit and established the National Aeronautics and Space Administration (NASA) in 1958 as the sole organization controlled by the government to intensify its space efforts. With that, the USA officially entered the Space Race.

With that, the Space Race continued for almost two decades, with the bar changing with each country trying to surpass the other. The Apollo Missions, specifically the first Apollo 11 is said to have won the USA the Space Race. This race could also be classified as one which pushed both countries to perform better and faster in the name of competition, but ultimately all of it translated into human achievements in the realm of space exploration. The Apollo-Soyuz mission of 1975 became a public closing to this rivalry. As the first cooperative mission, it paved the way for future collective projects, like the International Space Station (ISS) and so on.

1.3 Artemis Missions

The mythological Greek goddess of the Moon and the twin sister of Apollo, Artemis is the second set of crewed missions to the Moon established by NASA. The aim of the Artemis Missions is to explore the Moon for scientific discovery, technology advancement, and to learn how to live and work on another world as we prepare for human missions to Mars [("Artemis - NASA"). NASA's long-term goals are to use the technology and research developed during the Artemis flights to launch a future crewed mission to Mars (Artemis Programme: What You Need to Know About NASA's Moon Missions). Moreover, via the Artemis Missions, NASA will also land the first woman and person of colour on the Moon. Currently, there are four Artemis Missions in preparation, all of them riding on the success of Artemis 1, an uncrewed test flight. Connecting the storyline to Greek Mythology once again, the crewed spacecraft for the Artemis Missions is called Orion, the hunting companion of Artemis.

Unlike the Apollo Missions, Artemis Missions do not just aim to visit the moon. The goal here is to go and stay on the Moon. To achieve the same, establishment of lunar bases in orbit and on the surface of the Moon is being instituted.

The two main objectives of the missions as a collective are:

Lunar South Pole: The south pole of the Moon is famous for potentially containing water ice, which could be very useful as a resource on the moon, being utilized as drinking water, to cool equipment or to produce fuel and oxygen ("Explainer: Why Are Space Agencies Racing to the Moon's South Pole?"). Artemis 3, the third mission in the series plans on taking astronauts to the southern region of the Moon aboard SpaceX's reusable rocket Starship, in a lunar-adapted version. These astronauts will live in the Starship for almost a week, exploring the lunar surface, conducting multiple experiments and tests and performing a variety of scientific studies (Artemis Plan).

Commercial Lunar Payload Services: As part of the Artemis program, NASA initiated the CLPS program, fostering collaboration with commercial partners. CLPS missions intend to deliver science and technology payloads to the lunar surface. Notable examples include the Lunar Crater Radio Telescope (LCRT) and the Volatiles Investigating Polar Exploration Rover (VIPER), designed to study lunar water and test prospecting technologies ("Commercial Lunar Payload Services - NASA").

Lunar Gateway: A gateway can be considered a miniature version of the International Space Station, which once built, will continue to orbit the Moon. It is a module which can be deemed to be extremely helpful for missions on the Moon and beyond, and act as a platform for astronauts to live, conduct research and undertake scientific experiments and projects. International partners such as the European Space Agency and Japan Aerospace Exploration Agency are working with NASA on the modules of Gateway ("NASA's Gateway Program - NASA").

The Gateway modules under discussion are:

Habitation and Logistics Outpost (HALO): Acting as the foundation of the gateway, this first section shall be the habitation for the astronauts, while also acting as the station's command and control center. HALO will regulate the internal environment, provide power to the rest of the models of the Gateway and study the radiation levels inside and around the station ("NASA's Gateway Program - NASA").

International Habitation (I-HAB): Being the second habitable element of the Gateway, I-HAB shall act as the living room for all the Astronauts. Moreover, this section will have the space and the equipment to conduct experiments while living in orbit ("NASA's Gateway Program - NASA").

ESPRIT: Enhancing communication skills, refueling systems and taking care of the technological and mechanical section of the satellite, ESPRIT is an essential module ("NASA's Gateway Program - NASA").

In summary, the Artemis Program represents a significant step forward in humanity's quest to explore the Moon and beyond. It aims to build upon the legacy of the Apollo program by fostering international cooperation, achieving sustainability, and preparing for future missions to Mars and beyond. Artemis is a testament to the enduring human spirit of exploration and curiosity in the realm of space. ("NASA's Gateway Program - NASA").

The Artemis Missions are being worked on together by a variety of space agencies around the world, including SpaceX, the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the Canadian Space Agency (CSA). This global approach fosters collective exploration and resource sharing (Artemis Programme: What You Need to Know About NASA's Moon Missions).

2.   China's Lunar Projects

2.1. The Chang'e Missions

The Chinese National Space Administration (CNSA) established in 1933 is the governmental organization of People's Republic of China responsible for the management of space activities for civilian use and international space cooperation with other countries, and performs the corresponding governmental functions.

The Chinese Lunar Exploration Program (CNEP), popularly known as the "Chang'e Project", named after the Chinese goddess of the Moon, who is said to have flown from the Moon to the Earth. But contrary to the mythological meaning, the Chang'e mission a series of robotic lunar missions aiming to send rovers, orbiters, landers and so on, with a possibility of a crewed mission and a scientific outpost on the lunar surface, serving as a research site for scientists ("Live: Chang'e-4 Mission Press Conference") (中国航天日宣传片发布：共筑航天新时代-中国新闻网) (X)

The program is divided into roughly four phases to be carried out via multiple missions. But since the fourth phase hasn't begun yet, only the first three phases shall be discussed. Phase 1 involved launching and setting the first Chinese orbiting spacecraft, Chang'e 1 in the lunar orbit to scan and map the Moon's surface to form three-dimensional images of many lunar landforms and outline maps of major lunar geological structures. Moreover, the analysis of up to 14 chemical elements present in the lunar surface, a study of their composition across the plane and an investigation of the lunar soil was conducted (*Chang'e-1 (Lunar-1 Mission of China) - eoPortal*). In the same phase, Chang'e-2 was launched to perform the scientific objectives of Chang'e 1 but with an improvement in the performance of payloads on the basis of Chang'e 1. Hence, it also obtained three-dimensional images of the lunar surface, but with a spatial resolution of less than 10m. Similar to the first spacecraft, it studied the composition of the lunar soil along with the observation of the Earth-Moon and near-Moon space environment (*Chang'e-2 (Lunar-2 Mission of China) / CE-2 - eoPortal*).

Phase 2 required the soft-landing of spacecraft and the stationing of lunar rovers. From the data collected by the first two spacecraft, the landing spot for Chang'e-3 was decided as Sinus Iridum, but eventually landed on Mare Imbrium.

Some payloads onboard the lander and the rover and their functioning is as follows: The Moon-based Ultraviolet Telescope (MUVT) onboard the lander is the first long-term observatory deployed on the lunar surface, used to observe galaxies, binary stars etc. Terrain Camera (TCAM) to conduct color imaging and dynamic photography in order to study the geological structures of the Moon is one of the main scientific payloads of the mission. The

Extreme Ultraviolet Camera (EUVC) images the plasmasphere of the Earth from multiple angles. Lastly, the Landing Camera (LCAM) is mounted at the bottom of the lander in order to capture images during the landing procedure from an elevation range of 12 km to 3m for the accurate positioning and landing of the lander and rover (National Space Science Data Center).

Complementing the payload of the TCAM, the Panoramic camera (PCAM) also being one of the major payloads has the ability to take color and panchromatic images to investigate the morphology of the lunar surface around the landing site. The Lunar Penetrating Radar (LPR) is the first attempt at exploring the lunar sub-surface via the aid of ground penetrating radar with high resolution. The Active Particle-induced X-ray Spectrometer (APXS) mounted on the Yutu rover performed the in-site analysis of the chemical composition of the lunar soil and rocks (National Space Science Data Center). The function of the Visible and Near-infrared Imaging Spectrometer (VNIS) aboard the Yutu Rover is to make in-situ measurements of the composition and resources of the lunar surface via imaging and spectrometry in the visible and near-infrared wavelengths (Chang'e-3 Moon-landing Mission - eoPortal).

Chang'e 4, the last stage of the second phase, was originally designed as a back-up for Chang'e 3. But with the success of the latter, Chang'e 4's scientific payloads were adjusted in the following manner to act as the next step in the mission:

Firstly, The low-frequency radio astronomical study on the Moon's surface, which could only be conducted on the far-side of the Moon, which blocks the man-made radio frequency interference (RFI) and the auroral kilometric radiation (AKR) noise, as well as blocks the solar radio emission during the night time. Secondly, probing shallow structures of the patrol area in the moon's far side provides more information on the difference in the geological features between the nearside and far-side of the Moon. And finally, exploring the morphology and mineral constituents of the patrol area in the moon's far side will provide abundant information about the cratering mechanism, impacting effects and evolutionary history of the Moon (Jia et al.).

Phase 3, the lunar-sample return mission was kick-started by the launch of Chang'e 5 T-1, the precursor of the succeeding Chang'e 5 spacecraft. This mission was to validate the technology for the reentry vehicle ("Chang'e 5-T1"). Additionally, the capsule also carried experiments to expose bacteria and plants to the radiation environment beyond the low earth orbit

Chang'e 5, with the mission goal to land in the Mons Rumker region of Oceanus Procellarum on the 23rd of November 2020 ("Chang'e 5"), collected samples via two methods. The first method was to drill for subsurface samples. The sampling and drilling device is mounted on the Lander. One task of the Chang'e-5 Lunar Regolith Penetrating Radar (LRPR) is to provide information support for the drilling and sampling device (Shen et al.). The second method was to scoop for surface samples, using the device developed by The Hong Kong Polytechnic University. The device consisted of the shovel-shaped, around 35 cm in length Sampler-A, the approximately 30 cm long Sampler-B with teeth-like metal flaps used for collecting sticky samples, the Near-field cameras, which were attached to each sampler to

provide vision guidance in order to select scientifically valuable lunar samples and enable the sampler to deposit the samples into the container, grip the container and transfer it into the ascender precisely ("PolyU-developed Space Instruments Complete Lunar Sampling for Chang'e 5 | Media Releases | Media | PolyU").

The Chang'e missions aim to explore and understand the Moon, enhance China's space capabilities, and contribute to humanity's understanding of our celestial neighbor. They also focus on technological development, particularly in areas like lunar landing, rover deployment, lunar sample return and eventually conducting crewed missions to the Moon.

They represent China's ambitious space exploration goals, highlighting its growing space capabilities and commitment to lunar science and discovery. These missions have contributed significantly to the global understanding of the Moon, its geology, and potential future human exploration endeavors.

2.2 The Role in the Space Race

Via this operation, China seems to be participating in the second space race, with a foundation-building phase at the beginning led by instruments and robots, and a crewed phase in the latter half, along with an attempt at colonization of the Moon. With the Chang'e 5 mission launched in November 2020, China became the third nation to bring back geological samples from the Moon after the U.S. and Russia (Lüdtke). The pressure exerted by these Chinese propositions increases tension between Washington and Beijing, impeling the U.S. to send astronauts back to the Moon under the aforementioned Artemis Program (Lüdtke). Furthermore, the 2020 United States Defence Space Strategy lists China and Russia as "the most immediate and serious threats" to American space operations due to their military doctrines, which extend to space, and the nature of the technology they have deployed (Lüdtke). The Space Policy Review and Strategy on Protection of Satellites for the fiscal year 2023 published by the The United States of America Department of Defense also provides an assessment of the threat to the space operations of the United States and the allies of the United States, at present and with respect to the five-year period following the date of this review, with a detailed analysis of China's plans and their role in terms of the United States' standing also reflects a sense of threat felt by the crown of the West.

2.3. International Engagement

China has expressed interest in international collaboration, particularly through its participation in the United Nations Office for Outer Space Affairs (UNOOSA) and its offer to cooperate on lunar research with other nations ("The United Nations/China Cooperation on the Utilization of the China Space Station (CSS)"). This implies that China shall now abide by and safeguard the central role of the United Nations in managing outer space affairs and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies. It shall also uphold the guiding role of relevant UN principles, declarations and resolutions, actively participate in the formulation of international rules regarding outer space; and promote greater sustainability of

space activities. This olive branch towards a more cooperative international web in the realm of space advancement and technology shall also strengthen international exchanges and cooperation on space science in the international community, specially those based on common interests, goals and challenges. Moreover, China aims towards supporting the Asia-Pacific Space Cooperation Organization (APSCO) and the corporations under the BRICS and Group 20 mechanisms and the Shanghai Cooperation Organization to play an important role (China Proposes Cooperation in Outer Space).

3.   Comparative Analysis

3.1. Objectives

Both the USA and China share objectives of lunar exploration, including studying lunar geology, resource prospecting, and understanding lunar environments. Sustainability and resource utilization are key mutual goals. Moreover, both nations aim higher, keeping the visit to the Moon as a given, while planning colonization on the natural satellite and crewed missions to other planets as the foci. Additionally, both missions focus intensely on the south-polar lunar region, in hopes of advancing in the area of frozen water on the lunar surface.

3.2. Approach

While the USA emphasizes human spaceflight and international cooperation through the Artemis program, China has a series of successful robotic missions. China's Chang'e missions pave the way for future crewed lunar endeavors. The United States of America, while focusing on the scientific aspects of the mission, also ensures that the social and cultural views are kept in mind as well. Enthusiastic collaboration between NASA and other space agencies can also be observed in their missions. China, on the other hand, is extremely research-driven, but in recent years, the Chinese Government and the CNSA have been seen branching out, forming alliances with foreign space corporations and participating in multinational projects and organizations.

3.3. Lunar South Pole Emphasis

Water on the Moon has been a notion circulated for years, but it all began in 1645, when early astronomers and scientists speculated the presence of water on the Moon. Samples from the Apollo Missions at first seemed dry. A few decades later though, Brown University researchers revisited the samples using advanced technology, and found Hydrogen inside tiny beads of volcanic glass. Moreover, in 2009, a NASA instrument aboard ISRO's Chandrayaan-1 probe detected water on the lunar surface. In the same year, another NASA probe that hit the south pole found water ice below the moon's surface. An earlier NASA mission, the 1998 Lunar Prospector, had found evidence that the highest concentration of water ice was in the south pole's shadowed craters. Joining these dots, and having already discussed the possibly crucial role which could be played by frozen water on the Moon, the Lunar South Pole Region has gained sudden, but immense popularity among all scientists, researchers, astronauts and space agencies. Hence, both nations prioritize lunar exploration at the south pole in their reactive missions, aiming to understand the presence of water ice and its potential for supporting future lunar habitats.

4.	Future Space Exploration Ventures

In addition to lunar exploration, both the USA and China are actively pursuing broader space exploration goals.

The USA's Mars exploration, exemplified by the Mars Sample Return mission scheduled to launch in 2028, complements lunar efforts. The proposed mission aims to bring back samples of Martian soil, rocks and atmosphere back to Earth. Similar to the Lunar samples, the Martian samples shall be studied and analyzed thoroughly using the most sophisticated techniques by the scientists on Earth. Upon the collection of all the required samples, they will be loaded in a canister aboard the Mars Ascent Vehicle (MAV), the spacecraft which shall carry the container to the orbit of Mars, from where the Earth Return Orbiter will capture the container and seal it in a biocontainment system in order to prevent it from contaminating the atmosphere of Earth. Following the return to Earth, the capsule shall be released for the samples to be under special care for further analysis of the foreign materials (Mars Sample Return). Additionally, the launch of Artemis 2 in November 2024, building on the success of the uncrewed Artemis 1, shall carry four american astronauts aboard the Space Launch System (SLS) Rocket, paving the way for human landing on the lunar surface for Artemis 3 ("Artemis - NASA").

The Chinese Chang'e-6, Chang'e-7 and Chang'e-8, parts of Phase 4 of the Chinese Lunar Exploration Program, enter the active development stage of an autonomous lunar research station near the Moon's South Pole ("A Tentative Plan of China to Establish a Lunar Research Station in the Next Ten Years"). The subsequent missions include studying the topography of the South Pole–Aitken basin and returning samples from the region to Earth ("嫦娥四号着陆器、巡视器互拍成像图 - AcFun弹幕视频网 - 认真你就输啦 (?Ω?)ノ- (ﾟ-ﾟ)つロ"). Moreover, exploring the south pole for resources and verifying on-site resource and technology development are also planned (Jones).

Conclusion

The USA and China are at the forefront of lunar exploration, each with unique approaches and ambitions. Both nations prioritize lunar research and experimental activities, aiming to advance our understanding of the Moon's scientific and economic potential. International collaboration, sustainability, and resource utilization are key themes in their respective lunar projects, and their efforts contribute significantly to the global knowledge of lunar science and space exploration as a whole.

Works Cited

Peter, Nicolas. "The Changing Geopolitics of Space Activities." *Space Policy*, vol. 22, no. 2, Elsevier BV, May 2006, pp. 100–09. *Crossref*, https://doi.org/10.1016/j.spacepol.2006.02.007.

Nucera, Gianfranco Gabriele. "International Geopolitics and Space Regulation." *Oxford Research Encyclopedia of Planetary Science*, Oxford UP, May 2019. *Crossref*, https://doi.org/10.1093/acrefore/9780190647926.013.40.

Hickman, John. "Research Viewpoint: International Relations and the Second Space Race Between the United States and China." *Astropolitics*, vol. 17, no. 3, Informa UK Limited, Sept. 2019, pp. 178–90. *Crossref*, https://doi.org/10.1080/14777622.2019.1672507.

Seedhouse, Erik. *The New Space Race: China Vs. USA*. Springer Science and Business Media, 2010, books.google.ie/books?id=ey51Hy677mgC&printsec=frontcover&dq=The+New+Space+Race:+China+vs.+US&hl=&cd=1&source=gbs_api.

Jolliff, Bradley L., and Mark S. Robinson. "The Scientific Legacy of the Apollo Program." *Physics Today*, vol. 72, no. 7, AIP Publishing, July 2019, pp. 44–50. *Crossref*, https://doi.org/10.1063/pt.3.4249.

Apollo: A Retrospective Analysis. 2004, books.google.ie/books?id=i5Q9AQAAMAAJ&q=Project+Apollo:+A+Retrospective+Analysis&dq=Project+Apollo:+A+Retrospective+Analysis&hl=&cd=1&source=gbs_api.

Longobardo, Andrea. *Sample Return Missions*. Elsevier, 2021, books.google.ie/books?id=YqYsEAAAQBAJ&printsec=frontcover&dq=Sample+Return+Missions&hl=&cd=1&source=gbs_api.

Dreier, Casey. "An Improved Cost Analysis of the Apollo Program." *Space Policy*, vol. 60, Elsevier BV, May 2022, p. 101476. *Crossref*, https://doi.org/10.1016/j.spacepol.2022.101476.

Pernet-Fisher, John F., et al. "50 Years on: Legacies of the Apollo Programme." *Astronomy & Geophysics*, vol. 60, no. 4, Oxford UP (OUP), Aug. 2019, p. 4.22-4.28. *Crossref*, https://doi.org/10.1093/astrogeo/atz163.

"Artemis - NASA." *NASA*, www.nasa.gov/humans-in-space/artemis/#:~:text=With%20Artemis%20missions%2C%20we%20are,term%20presence%20on%20the%20Moon.

Artemis Programme: What You Need to Know About NASA's Moon Missions. www.rmg.co.uk/stories/topics/nasa-moon-mission-artemis-program-launch-date.

"Explainer: Why Are Space Agencies Racing to the Moon's South Pole?" *Reuters*, 24 Aug. 2023, www.reuters.com/science/why-are-space-agencies-racing-moons-south-pole-2023-08-22.

Artemis Plan. 2020, books.google.ie/books?id=l37rzgEACAAJ&dq=NASA%27s+Lunar+Exploration+Program+Overview&hl=&cd=1&source=gbs_api.

"Commercial Lunar Payload Services - NASA." *NASA*, 11 Jan. 2024,
www.nasa.gov/commercial-lunar-payload-services.

"NASA's Gateway Program - NASA." *NASA*, www.nasa.gov/reference/nasas-gateway-program.

CHINA:

"Live: Chang'e-4 Mission Press Conference." *YouTube*, 14 Jan. 2019,
www.youtube.com/live/v7FiaHwv-BI?si=rgC3cJ2pY3KiWxsD.

中国航天日宣传片发布：共筑航天新时代-中国新闻网.
www.chinanews.com.cn/m/sh/shipin/cns-d/2018/04-24/news765876.shtml.

X, Science. *China to Build Moon Station in "about 10 Years."* 24 Apr. 2019,
phys.org/news/2019-04-china-moon-station-years.html.

Chang'e-1 (Lunar-1 Mission of China) - eoPortal. 27 July 2022,
www.eoportal.org/satellite-missions/chang-e-1.

Chang'e-2 (Lunar-2 Mission of China) / CE-2 - eoPortal. 27 July 2022,
www.eoportal.org/satellite-missions/chang-e-2.

National Space Science Data Center. www.nssdc.ac.cn/nssdc_en/html/task/change3.html#.

Chang'e-3 Moon-landing Mission - eoPortal. 27 July 2022,
www.eoportal.org/satellite-missions/chang-e-3#gpr-ground-penetration-radar.

Jia, Yingzhuo, et al. "The Scientific Objectives and Payloads of Chang'E−4 Mission." *Planetary and Space Science*, vol. 162, Elsevier BV, Nov. 2018, pp. 207–15. *Crossref*,
https://doi.org/10.1016/j.pss.2018.02.011.

"Chang'e 5-T1." *NASA Space Science Data Coordinated Archive (NSSDCA)*,
nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2014-065A. Accessed 27 Jan. 2024.

"Chang'e 5." *NASA Space Science Data Coordinated Archive (NSSDCA)*,
nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2020-087A. Accessed 27 Jan. 2024.

Shen, ShaoXiang, et al. "The Design of Payload Lunar Regolith Penetrating Radar on Chang'E-5 Lander." *IEEE Aerospace and Electronic Systems Magazine*, vol. 36, no. 2, Institute of Electrical and Electronics Engineers (IEEE), Feb. 2021, pp. 4–16. *Crossref*,
https://doi.org/10.1109/maes.2020.3033439.

"PolyU-developed Space Instruments Complete Lunar Sampling for Chang'e 5 | Media Releases | Media | PolyU." *The Hong Kong Polytechnic University*,
www.polyu.edu.hk/en/media/media-releases/2020/1208_polyu_space_instruments_complete_lunar_sampling_for_chang_e-5.

Lüdtke, Lisa. "The Second Space Race." *GIS Reports*, 16 May 2022,
www.gisreportsonline.com/r/second-space-race.

"The United Nations/China Cooperation on the Utilization of the China Space Station (CSS)."
United Nations Office for Outer Space Affairs,
www.unoosa.org/oosa/en/ourwork/access2space4all/China-Space-Station/CSS_Index.html. Accessed 28 Jan. 2024.

China Proposes Cooperation in Outer Space.
lagos.china-consulate.gov.cn/eng/zlszc/202207/t20220719_10723332.htm#:~:text=China
%20calls%20on%20all%20countries,peaceful%20utilization%2C%20and%20inclusive%
20development.

Mars Sample Return.
www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/Mars_s
ample_return.

"A Tentative Plan of China to Establish a Lunar Research Station in the Next Ten Years."
NASA/ADS, ui.adsabs.harvard.edu/abs/2018cosp...42E3886Z/abstract.

"嫦娥四号着陆器、巡视器互拍成像图 - AcFun弹幕视频网 - 认真你就输啦 (?Ω?)ノ- (ﾟ-ﾟ)つ
ロ." *Copyright (C) AcFun*,
web.archive.org/web/20190415151408/http://passport.acfun.cn/a/ac4857461.

Jones, Andrew. "China Outlines Pathway for Lunar and Deep Space Exploration." *SpaceNews*,
30 Jan. 2023,
spacenews.com/china-outlines-pathway-for-lunar-and-deep-space-exploration.

Trauma Screening Tools for Youth: Current Practices and Future Directions By Aaron Kim

Abstract

Approximately 60.9% of American individuals have been exposed to trauma in childhood, with around 8% of affected youth developing PTSD by age 18. Early identification of trauma symptoms in young people is crucial, as untreated PTSD can disrupt neurodevelopment, impair emotional regulation, increase suicide risk, and lead to occupational and educational disabilities. This study presents a comprehensive review of current PTSD screening approaches for youth. First, an exploration into the various risk factors associated with PTSD is undertaken, pointing to the complex task of diagnosis and treatment. Next, the importance of the early identification of PTSD symptoms for timely intervention is investigated, highlighting the efficacy of various treatments in improving outcomes for affected youth. Furthermore, the study analyzes existing PTSD screening tools for youth, including the Child PTSD Symptom Scale (CPSS-5), the Clinician-Administered PTSD Scale for DSM-5 Child/Adolescent Version (CAPS-CA-5), and the Child Trauma Screen (CTS), showing their strengths, applications, and limitations. Lastly, highlighting the need for innovative screening tools, digital PTSD screenings are proposed as a potential option for increasing the accessibility and efficiency of PTSD screening tools for adolescents.

Keywords: child, adolescent, trauma, posttraumatic stress disorder, PTSD screenings, adverse childhood experiences

Introduction

According to the *Diagnostic Statistical Manual of Mental Disorders, Fifth Revision* (DSM-5), experiencing traumatic events such as death, severe injury, or violence one or multiple times can lead to the development and diagnosis of posttraumatic stress disorder (PTSD) (American Psychiatric Association, 2013). Exposure to traumatic events is common during childhood, with an estimated 60.9% of American adults having experienced an adverse childhood experience (ACE) at least once (Merrick et al., 2019; Swedo et al., 2023). Of these traumatized youth, an estimated 8% develop PTSD by age 18 (McLaughlin et al., 2013). PTSD is defined as a psychological disorder that anyone of any demographic can develop after a traumatic event and is diagnosed after a month of the following recurrent symptoms.
The DSM-5 classifies PTSD under a new category of trauma- and stressor-related disorders. The core diagnostic criteria for PTSD in youth aged 6 years and older are akin to the criteria for adults. The following symptoms emphasize the nature of PTSD: experience intrusive symptoms, an avoidance to traumatic stimuli, experience negative cognitions or emotions about the traumatic event that can lead an individual to feel guilty for the traumatic event or feel a persistent negative state of emotion, hypersensitivity or irritability.

The early identification of trauma symptoms in young people is vital due to the highly disruptive nature of PTSD. Left untreated, PTSD disrupts the proper course of neurodevelopment, reducing the size of the hippocampus (Teicher et al., 2016) impairing emotional regulation and threat reactivity in adolescents (Herringa, 2017). PTSD has also been discovered to heavily impact the quality of life of adolescents, affecting academic performance and increasing the likelihood of suicide risk (Panagioti et al, 2015) and occupational and educational disabilities (Holt et al., 2017). Given the severe consequences of unidentified PTSD symptoms, as well as the high prevalence of trauma exposure in childhood, the availability of effective PTSD screening options for youth is imperative.

The Present Study

The present study conducts a comprehensive review of the current landscape of youth PTSD screenings as seen in academic literature. First, the various risk factors for developing PTSD are discussed, illustrating the complexity of diagnosing and treating PTSD. Next, the importance of the early identification of PTSD symptoms for timely intervention is investigated, highlighting the effectiveness of various treatments like Cognitive Behavioral Therapy (CBT), Dialectical Behavior Therapy (DBT), and pharmacotherapy in improving outcomes for affected youth. This study then analyzes existing PTSD screening tools for youth, namely the Child PTSD Symptom Scale (CPSS-5), the Clinician Administered PTSD Scale for DSM-5 Child/Adolescent Version (CAPS CA-5), and the Child Trauma Screen (CTS), highlighting their strengths, applications, and limitations. Finally, digital screening tools are proposed as a potential alternative for increasing the accessibility and efficiency of PTSD screening tools for adolescents.

Risk Factors for PTSD in Youth

The effective diagnosis and the subsequent treatment of PTSD in young people hinges on a thorough understanding and consideration of various risk factors. This understanding not only facilitates the accurate diagnosis of PTSD, but also serves to identify specific populations at risk, thus promoting the availability of trauma screenings within communities (Sareen, 2014). Research demonstrates a variety of alternative screening options to address the diverse risk factors associated with PTSD in adolescents.

Adverse Childhood Experiences

A form of childhood trauma exposure, adverse childhood experiences (ACEs), such as exposure to neglect or violence, are highly common experiences, with approximately 64% of American adults reported experiencing at least one ACE during childhood (Swedo et al., 2023). ACEs have a strong, positive correlation with PTSD, as proven by a study that examined adolescents and concluded that those with moderate or high exposure to potentially traumatic childhood experiences had significantly greater posttraumatic stress disorder checklist for the fifth edition of the diagnostic and statistical manual of mental disorders (PCL-5), a self-report measure that assesses DSM-5 symptoms of PTSD.

Because of their prevalence, many states have recommended universal screening for ACEs at pediatric primary care visits. However, despite their high incidence, pediatricians have been slow to implement ACEs screening and it is only performed in a small portion of pediatric primary care visits. Additionally only 28% of trauma centers in the U.S. routinely screen for PTSD, a potential consequence of experiencing an ACE (Bulger et al., 2022). Screening for PTSD in a population, as well as providing accessible screening tools, that has experienced an ACE is critical, because evidence shows that ACEs are directly correlated with PTSD (Bulger et al., 2022). In order to successfully treat PTSD in a large number of youth, it is furthermore imperative that screenings are made more accessible to affected communities (Bulger et al., 2022).

Demographic Variables

To begin, biological risk factors, particularly epigenetic markers (Raabe & Spengler, 2013), play a significant role in the development of PTSD. Research shows that childhood exposure to trauma can induce genetic mutations in stressor-related genes, increasing susceptibility to the development of PTSD symptoms following traumatic experiences (Raabe & Spengler, 2013). In addition, demographic factors have been proven to be associated with PTSD outcomes in adolescents. individuals from lower socioeconomic backgrounds report higher levels of childhood trauma exposure (Mock & Arai, 2011), and research shows that Black communities are particularly at risk of trauma exposure due to increased susceptibility to racism (Assari, 2020). Gender also plays a significant role, with females exhibiting higher rates of PTSD despite males experiencing more traumatic events (Stein et al., 2000; Tolin & Foa, 2002). One report states that females have a lifetime prevalence for PTSD of 10% while males have a prevalence of 5% (Olff, 2017). This outcome is partly due to females experiencing more severe traumatic events in the form of sexual violence, which increases PTSD outcomes in young individuals (Stein et al., 2000; Yehuda, 1999). These demographic considerations in susceptibility to adolescent PTSD highlight the need for current screenings to consider these complex variables in assessing for PTSD risk.

Comorbid Conditions

Furthermore, existing literature suggests that comorbid conditions are a significant risk factor for PTSD. Young individuals with PTSD have a high likelihood of being diagnosed with other psychiatric disorders, shedding light on existing psychiatric issues as a risk factor of PTSD (Brady et al., 2000). In a large epidemiologic survey of U.S. adults diagnosed with PTSD, 79% of women and 88% of men have one or more diagnoses for other psychiatric disorders, particularly depression (Brady et al., 2000). Common psychiatric disorders that were found to be comorbid with PTSD are major depressive disorder, anxiety disorders, and substance use disorders (Brady et al., 2000; Peirce et al., 2008; Spinhoven et al., 2014). Comorbidity with these psychiatric disorders complicates treatment because it increases the number of interacting factors to account for when treating PTSD. For example, a portion of the PTSD population may misuse

substances to self-medicate for their trauma disorder, which can exacerbate withdrawal symptoms and worsen the symptom severity (Brady et al., 2000).

Current literature shows that the implementation of additional screening measures, including self-screening, prior to a PTSD screening is an effective method of accurately identifying comorbidity with a PTSD diagnosis (Linehan et al., 2015). Given that comorbidity with PTSD can lead to complications with treatment, research suggests self-screening measures as a potential solution for early identification, which saves the time of psychiatric clinicians and saves resources of the healthcare system (Brewin et al., 2002).

Early Identification and PTSD Interventions

The importance of PTSD screenings cannot be overstated, as early identification is necessary to begin evidence-based treatments for improving its symptoms. They enable an early identification of symptoms, allowing for timely intervention with appropriate treatments such as CBT, DBT, and/or psychopharmacological medications. Current literature shows that, by identifying PTSD early, young individuals can access effective interventions promptly (Kearns et al., 2012), potentially preventing symptom exacerbation and improving long-term health outcomes. As such, integrating PTSD screenings into routine healthcare practices and community interventions may be vital for enhancing the overall management of this condition (Keeshin et al., 2020).

A variety of treatments are available that have been proven to be highly effective in treating youth PTSD. Cognitive Behavioral Therapy (CBT), a psychotherapeutic approach, is the most commonly used treatment for PTSD in adolescents (Mendes et al., 2008). It focuses on altering negative thought patterns and behaviors that exacerbate PTSD symptoms (Hofmann et al., 2012). Studies show CBT significantly improves PTSD symptoms in youth, with high rates of success observed, with one study even identifying 92% of participants aged 8-18 no longer meeting criteria for PTSD after the administration of CBT (Smith et al., 2007). In addition, dialectical behavior therapy (DBT), originally designed for cases of complex and high-risk diagnoses, incorporates mindfulness and emotional regulation techniques (Bohus, 2022; Linehan & Wilks, 2015). DBT for youth with PTSD aims to develop tolerance for trauma, foster positivity, and enhance life satisfaction, and literature even suggests DBT to be even more effective than CBT in terms of decreasing youth dropout rates and PTSD remission rates (Bohus et al., 2020). These treatment modalities may be combined with pharmacotherapy, which involves prescribing drugs, for the treatment of PTSD in adolescents Selective serotonin reuptake inhibitors (SSRIs) like paroxetine and fluoxetine, along with venlafaxine, have shown effectiveness in treating youth PTSD (Isper et al., 2011). Studies suggest these medications are fast-acting and moderately effective, especially when combined with CBT or DBT (Moore et al., 2021). With these clinically effective interventions at hand, screening and identifying students impacted by potentially traumatic events can assist families and schools in offering vital support to youth (Eklund et al., 2018).

Current Screenings for PTSD Diagnosis in Youth

To improve adolescent PTSD screening methods, it is essential to first comprehensively understand the strengths and limitations of commonly used PTSD screening tools today. In this section, several of the most popularly implemented PTSD screening tools—CPSS-5, CAPS-CA-5, and CTS— are analyzed, as well as their unique approaches to assessing PTSD symptoms and trauma exposure in youth.

Child PTSD Symptom Scale (CPSS-5)

The CPSS-5, which evaluates the adolescent's trauma type and various symptoms, is clinician-administered in medical settings, and also comes in a self-report version (CPSS-5 SR) that is primarily administered in school settings (Foa et al., 2017). The CPSS-5 has been shown to be an internally consistent (α = .924), valid, and reliable (r = .800) assessment tool for the diagnosis of PTSD in children aged 8 to 18 (Foa et al., 2017). It is scored with an indication of PTSD severity, ranging from minimal severity (0-10) to very severe (61-80). The screening tool, which contains 27 items in total, is scored by adding together the ratings of 20 items that measure the presence of intrusion, avoidance, cognition, and arousal symptoms.

In an optional section of the CPSS-5, 7 items asking the participant a variety of potential trauma experiences are answered with either a "yes" or a "no." Examples of these questions include, "[Have you experienced] Being touched in your sexual/private parts by an adult/someone older who should not be touching you there," or "[Have you experienced] Serious accident or injury caused by a car or bike crash, being bitten by a dog, or caused by playing sports." Under these listed questions is a free response question that asks, "Which of these events bothers you the most?" Finally, the trauma screen section of the CPSS-5 asks for the participant's reaction to these traumatic events. For example, "When the event happened, did you feel fear that you were going to die or be seriously injured? Fear that someone else was seriously hurt? Unable to help yourself? Shame or disgust?"

In the main section of the CPSS-5, four items asking for the participant's experiences following a traumatic event serve to diagnose PTSD by targeting the four symptom types of PTSD. Responses are measured by frequency the patient experiences these symptoms, and are presented in a manner similar to a Likert scale. A sample of questions from each symptom type include: "Having upsetting thoughts or pictures about it that came into your head when you didn't want them to [Intrusive Symptom]", "Having bad thoughts about yourself, other people, or the world (for example, 'I can't do anything right', 'All people are bad', 'The world is a scary place') [Cognitive Symptom]", "Trying to stay away from anything that reminds you of what happened (for example, people, places, or conversations about it) [Avoidance Symptom]", and "Being jumpy or easily scared (for example, when someone walks up behind you, when you hear a loud noise) [Arousal Symptom]."

The strength of CPSS-5, which evaluates the participant's trauma type and various symptoms, is that it captures a large range of experiences due to being based on a Likert scale. Medical providers are able to use the CPSS-5 to obtain a useful metric that determines the severity of a patient's PTSD, which is a function that screening tools asking binary questions such as "yes" or

"no" cannot achieve. The CPSS-5, while effective, nevertheless presents challenges due to its time-consuming nature. The clinician-administered version of CPSS-5 requires upwards of 30 minutes for administration and scoring, adding strain to the medical system and hindering universal screening efforts (Foa et al., 2017). On the other hand, the self-reported version of the CPSS-5 is subject to social desirability bias, a phenomenon in which survey respondents respond to questions in a manner that is viewed favorably by others (Krumpal, 2011). As such, while more inexpensive and capable of reaching more affected youth compared to the clinician-administered CPSS-5, the self-reported version is not without limitations.

Clinician Administered PTSD Scale for DSM 5 Child/Adolescent Version (CAPS-CA-5)

In addition, the CAPS-CA-5 (Weathers et al., 2018) is another popularly used PTSD screening tool. The CAPS-CA-5 is based on the DSM-5 criteria for diagnosis, and it is also a modification of the Clinician Administered Scale for DSM (Weathers et al., 2018). Although there have been no studies measuring the internal consistency and reliability for the CAPS CA -5 specifically, the CAPS designed for adults demonstrates a strong internal consistency of (α = .88) and a good test-retest reliability (r = .78) (Weathers et al., 2018).

The CAPS-CA-5 contains 30 items used to assess PTSD symptoms and diagnose PTSD in children aged 7-18. The CAPS-CA-5 is a modification of the Clinician Administered Scale for DSM (CAPS), which is designed for the diagnosis of PTSD for adults. The CAPS-CA-5 is based on the DSM 5 criteria for children (aged 7-18). Critical revisions of the CAPS-CA-5 were made with changes to the DSM 5, which updated existing symptoms. Furthermore, a traumatic event must be identified for the use of CAPS CA - 5 screening and a single severity score is scaled.

Sample items include the following: "In the past month, did you get very upset, afraid, or sad when something reminded you of the bad thing that happened? [Criterion B4]", "In the past month, have you tried to stay away from people, places, or things that remind you of the bad thing that happened? [Criterion C2]", "In the past month, have you had trouble remembering important parts of the bad thing that happened? *(Do you feel there are gaps in your memory of [EVENT]?)* [Criterion D1]", and "In the past month, have there been times when you were quick to show your anger or got into arguments or physical fights? [Criterion E1]."

The CAPS-CA-5 exclusively clinician administered in medical settings with no self report version available (Weathers et al., 2018). Compared to the CPSS-5, the challenges posed by the time required to administer the screening is even worse with the CAPS-CA-5, which is exclusively clinician-administered and requires 45 to 60 minutes to administer (Weathers et al., 2018), straining the healthcare system. In addition, while these PTSD diagnostic tools are provided in multiple languages, this advantage does not fix the limitations of the language barrier between the medical provider and the participant in the case of clinician-provided PTSD screenings (Barroca et al., 2022; Lang & Connell, 2017; Serrano-Ibáñez et al., 2018). These problems posed by both the CPSS-5 and CAPS-CA-5 contribute to the underdiagnosis of PTSD, because an overburdened healthcare system is limited in its ability to frequently diagnose people, pointing to obstacles in the efficiency of the questionnaire (McBain et al., 2019).

Child Trauma Screen (CTS)

The CTS (Lang and Connell, 2017) is an empirically supported screening measure of trauma exposure and PTSD symptoms for children aged 6-17. It does not, however, provide a diagnosis. There are two formats of screenings, which are the child report answered directly by the child that experienced the traumatic event and the caregiver report answered by the parents of the child that experienced the traumatic event. The 10 items are identical in these reports aside from the language used to address either the child or the caregiver.

The CTS is internally consistent (α = .78 for both child and caregiver reports), maintains convergent validity (r = .83 and r = .86), divergent validity (mean across measures and reporters, r = .31; range r = .01-.70), and criterion validity (sensitivity = 0.83 and 0.76; specificity = 0.95 and 0.79, correct classification 89.3% and 81.4%).

The CTS is divided into two parts, titled "Events" and "Reactions". "Events" contains four items that identify a child's traumatic event experience and is answered with a "yes" or a "no." Items from this section include the following: "Have you ever seen people pushing, hitting, throwing things at each other, or stabbing, shooting, or trying to hurt each other?", "Has someone ever really hurt you? Hit, punched, or kicked you really hard with hands, belts, or other objects, or tried to shoot or stab you?", "Has someone ever touched you on the parts of your body that a bathing suit covers, in a way that made you uncomfortable? Or had you touch them in that way?", and "Has anything else very upsetting or scary happened to you (loved one died, separated from loved one, been left alone for a long time, not had enough food to eat, serious accident or illness, fire, dog bite, bullying)? What was it?"

"Reactions" contains six items that identify a child's symptom type and is answered by a scale of 0 to 3 that determines symptom frequency. These four choices are 0: "Never/ Rarely", 1: "1-2 times per month", 2: "1-2 times per week", and " 3+ times per week." Items in this section include "Strong feelings in your body when you remember something that happened (sweating, heart beats fast, feel sick)", "Try to stay away from people, places, or things that remind you about something that happened", "Trouble feeling happy", "Trouble sleeping", "Hard to concentrate or pay attention", and "Feel alone and not close to people around you."

The CTS is commonly utilized by clinicians and school counselors interested in quickly screening for potential trauma risk (Lang and Connell, 2017). Compared to the CPSS-5 and CAPS CA - 5, which take over 30 minutes for clinician-administered screenings, the CTS is brief as it only takes an estimated 10 minutes for a respondent to complete. This is a strength because it lowers the burden of time on the healthcare system, which is a critical limitation of both the CPSS-5 and the CAPS CA-5 that contribute to PTSD underdiagnosis. However, the CTS cannot be used as a tool to diagnose PTSD and does not include all possible trauma exposure or reactions (Lang and Connell, 2017), which strictly limits its usage to being a trauma screen. Lastly, as a self-report measure like the self-reported version of CPSS-5, the CTS is subject to social desirability bias (Krumpal, 2011), which poses obstacles in accurately depicting trauma symptoms in adolescents. Addressing these challenges of modern-day PTSD screening tools for

youth requires innovative approaches, and existing literature suggests that digital screenings may offer a promising solution (Graham et al., 2019).

Improving Current Screening Methods: Digital Screening Tools

Digital applications for the diagnosis of PTSD in youth are being studied, and this field is constantly being developed. Improving a digital form of screening is important because it can remove limitations of exclusion due to language (Escobedo, Cervantes, and Havranek, 2023), introduce an immediate PTSD intervention digitally, and remove limitations regarding hospital funding because of the low cost of screening (Patel et al., 2023). Furthermore, digital utilization rates among young individuals are high, with a study reporting that 87% of young adults had access to the internet using their smartphones (Villanti et al., 2017), rendering digital screening tools an effective option to diagnose PTSD in youth.

A digital application of PTSD screening can extend beyond the traditional paper and pencil self report assessment, which may be difficult for children who have not developed the sufficient reading comprehension skills to complete effectively (Beech, 2005). For example, a study conducted by Asnaani et al. examined the feasibility of the *CPSS-5 Screen Team Game,* a mobile game adaptation of the CPSS-5 with beach-themed aquatic characters that assess the participants 6 PTSD symptoms using engaging activities such as "swiping squid ink away from the screen to reveal questions (Asnaani et al., 2020). The study demonstrated internal consistency ($\alpha = .79$) and high convergent validity ($r\ (49) = .79, p < .001.$)

This establishes the potential benefits of digital screening tools as a low cost and accessible screening tool, and the effectiveness of digital evaluation has been confirmed to be as accurate as evaluation from a trained clinician (Bourla et al., 2018). Another study (Wolff et al., 2015) found that computer-administered PTSD screening was equally effective to clinician-administered PTSD screening. The same study confirmed the feasibility of the computer-administered screening and found that participants were willing to enter sensitive personal information regarding PTSD. A different digital application is the use of smartphone sensors to passively collect relevant markers of PTSD, which include avoidance behaviors, signs of cognitive changes, and tracking sleep data (Bourla et al., 2018).

In addition, the advancement in technologies in digital applications and machine learning has allowed for many studies to investigate an emerging digital marker for PTSD (Bourla et al., 2018; Malgaroli & Schultebraucks, 2020). Generative AI has a high potential for administering and processing digital screenings as they can adapt to the user's responses and ask questions similarly to the procedure a provider would perform. Furthermore, by analyzing user responses together with internet data and electronic health records, artificial intelligence is proven to be able to accurately predict psychiatric illness in patients (Graham et al., 2019). Although the use of artificial intelligence is not an established method for screening, the integration of AI into digital screening devices can dramatically reduce the cost of administering PTSD screening. Potential digital applications can be paired with the use of machine learning in artificial intelligence, which in the most common case is defined as the training and artificial intelligence on data that has been verified by human beings to provide a basis of truth so that an intelligence

can emerge that is capable of correctly identifying data types without human intervention (Graham et al., 2019). Artificial intelligence and machine learning can be used to generate new markers of PTSD using both passively (data collected from the phone) and actively collected data (screenings and questionnaires) (Graham et al., 2019). Another limitation is that technology has a high initial cost to implement, since hospitals need to buy mobile technology with touch screen capabilities (Ruzek et al., 2017).

Conclusion

Youth PTSD is prevalent and highly disruptive. PTSD affects neurodevelopment in youth and is associated with a high likelihood of comorbidity with other severe mental disorders, suicide risk, and educational disability.

Early identification of trauma symptoms is crucial for effective PTSD treatment, yet PTSD remains underdiagnosed due to barriers present in the CPSS-5 CAPS-CA 5, and the CTS. These commonly used screening tools, though statistically valid with applications in school and medical settings, are limited by costs to screening, time burdens due to the length of administering clinician-based screening tools on a healthcare provider, and language barriers that prevent effective communication between the patient and provider. Furthermore, current screening tools do not assess the multitude of biological, sociodemographic, and ethnoracial risk factors that affect PTSD outcome.

Given the presence of complex obstacles impacting the treatment of PTSD in youth, as well as the importance of early intervention, effective and accessible PTSD screening tools are crucial. Digital screening tools and the emergence of machine learning offer a potential alternative mode of screening that addresses obstacles found in current clinician-administered screening tools due to the advantages of automatically screening for PTSD without the need for a certified psychologist and the ability for machine learning to develop new markers for PTSD that can effectively be implemented into a digital, AI assisted format of PTSD screening.

Works Cited

American Psychiatric Association, D. S. M. T. F., and American Psychiatric Association. Diagnostic and statistical manual of mental disorders: DSM-5. Vol. 5. No. 5. Washington, DC: American psychiatric association, 2013.

Asnaani, Anu, et al. "An innovative mobile game for screening of pediatric PTSD: A study in primary care settings." Journal of Child & Adolescent Trauma 14 (2021): 357-366.

Assari, Shervin. "Family socioeconomic status and exposure to childhood trauma: Racial differences." Children 7.6 (2020): 57.

Barroca, Ines, et al. "Translation and validation of the clinician administered PTSD Scale (CAPS-CA-5) for Portuguese children and adolescents." Acta Medica Portuguesa 35.13 (2022).

Beech, John R. "Ehri's model of phases of learning to read: A brief critique." Journal of research in reading 28.1 (2005): 50-58.

Bohus, M. "Dialectical-Behavior Therapy for Complex PTSD." Trauma Sequelae. Berlin, Heidelberg: Springer Berlin Heidelberg, 2022. 317-329.

Bohus, Martin, et al. "Efficacy of a Psychosocial Pain Management Intervention for Men and Women With Substance Use Disorders and Chronic Pain A Randomized Clinical Trial." JAMA PSYCHIATRY 77.12 (2020): 1235-1245.

Bourla, Alexis, et al. ""e-PTSD: an overview on how new technologies can improve prediction and assessment of Posttraumatic Stress Disorder (PTSD)."" European Journal of Psychotraumatology 9.sup1 (2018): 1424448.

Brady, Kathleen T., et al. ""Comorbidity of psychiatric disorders and posttraumatic stress disorder."" Journal of clinical psychiatry 61 (2000): 22-32.

Brewin, Chris R., et al. ""Brief screening instrument for post-traumatic stress disorder."" The British journal of psychiatry 181.2 (2002): 158-162.

Brooks, Keeshin, et al. ""Screening for trauma in Pediatric primary care."" Current Psychiatry Reports 22.11 (2020).

Eklund, Katie, et al. "A systematic review of trauma screening measures for children and adolescents." School Psychology Quarterly 33.1 (2018): 30.

Escobedo, Luis E., Lilia Cervantes, and Edward Havranek. "Barriers in healthcare for Latinx patients with limited English proficiency—a narrative review." Journal of general internal medicine 38.5 (2023): 1264-1271.

Foa, Edna B., et al. "Psychometrics of the child PTSD symptom scale for DSM-5 for trauma-exposed children and adolescents." Journal of Clinical Child & Adolescent Psychology 47.1 (2018): 38-46.

Foa, Edna B., et al. "The Child PTSD Symptom Scale: A preliminary examination of its psychometric properties." Journal of clinical child psychology 30.3 (2001): 376-384.

Graham, S., Depp, C., Lee, E. E., Nebeker, C., Tu, X., Kim, H. C., & Jeste, D. V. (2019). Artificial intelligence for mental health and mental illnesses: an overview. Current psychiatry reports, 21, 1-18.

Herringa, Ryan J. "Trauma, PTSD, and the developing brain." Current psychiatry reports 19 (2017): 1-9.

Hofmann, Stefan G., et al. "The efficacy of cognitive behavioral therapy: A review of meta-analyses." Cognitive therapy and research 36 (2012): 427-440.

Holt, Melissa K., David Finkelhor, and Glenda Kaufman Kantor. "Multiple victimization experiences of urban elementary school students: Associations with psychosocial functioning and academic performance." Child abuse & neglect 31.5 (2007): 503-515.

Ipser, Jonathan C., and Dan J. Stein. ""Evidence-based pharmacotherapy of post-traumatic stress disorder (PTSD)."" International Journal of Neuropsychopharmacology 15.6 (2012): 825-840.

Kearns, Megan C., et al. "Early interventions for PTSD: a review." Depression and anxiety 29.10 (2012): 833-842.

Krumpal, Ivar. "Determinants of social desirability bias in sensitive surveys: a literature review." Quality & quantity 47.4 (2013): 2025-2047.

Lang, Jason M., and Christian M. Connell. "Development and validation of a brief trauma screening measure for children: The Child Trauma Screen." Psychological trauma: theory, research, practice, and policy 9.3 (2017): 390.

Linehan, Marsha M., and Chelsey R. Wilks. ""The course and evolution of dialectical behavior therapy."" American journal of psychotherapy 69.2 (2015): 97-110.

Malgaroli, Matteo, and Katharina Schultebraucks. "Artificial intelligence and posttraumatic stress disorder (PTSD)." European Psychologist (2021).

McBain, Sacha A., et al. "Barriers to and facilitators of a screening procedure for PTSD risk in a level I trauma center." Trauma Surgery & Acute Care Open 4.1 (2019): e000345.

McLaughlin, Katie A., et al. "Trauma exposure and posttraumatic stress disorder in a national sample of adolescents." Journal of the American Academy of Child & Adolescent Psychiatry 52.8 (2013): 815-830.

Mendes, Deise D., et al. "A systematic review on the effectiveness of cognitive behavioral therapy for posttraumatic stress disorder." The International Journal of Psychiatry in Medicine 38.3 (2008): 241-259.

Merrick, Melissa T. "Vital signs: estimated proportion of adult health problems attributable to adverse childhood experiences and implications for prevention—25 states, 2015–2017." MMWR. Morbidity and Mortality Weekly Report 68 (2019).

Moore, Bret A., et al. ""Management of post-traumatic stress disorder in veterans and military service members: a review of pharmacologic and psychotherapeutic interventions since 2016."" Current psychiatry reports 23 (2021): 1-7.

Olff, Miranda. "Sex and gender differences in post-traumatic stress disorder: an update." European journal of psychotraumatology 8.sup4 (2017): 1351204.

Panagioti, Maria, et al. "Suicidality and posttraumatic stress disorder (PTSD) in adolescents: a systematic review and meta-analysis." Social psychiatry and psychiatric epidemiology 50 (2015): 525-537.

Patel, Shreeya, et al. "Cost-effectiveness of targeted screening for non-valvular atrial fibrillation in the United Kingdom in older patients using digital approaches." Journal of Medical Economics 26.1 (2023): 326-334.

Peirce, Jessica M., et al. "Posttraumatic stress disorder, gender, and problem profiles in substance dependent patients." Substance use & misuse 43.5 (2008): 596-611.

Raabe, Florian Joachim, and Dietmar Spengler. "Epigenetic risk factors in PTSD and depression." Frontiers in psychiatry 4 (2013): 80.

Ruzek, Josef I., and Carolin M. Yeager. "Internet and mobile technologies: addressing the mental health of trauma survivors in less resourced communities." Global Mental Health 4 (2017): e16.

Serrano Ibáñez, Elena Rocío, et al. "Validation of the child PTSD symptom scale (CPSS) in Spanish adolescents." Psicothema (2018).

Smith, Patrick, et al. "Cognitive-behavioral therapy for PTSD in children and adolescents: A preliminary randomized controlled trial." Journal of the American Academy of Child & Adolescent Psychiatry 46.8 (2007): 1051-1061.

Spinhoven, Philip, et al. "Comorbidity of PTSD in anxiety and depressive disorders: Prevalence and shared risk factors." Child abuse & neglect 38.8 (2014): 1320-1330.

Stein, Murray B., John R. Walker, and David R. Forde. "Gender differences in susceptibility to posttraumatic stress disorder." Behaviour research and therapy 38.6 (2000): 619-628.

Swedo, Elizabeth A. "Prevalence of adverse childhood experiences among US adults—behavioral risk factor surveillance system, 2011–2020." MMWR. Morbidity and Mortality Weekly Report 72 (2023).

Teicher, Martin H., et al. "The effects of childhood maltreatment on brain structure, function and connectivity." Nature reviews neuroscience 17.10 (2016): 652-666.

Villanti, Andrea C., et al. ""Social media use and access to digital technology in US young adults in 2016."" Journal of medical Internet research 19.6 (2017): e196.

Weathers, Frank W., et al. "The Clinician-Administered PTSD Scale for DSM–5 (CAPS-5): Development and initial psychometric evaluation in military veterans." Psychological assessment 30.3 (2018): 383.

Wolff, Nancy, et al. ""Screening for PTSD among incarcerated men: A comparative analysis of computer-administered and orally administered modalities."" Criminal justice and behavior 42.2 (2015): 219-236

The Printing Press as a Catalyst for Social Change By Jaemin Cho

Abstract

The printing press, created by the German inventor Johannes Gutenburg, has been credited as the single most important factor in the Protestant Reformation because it enabled the spread of Protestant ideas across cities in Europe. However, it would have been impossible for new religious ideas to take hold if the populace had not been receptive to them already. Thus, to understand the true role of the printing press, the existing political and social landscape in Europe must be taken into account first. This paper analyzes primary sources from the Library of Congress and scholarship about European societies under the Roman Catholic Church to understand why certain cities were eager for religious and social change. I argue that the printing of Martin Luther's 95 Theses via the printing press sparked interest in alternative forms of governance and religious beliefs, not the printing press alone. The printing press and Luther's 95 Theses together changed the publishing industry and the social landscape of Europe in the short and long term. It eventually toppled the power that the Roman Catholic Church held on society and gave rise to Protestantism, which is now the second-largest form of Christianity. Moreover, the heightened interest in the written word increased literacy rates and bolstered the exchange of ideas that gave birth to the modern era.

Christianity and Printing in Pre-Reformation Germany

Before Johann Gutenburg invented the first printing press that used movable metal type in Europe, scribes copied books by hand (Miélot). It was a long and arduous process that could only produce a small number of books per year, so books were expensive and inaccessible to most of the poor and illiterate populace. The Roman Catholic Church, instead served as the source of mass media; clergyman conveyed knowledge, announcements, and information imperative to daily life alongside sermons to the public. Thus, the Church had a monopoly on both salvation and communication. These monopolies allowed the church to "project the interests that reflected the values of the religion and its own self-interest upon their audiences" (Scialabba 76). In other words, the Church did not only determine what information reached the public, but it controlled how the public understood and utilized said information, often to the Church's benefit. This kind of control ensured that the Church held the most political power in society.

When German craftsman Johann Gutenburg invented the printing press in the early 1450s, the technology revolutionized printing. To use the device, printers placed individual metal letters in a grid, inked them, and then pressed the paper onto the inked letters (World History Commons, "Printing Press"). This method was much faster than employing scribes or monks to copy each word by hand and reduced the margin for error. Between the printing press and changes in the ink and paper production, the price of books fell dramatically — up to 85 percent (Rubin 276). While the numbers of printed texts increased, the content of printed materials remained conservative as "printers had either published the books urged on them by

intellectuals" or medieval bestsellers that the few literate elite were sure to buy (Pettegree 982). Additionally, the Church became one of the biggest customers of printers. The Church used the new technology to print ordinances, papal bulls, indulgences, and liturgical books (Rubin 276). In fact, half of the texts published between 1450 and 1520 were religious texts commissioned by the Church (Pettegree 982). So, while the printing press was a revolutionary technological innovation, the technology alone did not transform the structure of European society. Instead, the Church subsumed the printing press to perpetuate its own ideologies.

However, there were seeds of dissatisfaction growing in European populations regarding the position of the Church. Kreiss comments that people perceived the church as "stern and formal" because of its emphasis on religious rituals in the pursuit of salvation. Kreiss writes: "The notion that salvation could be won through good words and fasting, chastity, abstinence, and asceticism didn't offer them a profound sense of assurance that they would, indeed, be saved (Kreis)." Evidence of this skepticism is apparent in the numbers of attempted rebellions. In the early 15th century, Jan Hus, a Prague preacher, spoke against the Church practice of selling indulgences and "sinful nature" of the clergymen. His beliefs gained traction within Bohemia (modern-day Czech Republic) and culminated in the Hussite movement. The movement was later violently suppressed by the church and Hus was burned at the stake (Becker at al. 8). Suppressing the movement did not remove society's negative sentiments towards the Church, however. They remained dormant and then once again bloomed almost a century later; some of Hus's criticisms are similar to the ones used by the Reformers during the more successful Protestant Reformation in the early 16th century.

Martin Luther and the Indulgence Controversy

Martin Luther, who became the face of the Protestant Reformation, was a German preacher and university professor also dissatisfied with the state of the Church. Luther was born in Eisleben in 1483 and was so successful in his formal education that he was able to enroll at the prestigious University of Erfurt in 1501 ("Martin Luther: A Reformer is Made"). After a religious experience, he decided to end his study of law and become a monk in the Order of Saint Augustine. Shortly after, he was ordained a priest. Then, in 1509 he entered the University of Wittenberg to study theology; upon graduating, he became a professor of the subject at the university.

During his study of theology, Luther developed views that contradicted those of the Church. He believed that salvation could be achieved through faith in God alone. This departed from the Church's teachings that asserted that salvation is achieved by performing good deeds on Earth. Moreover, like some religious leaders before him, Luther began to question the sale of indulgences because the practice lacked biblical basis. In fact, it was his thoughts about indulgences that would catapult him into the spotlight and begin the Protestant Reformation in earnest.

To understand why Luther was against indulgences, it is necessary to discuss what indulgences were. Indulgences were full or partial remission of punishment for sins after the sinner confesses and receives absolution. Indulgences were granted on the authority of the pope,

who delegated the sale and distribution of indulgences to other religious agents. Originally, they were not intended to give the impression that divine forgiveness could be purchased, but as papal finances decreased during the Middle Ages, abuses of the system grew more and more "common" (Encyclopedia Britannica, "Martin Luther"). By Martin Luther's time, the practice of selling indulgences was at an all time high because the Church could print more indulgences with the printing press. The Church's rhetoric around indulgences and salvation was so convincing that even in areas where the sale of indulgences had been banned, such as Germany, people would travel to other areas to purchase one (Bossick).

Amidst this indulgence frenzy, a Dominican friar in neighboring Brandenburg named Johannes Tetzel began preaching that purchasing an indulgence would lead to the forgiveness of sins (Bossick). He exalted the sale of indulgences to raise money for the renovation of St. Peter's Basilica in Rome (HISTORY, "Martin Luther and the 95 Theses"). Angered by the blatant abuse of indulgences, Luther penned the "Disputation on the Power and Efficacy of Indulgences," now commonly known as The 95 Theses, a document that posed questions and propositions for an academic debate about the theological basis for selling indulgences (Luther). He sent a copy of this document to Tetzel's superior, Archbishop Albert of Mainz, as well as a few friends. Though Luther is said to have first circulated the controversial document privately, The 95 Theses somehow fell into the hands of German printers who began distributing it in both the original Latin and translated German.

Changes to Germany's Printing Industry

The printing of Martin Luther's 95 Theses had an immediate effect on the printing industry and slowly but surely toppled the power of the Church through the Protestant Reformation. As previously mentioned, the printing industry had only taken root in larger German cities where literate elite were more likely to live; additionally, the industry was rather conservative because the texts were either commissioned by the Church, medieval best sellers, or texts written by intellectuals. The printing of Martin Luther's 95 Theses, however, expanded the number and genres of texts that were printed. This shift altered the amount and flow of information available to the public, especially from non-Church sources, and changed how the public engaged with printed materials.

By the end of 1517, the year that Martin Luther wrote the document, three editions of 95 Theses had been printed in Leipzig, Nuremberg, and Basel. Between the three editions, it is estimated that about 300 copies had been printed that year (Luther). Because the document could be seen as a controversial statement against the statutes of the Church, printers saw it as a hot commodity (Gjelten). The London Library, which is in possession of one of the original prints, explains that there were multiple errors in the Thanner broadsheet printed by Joseph Thanner of Leipzig. The 95 Theses printed in Leipzig contained errors in the roman numerals used to number each thesis: "item 24 becomes 42; 27 becomes 17; and 46 hovers in the middle of item 45, 75 in the middle of 74 leaving a nominal tally of 87" (Bossick). These mistakes point to the

fact that copies of 95 Theses were made hastily as printers rushed to distribute as many copies as soon as possible.

One reason that printers were able to reproduce it so quickly was because of its brevity. Larger books took months to produce, but a pamphlet like 95 Theses could be printed within a day or so (The Economist). Once copies were printed, they circulated in town, and then locals recommended it to friends or shared the pamphlet with others. Once enough people in a neighboring town shared interest in the document, local printers would rush to reproduce it to turn a profit. In this way, 95 spread far and wide throughout Germany without Martin Luther's knowledge or direct involvement. What also helped the 95 Theses catch on was the printer's decision to translate the document into German. Because greater numbers of people could understand German, the audience for 95 Theses was greater than that of Church-commissioned texts written in Latin. Realizing this was a main reason for the success of his works, Martin Luther wrote his next publication, "Sermon on Indulgences and Grace," in German without relying on regional vocabulary (The Economist). This ensured that the original nuances of his arguments would be understood throughout the country.

Martin Luther's literary output correlated positively with the growth of Germany's printing industry. He produced 30 works between 1517 and 1520, which sold over 300,000 copies during the same time period (Rubin 277). In his town of Wittenberg, which had not been a major printing hub prior, five active publishers had sprung up by 1525, and they began to produce an average of 90 works per year, totaling 2,721 works between 1517 and 1546. About one-third of these works were Luther's, and a large fraction of the remaining two-thirds were produced by Luther's colleagues and friends (Rubin 278). As Luther's popularity spread throughout Germany, smaller towns that had lacked printers suddenly had multiple publishing houses. Therefore, Martin Luther effectively dethroned the Church's rule of publishers and by extension, the monopoly on mass media. Greater numbers of people were digesting written information and formulating their own opinion because of the availability of alternate reading materials.

Changes to Christianity

With the spread of Martin Luther's publications came the spread of his ideas about salvation, a phenomena referred to as the Protestant Reformation. Scholarship about the Reformation often refers to it as an "urban event" since it first took hold in cities when local literate priests and scholars decided to spread Luther's message. According to Rubin, these Reformers were the reason that the Reformation spread so quickly; because they held positions of esteem in the local churches, they could aggressively question Church practices and preach biblical tenets of salvation to the public from the pulpit (Rubin 280). Their efforts were most effective in the cities of Central Germany in the 1520s. By 1522 in Wittenberg, priests had started dressing in garb similar to the common folk and called themselves ministers; they preached in German instead of Latin; and some even began to marry, a practice which had been prohibited in the Catholic Church. Most importantly, with the increased availability of books,

especially Luther's German's translation of the New Testament, more people were reading the Bible for themselves instead of solely relying on the interpretations of Catholic priests (CK-12 Foundation).

In cities such as Strasbourg and Ulm, the Reformation was spread by city council members who took the initiative to appoint preachers who agreed with Luther's ideology. For Northern cities, it was neither pirests or city council members but the nobility who supported the Reformation. These "middling bourgeoisie, who were wealthy but had little political power within the cities" felt that their financial and social mobility was limited by the Church and sought to remove the Church from power to improve their own standing (CK-12 Foundation). Once the nobles used their influence to ensure the town accepted the Reformation, "the old privileges and status of the priesthood and hierarchy were removed" and the Church's material wealth was redistributed or destroyed (CK-12 Foundation). This occurred in 50 of Germany's 65 cities (Rubin 278). Thus, the Protestant Reformation toppled existing power structures within a decade or two after the publication of Luther's 95 Theses.

Moreover, the Protestant Reformation signaled permanent and long-term changes to Germany's (and Europe's) landscape. With the loss of Roman Catholic Church positions and material wealth, the political and financial power of the Church decreased accordingly. New Protestant rulers turned to parliaments to provide revenue and support their rule, which were more aligned with long-term economic development because parliaments included "protection of property rights, provision of public goods, and investment in trading companies (Becker et al. 22). Additionally, Reformers essentially proposed a separation of church and state with a doctrine called "two kingdoms," that allocated government function to a prince and limited the Church involvement to only spiritual affairs. The "two kingdoms" system "created the bases for integrated bureaucracies and legal formalism that provide the foundation of the "civil service state" characteristic of modern Northern and Central Europe (Becker et al. 23). In other words, seizing power from the Church enabled Reformers to change legal, economic, and government systems that had long-served as the basis for society. One final life-changing contribution was the Reformer's change to the educational system. Because Luther believed that everyone should be able to read the Bible for themselves, Reformers began creating schools for girls alongside boy's schools. Although data from the 16th and 17th centuries is limited, researchers have shown that Protestant areas in the 19th century had higher literacy rates than Catholic areas in Europe and smaller gender gaps in literacy as well (Becker et al. 7). Thus, Protestant ideals precipitated by Luther and his followers had long-term and far reaching effects that influenced the rise of modern nations in Europe today.

Conclusion

This paper has argued that the printing of Martin Luther's 95 Theses was a turning point in history because it removed the monopoly the Roman Catholic Church had on mass media and sparked public interest in alternative religious beliefs. Some may argue that the invention of the printing press alone accomplished this feat, but this is false because for nearly half a century after the printing press, the Church still retained the greatest political and financial power in

society. Luther's 95 Theses was the catalyst that reached a disillusioned populace and spurred scholars, council members, and sympathetic priests to finally take action. As far as immediate effects, Luther's publications led to more publishers all over Germany and priests began changing the content of their sermons. When the Reformation took hold in a city, it altered the make-up of city councils, parliaments, and royal councils. As far as the long-term effects, Reformer ideals about the separation between city and state served as the foundation for more modern forms of governance, and their focus on parliaments meant greater long-term economic prosperity. In conclusion, although no one knew it at the time, even Luther himself, the printing of the 95 Theses changed the fabric of German society and contributed to Europe and America's development many years later.

Works Cited

Becker, Sascha O., Steven Pfaff, and Jared Rubin. "Causes and Consequences of the Protestant
    Reformation." Explorations in Economic History 62 (October 1, 2016): 1–25.
    https://doi.org/10.1016/j.eeh.2016.07.007.

Bossick, Charlotte. "The 95 Theses – a Tale of Survival," n.d.
    https://www.londonlibrary.co.uk/theses.

CK-12 Foundation. "The Protestant Reformation and Catholic Counter Reformation," n.d.
    https://flexbooks.ck12.org/user:zxbpc2rzcziwmthaz21hawwuy29t/cbook/world-history-st
    udies_episd/section/6.2/primary/lesson/the-protestant-reformation-and-catholic-counter-r
    eformation/.

Encyclopedia Britannica. "Martin Luther | Biography, Reformation, Accomplishments, Quotes,
    & Facts," January 16, 2024.
    https://www.britannica.com/biography/Martin-Luther/The-indulgences-controversy.

Gjelten, Tom. "How Technology Helped Martin Luther Change Christianity." *NPR*, November
    20, 2016.
    https://www.npr.org/2016/11/20/502437123/how-technology-helped-martin-luther-chang
    e-christianity.

HISTORY. "Martin Luther and the 95 Theses - Summary, Origins & Video | HISTORY," October
    29, 2009. https://www.history.com/topics/religion/martin-luther-and-the-95-theses.

Luther, Martin, Author. *Ninety-Five Theses*. Nuremberg: Hieronymus Höltzel, 1517. Image.
    https://www.loc.gov/item/2021667736/.

Miélot, Jean, Active 15Th Century. *Medieval scribe Jean Miélot, sitting at a desk, making a copy
    of another book.*, 1885. Photograph. https://www.loc.gov/item/2006680149/.

Pettegree, Andrew. "Print and the Reformation: A Drama in Three Acts."
    Church History 86.4 (2017): 980-997.

"Printing Press," in World History Commons, https://worldhistorycommons.org/printing-press

Rubin, Jared. "Printing and Protestants: An Empirical Test of the Role of Printing in the
    Reformation." *The Review of Economics and Statistics* 96, no. 2 (May 1, 2014): 270–86.
    https://doi.org/10.1162/rest_a_00368.

Scialabba, Karen F. "The Protestant Reformation and Catholic Publishing: A Framework for
    Contemporary Understanding." Journal of Religious & Theological Information 12, no.
    3-4 (2013): 71-89.

The Economist. "How Luther Went Viral." *The Economist*, January 20, 2013.
    https://www.economist.com/christmas-specials/2011/12/17/how-luther-went-viral.

Wellesley College. "Martin Luther: A Reformer Is Made," n.d.
    https://www.wellesley.edu/davismuseum/whats-on/Virtual_platform/martinluther/node/18
    2141.

Artificial Intelligence, Leisure, and Entrepreneurship: Re-introducing John Keynes' "Age of Leisure" Theory By Xinyi Huang

Introduction

High-profile instances like Google's AlphaGo defeating a Go world champion or Baidu's Duer taking orders at KFC in China underscore the rapid progress of AI (UBS). Today, approximately 2,000 start-ups around the world incorporate AI into their core business models. Statistically speaking, 77% of current businesses have already incorporated AI in their operations, and over 53% of IT companies reported expedited AI adoption in 2021 and 2022 (Wardini). AI's pervasive expansion in businesses is largely driven by its scalability, cost-effectiveness, and consistency with rule-based programs (UBS). Furthermore, AI has the advantage of programmatic longevity with frequent and rapid improvements. This trend will only continue and accelerate now with more accessible AI systems that have been tested and developed in the economy.

Despite its pervasiveness, the integration of artificial intelligence, or AI, into the labour market has sparked debates about its implications. Some people are optimistic about the systematic changes AI will bring. James Manyika, Chairman and Director of the McKinsey Global Institute has stated that "We're going to see tremendous occupational shifts. Some jobs will climb while others decline" (Ward). Others are raising concerns about whether AI integration may bring ethical dilemmas into business decision-making. According to the World Economic Forum, the proportion of tasks completed by humans and machines respectively will change: Even in a 5-year time frame from 2022 to 2027, the utilisation of machines in industrial tasks is likely to increase from 34% to 43%, while humans have fewer tasks assigned, losing work from 66% to 57% (Sharma). This possible trend of a 9% transfer of tasks from humans to AI in just 6 years can be quite alarming, considering people's working conditions and job opportunities. Nevertheless, a more thorough examination is needed to identify the impact of AI on the human workforce.

One classic economic concept by John Maynard Keynes (1883-1946) may enlighten this debate on whether AI development will have positive or negative impacts on employment and productivity. "Age of leisure," brought forward by Keynes in 1928 in the short essay "Economic Possibilities for Our Grandchildren" during the Great Depression, suggests that as productivity grows and living standards rise four to eight times, people will choose to work less than 15 hours per week (Keynes). This change will result in an increase in leisure time for people and an increased need for entertainment. The central thesis of this paper is that the integration of AI technologies into some industries in the labour market will likely usher in an unprecedented Keynesian "age of leisure."

The new concept of "leisure-based entrepreneurship" is a recent term scholars use to describe how an "age of leisure" transforms our lives. It is defined as a "core activity that people find so substantial, interesting and fulfilling that, in the typical case, they launch themselves on a (leisure) career centred on acquiring and expressing a combination of its special skills, knowledge, and experience' (Kwapisz). Other researchers introduce "lifestyle entrepreneurship" as a mode of work with financial incentives given to employees, connecting work with pleasure to "making a life" (Ivanycheva et al.). Some researches focus on characteristics captured in leisure-based entrepreneurship, including

team size, individual passion, ownership percentage, and team functional diversity (Kwapisz), the measured efficiency of leisured-based entrepreneurship compared with traditional enterprises, depending on work nature, as well as active immigrant leisure-based entrepreneurship (Golob). These traits help to create a better image for leisure-based entrepreneurship. At the same time, there are also further studies on "leisure-based entrepreneurship" against the backdrop of the COVID-19 crisis regarding the connection between work and leisure when an unprecedented number of people work remotely (Kim et al.). Apart from the discussions and studies above, how to define leisure-based entrepreneurship more precisely under the observable growth of AI is still an ongoing debate, due to the differentiation between small family businesses and lifestyle entrepreneurship.

As 66% of business owners consider video content as the most effective form of content marketing (Tiushka), vloggers have been preferred as the latest popularised marketing trend. Vloggers can expand their influence on social media platforms, such as YouTube. Leisure-based entrepreneurship can be specifically identified as an activity that combines leisure and business opportunities to generate profits. One example is the rise of leisure-themed YouTube vloggers who are influential figures that grab people's attention by producing engaging video content while benefiting monetarily from it. The types of leisure themes include food tours, travel and sightseeing, meditation and relaxation, workouts, and lifestyle. By getting 4,000 watch hours and 1,000 subscribers (Tiushka), vloggers could then take advantage of the volume or viewer traffic to make considerable profits. Through this collaborative nature of leisure and work, vloggers, acting as representatives of leisure-based entrepreneurship, could introduce a new way of work. A recent development for vloggers is that they utilise AI to teach and share content. This allows them to quickly build out and populate more channels of content, adding more income from a diversified portfolio of viewership.

The way leisure-based entrepreneurship advances Keynes' "age of leisure" is that it blurs the boundary between "work" and "leisure." When Keynes penned his "age of leisure" theory, he probably did not expect that even a lot of leisure activities, in addition to manufacturing and business activities, could be turned into profitable commercial opportunities with the advance of technology. However, what we could show is that under the integration of AI, leisure, and enterprise, the "age of leisure" theory could still be reliable in interpreting people's businesses and utility through leisure.

By using this theory, we could explain the leisure enjoyed by people as they fit in the AI-included labour market: how they could utilise AI to improve their lives. This concept, combined with the "age of leisure" theory, stands because of prevailing trends in our time, including a dramatic decline in work time in traditional job positions, the rise of purchasing power among workers, and more entertainment options assisted by new media, and we are seeing more examples of leisure-based entrepreneurship.

Dramatic Decrease in Work Time

In recent decades, working hours for people in different countries have decreased considerably. For instance, in the United States, average weekly working hours decrease from 34.6 to 34. Excluding the factors of increasing working hours during the pandemic times between 2020 and 2022, the working time is still declining starting from 2022 to 2024, from 34.5 to 34.1 (U.S. Bureau of Labor Statistics,

'United States Average Weekly Hours'). Suppose the workload assigned to employees is unchanged, and as the working time is decreased, employees can gain more free time after work and subsequently enjoy more "leisure."

First of all, as AI integration matures and the economy evolves around it, the average working adult's working time will likely decrease significantly. This is because, with the assistance of AI, which is used as a complementary tool for white-collar employees, employees' productivity will improve. While employees are catching up with the technological trend, AI, specifically robotic machines, can help employees manage comparatively trivial or physically demanding tasks, freeing them for more complicated tasks. Taking the quality control stage of steel production as an example: AI and quality control inspectors can work together in identifying defects through an algorithm with the interface respectively within shorter timeframes (Ebert). By freeing human hands from high-hazard work conditions in steel production, this integration will make steel production safer and more efficient. Another example of cooperation between humans and AI is through Protection Assistant for Wildlife Security, also called PAWS, a recently innovated AI technology that utilises previous poaching activities as data for determining the routes with a high probability of poaching (Ebert). Technological advancement can help increase wildlife preservation staff's efficiency and productivity, enabling them to finish the assigned tasks in shorter periods of time. Also, YouTubers create intriguing videos ranging from a single afternoon to over 20 hours per week (Kumar). But with the help of advanced media equipment and editing tools, YouTubers could focus more on content creation and video promotion, reducing their working time when compared to the weekly average of 40 hours (Kulakov).

Secondly, by taking on onerous and risky tasks and reducing employees' workload, AI added to the workforce will result in fewer working hours. For instance, annually, over 20,000 assembly line workers suffer from physical pain, such as eye injuries and vision loss (Matt Fendon Law Group). These injuries will potentially undermine their work productivity and health in the long term. However, with the help of AI, these assembly line workers do not need to perform repetitive working tasks in the factories and can stay in the working environment for less time. This can improve people's leisure as they have an actual gain of time after work as well as a better health condition.

Nevertheless, despite the potential benefit of having a lower workload for employees, there may be higher unemployment in the economy. Self-employment may be common. This means that companies may hire temporary employees for epiboly, forming a gig economy. However, these adverse effects can be explained. Firstly, the rise in the unemployment rate is often a temporary condition, as people's unemployment rate will more likely be maintained at a natural level in the long run. The addition may lead to the loss of employees in traditional sectors, including foreign language teachers, salesmen, and bookkeepers. However, AI integration generally results in the creation of diversified, latest, and irreplaceable jobs. For instance, AI trainers and operators, in SumUp, train and improve AI systems. Also, AI-generated work auditors will be required, in businesses such as Mitek Systems, to spot potential defects and illogical details found in AI-generated articles and pictures (Forbes). Moreover, vloggers can generate substantial profits from producing leisure-based videos while being self-employed.

The World Economic Forum's 2018 report predicts that by 2025, machines will handle more than 50% of tasks, which will be a significant increase from 29% in 2018 (Peristic). The report further posits that a new labour market composition will accompany this rapid shift of labour requirements, leading to more jobs, especially in technological sectors (Peristic). Also, some economists predict that by 2025, while 85 million jobs will be obsolete in the areas including technological and content-creation industries, 97 million new jobs will be added to the global economy (Russo). This means that a higher number of people will be accepted to job positions, and more people will be able to benefit from working productively with AI. Therefore, unemployment will not be a serious concern.

Secondly, the growing trend of the gig economy during and after COVID-19 will not be considered as a critical factor as expected. The gig economy could enable employees to develop the ability to work remotely and flexibly while gaining greater potential returns. For example, researchers found that 44% of freelancers suggest they earn a higher return than as a traditional employer, and 18% of freelancers indicate their returns as being the same, showing the freelancers having a positive economic condition when transiting to the gig economy (Ozimek). This reveals that a free-lance economy can bring more individual benefits, including versatility and flexibility. Freelancers can utilise their increased income and flexible time schedules for more leisure.

More Purchasing Power by Employees

When AI integration upgrades certain industries, they may also elevate employees' wage levels in these sectors. Therefore, it is likely that they will have higher purchasing power. Admittedly, there will still be low-wage jobs in the economy, including agricultural jobs, as AI tools have trouble distinguishing fruit and vegetable sizes as an example (AgriTech Tomorrow). This still makes agricultural workers an important proportion of agricultural work. However, AI-integrated new jobs will also boost the wage levels of many. According to a study from researchers at the Oxford Internet Institutes as well as other centres and institutes, the combination of artificial intelligence skills can increase hourly salaries by as much as 40%, especially for the integration of machine learning abilities (Oxford Internet Institute).

In addition to the rise in employees' wages following technological advances, some governments have also played a supportive role by investing in the labour force during job shifts. In 2019, the aggregate government spending in the United States on 47 training programs for employees equaled $18.9 billion alone (Holtz-Eakin and Lee). This further facilitates employees to transition to better, highly demanded jobs, such as software developers. These trends all have led to an upgrading trend of jobs, supporting employees' choices of using leisure time.

The claim that AI integration may lead to an increase in purchasing power often encounters two opposing factors: inflation and the general condition of the young generation earning less. Firstly, under the undermining force of inflation, with the sustained increase of price levels of goods and services, people tend to suffer from purchasing loss as they have less ability to enjoy the increase in leisure time and the increased return to entertaining activities. However, it is equally an important fact that inflation is usually categorised into demand-pull inflation and cost-push inflation. Demand-pull inflation is a type of demand-side inflation that occurs when growing demand for goods or services meets insufficient

supply, driving prices higher (Lock, 'What Is Demand-Pull Inflation? How Does It Work?'). As employees improve their living standards by spending on goods and services, aggregate demand will increase as consumption increases, contributing to a higher general price level of the economy. Cost-push inflation is another type of supply-side inflation that occurs when rising prices are due to a disruption in the supply of goods and services (Lock, 'What Is Cost-Push Inflation? How Does It Work?'). This happens especially when employees search for higher wages to keep pace with the price increase. However, inflation does not contribute fully to a lower pay per capita. Due to the persistent population growth of 1% (World Economics) on a global scale, people suffer from greater competitive pressure in striving for job vacancies. This may lead to difficulties for young people in gaining a higher average income when compared to their parents or the former generations. As a result, inflation will be perceived in the consideration of people's living standards but will not be considered the sole force that affects people's purchasing power.

Secondly, the purchasing power may not increase as expected as the young generation generally earns less than their parents, after adjusting for inflation at present, showing a constant decline of real per capita personal income growth of 3.49% (Bureau of Economic Analysis). This can also be indirectly shown by the continuously ascending consumer price index of the United States from 1960 to 2021, which is from 13.56 in 1960 to 124.27 in 2021 (index mundi). Nevertheless, as present employees receive lower incomes, firms can cut back labour costs. This enables firms to have more budget to spend on more advanced or even safer AI tools, including ChatGPT and Adept. Instead, firms can invest this part of the saved budget into 3D sensing, computer vision, and AI in manufacturing businesses such as Veo Robotics (Daley). In these scenarios, AI can be utilised to better help support the production of various goods and services, thus contributing to the positive growth of productive capacity in the economy. At the same time, as people are accommodating to their lower-income circumstances, they can control their spending on goods and services in the short term, control demand-pull inflation, and keep pace with the increased aggregate supply in the long term. Combining these effects together, AI, while potentially supporting people's living standards as a whole, will not trigger higher and more severe inflation as concerned or expected.

Increase in Entertainment Advancement and Options

As employees benefit from greater employment opportunities and higher purchasing power, they could have more possibilities to enjoy entertainment as they are able to pay for more forms of entertainment options, which fits what Keynes predicts in his theory. In the consumer expenditure surveys released by the U.S. Bureau of Labor Statistics, from 2013 to 2019, people's entertainment expenditures, including toys, hobbies, and playground equipment, have undergone an increasing amount from 569 to 880 dollars in all consumer units (U.S. Bureau of Labor Statistics, 'Expenditures: Entertainment: Fees and Admissions: All Consumer Units'). This suggests the irresistible trend of people's greater interest in entertainment due to the higher availability of these choices. In addition, the appearance of AI can not only be featured in the workforce but also recreational fields.

Take the gaming industry for example. AI serves as a driving force to develop game design adapting to players, cloud gaming and streaming, digital distribution, real-time guidance as well as all

other potential aspects, improving people's gaming experience (Notomoro). This significantly promotes people's inclination towards entertainment, particularly games. In 2020, there were 3.1 billion worldwide gamers, which is also estimated to increase by another 500 million, nearly half of the global population on Earth (Buser). The gaming industry has established a widespread influence on society, especially for the younger generations who are becoming the pillar labour force. Moreover, around the world, there are over 831,000 games in total (Prodanoff), providing sufficient access to entertainment by people. While under the utilisation of new technology and the greater ability to make games for this appealing field, people are providing optimistic feedback towards the development and the establishment of games.

In terms of what benefits the gaming industry brings to society, research shows that 93% of players benefit from experiencing joy, 91% of players are provided with mental stimulation, and 89% of players have undergone stress relief (urbanemujoe). This means people acquire these psychological benefits when having more leisure time. In this scenario, people will be more likely to choose to play recreational games to maximise their utility and happiness, which is shown by an increasing amount of video game subscriptions from less than $250 to nearly $400 during 2020-2021(Circana). From the responses above, we can conclude that people are gaining more leisure from playing games as entertainment during their free time, under the use of AI to revolutionise the gaming industry. This further supports Keynes' "age of leisure" under the present scene of the rapid growth of AI in the workforce.

Concluding Reflections

Our paper focuses on the discussion of the potential positive impacts of AI on the labour market. It stresses the three main benefits: curbing work time, improving purchasing power, and enabling more AI choices. By combining the AI-based labour market with Keynes' theory of the "age of leisure" and leisure-based entrepreneurship, a better conclusion on employees' gains could be discovered through monetary benefits and time benefits.

Keynes' theory may provide specific insights into the employees' increased time-offs and rewards. There has been an increased number of job postings with unlimited PTO by 178%, from 450 postings per million to 1,300 postings per million to follow up with employees' preferences over unlimited PTO, as over a quarter of employees prefer unlimited PTO during work, with a 27% over two weeks of pay time off and a 29% over an accumulating base of PTO (Baluch).

Admittedly, the "age of leisure" prediction does not reflect the whole picture of the relations between economic development and employees' gain of leisure time. There are of course other economic and social factors to consider: the productivity-pay trap, as well as the varied workload and the use of time.

Firstly, employees may be caught in the "productivity-pay trap", a concept discovered by the Economic Policy Institute, which reveals the deviation of wage growth from productivity growth. This means that as employees' productivity increases with the addition of AI in the workforce, their salaries do not keep pace with the upward increasing trend of the salary proportionately. More specifically, for example, from 1979 to 2021, employees' compensation growth increased at a much slower pace of

17.3% when compared to employees' rapid growth of efficiency in work, which is 64.6% (Economic Policy Institute). As a result, even if the sources of entertainment increase, indicating a potential increase in the average standards of living, as employees' wage levels do not increase with their higher productivity in work, their purchasing power is not as high as expected, triggering lower ability and inclination for leisure. Thus, leisure cannot be considered to increase, even in a large amount, as suggested by Keynes in reality.

Additionally, Keynes' theory is based on the assumption that workload will reach a constant in the future. In Keynes' own words, the absolute needs, or the total workload of the economy, is "a point may soon be reached, much sooner perhaps than we are all of us aware of, when these needs are satisfied in the sense that we prefer to devote our further energies to non-economic purposes" (Keynes). The assumption that additional time can be gained from increased productivity is not always true. Even though employees have higher productivity to finish tasks in less time, they are not allowed to leave early. Employees will more likely be assigned more tasks to accomplish during work hours because of entrepreneurs' interest in maximising profits. For instance, for a factory with advanced machines, employees will increase from producing 100,000 cars to 150,000 cars a day. This shows that employees' tasks do not stop at 100,000 but at 150,000, leaving no more extra free time for employees. With this increase, employees will not enjoy much leisure as Keynes' theory of leisure predicts. Moreover, non-working time does not necessarily contribute to leisure time, because people may not use all their time off work for entertainment, but for other non-working purposes, including commuting. A more typical example is given by working parents who may use part of their non-working hours to pick up and drop off children at school, which certainly cannot be treated as a part of leisure as we have normally defined. Therefore, with these additional factors that are not included in the theory of "age of leisure", it is much more difficult to determine how much more leisure time people enjoy.

To a certain extent, AI's influence on the labour markets has positively proved the credibility of Keynes's age of leisure theory. Employees' standard of living is improved under the utilisation of AI, through the decrease in work time, greater entertainment options, and improved purchasing power. Nevertheless, the theory has certain limitations as it is given under the assumption of fixed work tasks, the narrow definition of wage, as well as the real wage growth compared to productivity growth.

However, this discussion on how to apply Keynes' theory in the workforce under the backdrop of AI development is based on the observation of the raw interpretation of past data to decide the direct relationship between AI and various factors suggested in the main content above. More research is needed for us to arrive at a stronger conclusion. One possible approach is to construct a model to establish the logical relationship between AI and the workforce as well as its intended impact on people's leisure.

Works Cited

AgriTech Tomorrow. 'Will AI Replace Farmers? Yes, and No | AgriTechTomorrow'. *AgriTech Tomorrow*, 20 Oct. 2021, //agritechtomorrow.com/story/2021/10/will-ai-replace-farmers-yes-and-no/13238/.

Baluch, Anna. 'Average PTO In USA & Other PTO Statistics (2024)'. *Forbes*, 30 May 2023, https://www.forbes.com/advisor/business/pto-statistics/.

Bureau of Economic Analysis. 'United States | Per Capita Personal Income Trends over 1958-2022'. *United States Regional Economic Analysis Project*, Nov. 2023, https://united-states.reaproject.org/analysis/comparative-trends-analysis/per_capita_personal_income/tools/0/0/.

Buser, Jack. 'Game Industry Trends 2022: Millions More Players, Billions More Streams'. *Google Cloud Blog*, 2 Mar. 2022, https://cloud.google.com/blog/products/gaming/gaming-industry-predictions-technology-trends-cloud-streaming-ai-ar.

Circana. 'The US Video Game Industry Gets Back to Growth'. *GamesIndustry.Biz*, 28 Aug. 2023, https://www.gamesindustry.biz/the-us-video-game-industry-gets-back-to-growth.

Daley, Sam. '11 AI in Manufacturing Examples to Know | Built In'. *Built In*, 26 Jan. 2023, https://builtin.com/artificial-intelligence/ai-manufacturing-robots-automation.

Ebert, Julia. 'Five Things That Demonstrate That AI and Human Collaboration Is the Future'. *Vodafone Institute*, 17 May 2018, https://www.vodafone-institut.de/aiandi/five-things-that-demonstrate-that-ai-and-human-collaboration-is-the-future/.

Economic Policy Institute. 'The Productivity–Pay Gap'. *Economic Policy Institute*, Oct. 2022, https://www.epi.org/productivity-pay-gap/.

Forbes. 'Council Post: 20 New And Enhanced Roles AI Could Create'. *Forbes*, 6 July 2023, https://www.forbes.com/sites/forbestechcouncil/2023/07/06/20-new-and-enhanced-roles-ai-could-create/.

Golob, Matias Ignacio. *Leisure-Oriented Immigrant Entrepreneurship- Sites for Active Citizenship.Pdf*. 2008. School of Human Kinetics - University of Ottawa, PhD in Human Kinetics.

Holtz-Eakin, Douglas, and Tom Lee. 'An Analysis of Federal Training Programs - AAF'. *AAF*, 17 Sept. 2019, https://www.americanactionforum.org/research/an-analysis-of-federal-training-programs/.

index mundi. 'United States - Consumer Price Index'. *Index Mundi*, 28 Dec. 2019, https://www.indexmundi.com/facts/united-states/consumer-price-index.

Ivanycheva, Diana, et al. 'Lifestyle Entrepreneurship: Literature Review and Future Research Agenda'. *Journal of Management Studies*, Sept. 2023, p. joms.13000. *DOI.org (Crossref)*, https://doi.org/10.1111/joms.13000.

Keynes, John. 'Economic Possibilities for Our Grandchildren'. *Marxists*, 1963, https://www.marxists.org/reference/subject/economics/keynes/1930/our-grandchildren.htm.

Kim, Phillip H., et al. 'The Tortoise versus the Hare: Progress and Business Viability Differences between Conventional and Leisure-Based Founders'. *Journal of Business Venturing*, vol. 30, no. 2, 2014, pp. 185–204. *DOI.org (Crossref)*, https://doi.org/10.1016/j.jbusvent.2014.02.005.

Kulakov, Mike. 'Average Working Hours: Navigating Compensation Expectations & Labor Compliance'. *Everhour Blog*, 23 Feb. 2024, https://everhour.com/blog/average-working-hours/.

Kumar, Braveen. 'How To Make Money as a Full-Time YouTuber'. *Shopify*, 30 June 2022, https://www.shopify.com/blog/how-to-become-a-youtuber-yes-theory.

Kwapisz, Agnieszka. 'Team Aspects of Leisure-Based Entrepreneurship'. *Leisure Studies*, vol. 40, no. 4, July 2021, pp. 529–44. *DOI.org (Crossref)*, https://doi.org/10.1080/02614367.2020.1858328.

Lock, Cheryl. 'What Is Cost-Push Inflation? How Does It Work?' *Forbes*, 21 July 2022, https://www.forbes.com/advisor/investing/cost-push-inflation/.

---. 'What Is Demand-Pull Inflation? How Does It Work?' *Forbes*, 21 July 2022, https://www.forbes.com/advisor/investing/demand-pull-inflation/.

Matt Fendon Law Group. 'Biggest Risks for Assembly Line Workers | Matt Fendon Law Group'. *Fendonlaw.Net*, 15 July 2019, https://www.fendonlaw.net/blog/biggest-risks-for-assembly-line-workers/.

Notomoro. *What Is the Role of AI in the Entertainment Industry?* 18 July 2023, https://webisoft.com/articles/ai-in-entertainment-industry/.

Oxford Internet Institute. 'Artificial Intelligence Skills Can Increase Salaries by as Much as 40%'. *University of Oxford*, 24 Oct. 2023, https://www.ox.ac.uk/news/2023-10-24-artificial-intelligence-skills-can-increase-salaries-much-40.

Ozimek, Adam. 'Freelance Forward Economist Report'. *Upwork*, 2021, https://www.upwork.com/research/freelance-forward-2021.

Peristic, Igor. 'How Artificial Intelligence Is Shaking up the Job Market'. *World Economic Forum*, 17 Sept. 2018, https://www.weforum.org/agenda/2018/09/artificial-intelligence-shaking-up-job-market/.

Prodanoff, Jordan. 'How Many Video Games Are There? 17 Playful Stats for 2023'. *WebTribunal*, 6 Mar. 2023, https://webtribunal.net/blog/how-many-video-games-are-there/.

Russo, Amanda. 'Recession and Automation Changes Our Future of Work, But There Are Jobs Coming, Report Says'. *World Economic Forum*, 20 Oct. 2020, https://www.weforum.org/press/2020/10/recession-and-automation-changes-our-future-of-work-but-there-are-jobs-coming-report-says-52c5162fce/.

Sharma, Shivangi. 'Will AI Take Away Your Job?' *ETHRWorld.Com*, 28 Aug. 2023, https://hrsea.economictimes.indiatimes.com/news/industry/will-ai-take-away-your-job/103109447.

Tiushka, Nazar. '50+ Vlogging Statistics: Business, YouTube, Mobile Trends, Demographics'. *MarketSplash*, 27 Oct. 2023, https://marketsplash.com/vlogging-statistics/.

UBS. 'The Evolution of Artificial Intelligence (AI) – a New Dawn'. *Artificial Intelligence*, 15 Aug. 2016, https://www.ubs.com/microsites/artificial-intelligence/en/new-dawn.html.

urbanemujoe. '2022 Essential Facts About the Video Game Industry'. *Entertainment Software Association*, 7 June 2022, https://www.theesa.com/resource/2022-essential-facts-about-the-video-game-industry/.

U.S. Bureau of Labor Statistics. 'Expenditures: Entertainment: Fees and Admissions: All Consumer Units'. *FRED, Federal Reserve Bank of St. Louis*, FRED, Federal Reserve Bank of St. Louis, 14 Sept. 2023, https://fred.stlouisfed.org/series/CXUFEESADMLB0101M.

---. 'United States Average Weekly Hours'. *Trading Economics*, 2024, https://tradingeconomics.com/united-states/average-weekly-hours#stats.

Ward, Abby. 'Survey: 79% of Americans Don't Trust Businesses With AI'. *Tech.Co*, 9 Nov. 2023, https://tech.co/news/americans-dont-trust-businesses-ai.

Wardini, Josh. '101 Artificial Intelligence Statistics [Updated for 2023]'. *Techjury*, 26 July 2023, https://techjury.net/blog/ai-statistics/.

World Economics. 'Population Annual Growth Rates'. *World Economics*, 2024, https://www.worldeconomics.com/Indicator-Data/Demographics/Population-Annual-Growth-Rate.aspx.

Importance of transformation from Semashko healthcare system in post-Soviet states By Sohibjon Dilmurodov

Abstract

The Semashko model had a great impact on healthcare in the world by being an example of how to solve centuries-long societal health issues through mass projects. For years, it has not lost its effectiveness, and although it is still effective in many developing countries, nowadays certain issues are visible signs that this model needs a transformation or at least some major improvements. It is crucial to understand the strengths and weaknesses of the Semashko model because it can succeed for many developing countries but neglecting its weaknesses can cause more trouble. The method of research included the analysis of important aspects of the Semashko model and the case studies of independent countries that took different approaches after the dissolution of the USSR. The paper proposes possible reforms and procedures to be followed. These findings can be useful in optimizing the health organization that is responsible for millions of people.

Introduction

Soviets seized power in the gravest state of the country when there was practically no systematic healthcare in Russia. The biggest country by land area, Russia, was also known for its diversity including a wide range of diseases (Izmailova 109).. Ordinary people did not have medical literacy or access to basic sanitation. For a new communist regime to become powerful as a state, it was urgent to address the healthcare issues.

Nikolai Semashko had to construct a health services architecture that had to solve the problems of the past and be a role model in the future. The Semashko system was successful throughout the history of the USSR, making the USSR one of the top countries in terms of healthcare. On top of that, it was not expensive to keep the country healthy. All health problems of the community were addressed through mass campaigns.

After the dissolution of the Soviet Union, countries went through disparate ways in terms of politics and economy. However, the majority decided to keep the healthcare model which was still working satisfactorily. However, now post-Soviet countries are facing severe problems with healthcare proving that this system cannot be described as "old but gold" and it is imperative to enforce reforms.

This article outlines the distinctive features of the Semashko system and through case studies tries to propose possible solutions for the post-Soviet countries that need healthcare reforms. The recommendations are applicable for general use, while certain issues might need a specific approach. They consist of showing which aspect of the current model might be causing certain problems and the procedure they need to be addressed.

Background- The need for a strong healthcare in early USSR

At the start of the 20th century life expectancy in the Russian Empire was about 30 years (Eberstadt and Szymanski). While the average life expectancy in Europe was 40 years, in Great Britain it had exceeded 45 years in the same period (Mackenbach and Looman 1103; "Grey Britain"). Healthcare issues were further exacerbated during the World War 1. Although Russia was a land superpower, it had visible weaknesses in its socioeconomic state compared to other European powers.

After the Russian Revolution, it was crucial to enforce a healthcare reform to provide the agricultural and industrial sites with sufficient workforce for the long term. Nikolai Semashko, People's Commissar of Public Health of the USSR between 1918 and 1930, was tasked to devise a new healthcare model for an early Socialist state, later what is known as the Semashko system.

For the rest of the USSR's history, this healthcare policy played a crucial role in the both internal and external affairs of the country. Successful social services were on the frontline of Soviet propaganda: banners showcasing the superiority of the USSR were widely distributed throughout all the Republics. Furthermore, it was also used as an external propaganda tool to display the Soviet Union as a benefactor of all the communist states around the globe.

Furthermore, the need for strong health services remained for many years in the USSR due to heavy alcoholism and workload, social stress and poor diet were prevalent among working-age men (Cockerham 117). Repressions and dangerous working conditions for certain groups of individuals also reflected adversely on the average life expectancy and the availability of the workforce.

Therefore, for over 60 years the healthcare system remained unchanged due to cost-efficiency and relative success of the Semashko model. As a result, by 1970 the life expectancy gap between the US and the USSR was reduced to 3 years. However, the gap further started to increase as the USSR moved away from the Semashko model starting in the 1970s (Sheiman, "World Bank Open Data")

Role of sanitation

The USSR had a mission to eradicate epidemics in the country. Lenin is reported to have commented that "If socialism cannot conquer the lice, then lice will conquer socialism". In 1913, one in four children in Russia died in the first year of life, and 43 percent died before age 5 (Glass 154). The early years of the Soviet Union have already shown that it was crucial to reach this goal. There was considerable progress in the field of vaccination, but it was clear that vaccination is not only not enough, but also expensive. Setting up a good sanitation system could create an effective combination with massive vaccination campaigns to prevent epidemics. SANEPID stations were already set up during the Russian Empire, but it was not effective enough to combat the outbreak of diseases. Therefore, the Semashko system centralized SANEPID stations. These stations now started playing a crucial role in gathering and analyzing epidemiological data, and organizing and actively enforcing the sanitation policies passed by the State. Furthermore, SANEPID services included the pasteurization of milk and hygienic disposal of waste and sewage (Glass 155).

Significant financing was allocated to SANEPID. Sanitary stations and inspections were installed primarily to combat epidemic strikes. Later, the USSR facilitated public health education with its strong propaganda tools, including posters in public places (Glass 155). While only 1760 SANEPID stations operated in the USSR to combat epidemics, this number nearly tripled to 4800 in 1976 employing more than 30,000 physicians and medical specialists (Glass 155).

Epidemiological problems were addressed by the network of research institutes and certain faculties had been dedicated to training sanitary-specialists in preventive care. Post post-war Soviet Union had a mission to rebuild the destroyed infrastructure and industrial sites as quickly as possible. The job of hygienists was to protect the population from industrial pollution, sustainable urban planning, and ensure optimum conditions for new apartments, and safety standards for pollutants. Now the job of SANEPID Service shifted from preventing the spread of diseases to setting and enforcing safety measures (Glass 155).

Organization of the healthcare system

Managing the infectious diseases in the USSR was not easy considering the vast land it occupies and the diversity of the population that inhabits that land. Every type of endemic disease could be found in the USSR ranging from tropical malaria to pneumonia in cold places. Especially the borderlands contributed significantly to the former Russian Empire and now the USSR to be the country with the highest infectious disease-linked mortality rates (Izmailova 109).

Imperial Russia had no centralized agencies of healthcare and disease control mostly depended on the local authorities and the financing was mostly done by the voluntary philanthropic organizations. Furthermore, actions would be taken usually to fight outbreaks not to prevent them and the population had no medical literacy (Izmailova 111). On top of that, the Imperial government would reject the policies that contradicted Great Russian chauvinism. The government focused on colonialism and often refused to treat local people of colonies in Central Asia and the Caucasus, focusing only on the settlers from Russia (Izmailova 113).

Semashko's model focused on fixing the mistakes of the former government. It started by substantially improving the funding. Next, the whole system was built to centralize public healthcare. A sanitary network covering the whole country was soon set up at levels from District to Republic. Sanitary stations were divided into three types: general purpose, anti-plague (also addressed cholera, smallpox, tularemia, and other highly infectious diseases), and anti-malaria. Furthermore, those stations were indiscriminate when it came to treating the patients, which led to the eradication of diseases like malaria: quartan malaria in 1950, tropical malaria in 1957, and tertian malaria in 1960 (Izmailova 115).

Soviet healthcare was very authoritarian and it focused on the public well-being while ignoring individual confidentiality and privacy rules. The medical history of the patient would often be disclosed if its privacy contradicts the common interests of the population. In the case of

certain infectious diseases, the doctors were obliged to inform the local authorities (Izmailova 110).

Countries currently running with Semashko system:
      Case-study: Russia

Currently, Russia has kept the Semashko model but with certain minor changes. Originally, the Semashko system put strong emphasis on the district physicians, since they are the ones who were the ones who kept the records of the patients in the area and were responsible for them. However, now in Russia district physicians have lost their status, and even the population approval of those medical workers is also hitting as low as 14 percent. Patients have to navigate through the system on themselves, in other words, patients skip the district physicians and directly go to the specialists (Sheiman).

The major triggers of these and other socioeconomic problems in Russia are linked to the early days of their independence when the government decided to carry out shock therapy. Although the government tried to mitigate the effects of the reform on healthcare by implementing certain new innovations, it was not sufficient to make any improvements, because of underfunding. Basically, the state did not have enough resources to keep any system running including healthcare. However, the health sector was at least not as damaged as others owing to the minor changes applied (Sheiman).

Nowadays, Russia among the countries that have kept the Semashko model (all the former USSR states except for Baltic states, Kirghizia, and Turkmenistan) has the highest GNI per capita but its healthcare rating is in the lower half of those countries (Heinrich, Macrotrends). In other words, currently, Russia can afford better healthcare but it is still lagging behind most of the other post-Soviet republics (Sheiman).

The Russian government has taken measures to improve the basic infrastructure and equipment. Furthermore, there was an increase in the salaries of the district physicians and general practitioners. However, no changes in the healthcare structure have been made, so the state funding is being mismanaged due to hospital doctors having negative opinions about the adequacy of the primary healthcare workers, which leads to redundancy in the diagnostic tests and a lag in the treatment (Sheiman).

Case study: Lithuania

After independence, Lithuania was left with a medical system that was centralized and was not managed well enough as well as with ineffective resource distribution. To make the organization more effective, the government decided to redesign and decentralize it. Decentralization followed the separation of primary (family physicians), secondary (specialist physicians), and tertiary healthcare (high-specialization university clinics). Although practically decentralization does not improve the situation in itself, Lithuanian healthcare reform was mostly based on it. Certain problems still remain even after the restructuring: inefficiency of allocating resources, covertness in voting, and inadequate managerial bodies (Jakušovaitė and Irayda).

Furthermore, the benefit of buying in bulk could be also lost if the system consists of many small parts.

Another novelty introduced was the private sector in healthcare which was the reason for certain discussions. According to Segall "Privatization in health care does not lend itself to a quick technical fix" (Jakušovaitė and Irayda). It is a complex process, essentially political and ethical in character, and involves the interplay of a number of considerations among which are not only those of equity and efficiency".

Decentralization mentioned earlier also included giving some authority to the counties from the Ministry of Health and shifting the financing from the Ministry to the State Sickness Fund. While the counties should enforce the programs approved by the state, the municipalities provide primary healthcare (Jakušovaitė and Irayda). This practice makes the patients, and their complaints closer to the decision-making body, which can potentially help to come up with optimal solutions for the given area rather than time-consuming bureaucracy at a government level.

Case study: Uzbekistan:

Among the post-Soviet countries Uzbekistan currently has the second-best healthcare system and the best among countries that retained the Semashko model (World Population Review). The odd thing about this data is that Uzbekistan is one of the poorest countries of the former Soviet Union with its GNI per capita being 13th out of 15 countries (Macrotrends) Furthermore, the monthly salary of doctors is around $125 (*"Monthly salary of doctors in Uzbekistan is around $125"*)

The major reason for the good healthcare in the country is that more talented youth choose to be a doctor mostly due to the prestige and stereotypes that root back to the Soviet Union. During the Soviet times, being a doctor was a well-respected job. Although the salaries of doctors and any other job did not have a huge gap, doctors worked in a cleaner space compared to other workers, most of whom occupied jobs in agriculture or heavy industry. Therefore, many parents wanted their children to be doctors. The Academy of Medical Sciences was one of the most prestigious higher education institutions in the country (Field 1912).

This trend is still present in many families today in Uzbekistan, which can be seen in the statistics of the passing scores for the universities in Uzbekistan with medical academies demanding one of the highest scores (*"Tashkent Pediatric Medical Institute Entrance Scores"*). Moreover, the doctor to individual ratio is 1:358, which is superior to the global average of 1.7:1000 which is equal to 1:588 (*"Each physician in Uzbekistan serves over 350 people on average"*, World Bank). On the surface Uzbekistan has no significant issues with its health system.

However, it is worth noting that health services in Uzbekistan, although free, are very underfunded being $121 per capita per year in 2020, which is roughly 10 times lower than the global average of $1221 (Macrotrends, World Bank)

Discussion

In the case of Russia, medicine was one of the few sectors in Russia that did not undergo privatization. The government could not keep up the salaries of doctors with that of other workers in the private sector. Therefore, a once-respected job in the USSR has become an occupation with a mediocre salary with respect to the market trends, making fewer people interested in the field, which caused a shortage of adequate workers.

On the other hand, the reforms in Lithuania in theory would not lead to any gain on themselves, but the combination of them implemented with the right timing proves to be effective as it has one of the best health systems among former Soviet countries (World Population Review)

As regards Uzbekistan, the best way to describe the healthcare conditions in the country is a time bomb since it will encounter the same problems that other richer former Soviet countries have faced earlier. Currently, Uzbekistan is striving for mass privatization and denationalization in transportation, chemical enterprises, extraction of mineral resources, etc. ("*On denationalization and privatization*" 1). Consequently, as the country shifts to open trade from state-owned and state-governed structures in other spheres, more job opportunities with better pay will be created in the job market, leaving medicine as a not favorable occupation in the long term. More and more talented young people might be choosing not to pursue a career in this field.

Early Soviets mostly focused on fixing the problems that they inherited from the Russian Empire. Therefore, the Semashko system does not treat an individual but it is focused on keeping the community healthy effectively. It was good for developing countries with a lot of problems in healthcare that need to be solved or mitigated quickly. This approach works well with preventive medicine and during epidemics. However, it is not effective at developing advanced medicine nor at solving today's treatment problems

Nowadays most common diseases are non-communicable such as cancer, respiratory diseases, atheromatous diseases, etc**.** ("What are the 10 most common diseases?") The patients now need a specific approach rather than epidemiological.

The effectiveness of the Semashko system is also inversely proportional to human rights adherence and government transparency in the country since public health was above everything and doctors were told to inform the local government if a patient with a contagious disease was found. It worked well in the USSR because there was no patient confidentiality.

Possible solutions

As the countries develop economically and enter open trade, the centralized system might be unnecessary if there is sufficient medical literacy in the population. Thus, switching to a decentralized system can be a solution to certain problems. Decentralization was unsuccessful in the Russian Empire because people had very poor medical literacy, and healthcare was also underfunded. Nevertheless, it is risky to fully decentralize, so Lithuania chose to keep the balance between the two and find an optimal approach.

Still, a sudden transformation of health services is unnecessary and might create more issues than it solves. The Semashko system is only gradually losing its effectiveness, so it is imperative to make unhurried changes by both addressing the problems that the Semashko system is creating and also implementing new healthcare architecture step by step.

Further research recommendation/weakness of the research

This paper discusses the Semashko system in general and why it does not suit the standards of modern days while neglecting certain country-specific aspects of healthcare in the countries that enforced this model. Therefore, the proposals should be viewed from an overall perspective, taking into account that some problems might need more intricate attention to detail. Further research that is specific to the country and the issue might be needed to address the matter more effectively.

Works Cited

Cockerham, William. "The Social Determinants of the Decline of Life Expectancy in Russia and
Eastern Europe: A Lifestyle Explanation." *Journal of Health and Social Behavior*, vol.
38, no. 2, June 1997, p. 117, https://doi.org/10.2307/2955420.

"Each Physician in Uzbekistan Serves over 350 People on Average." *Daryo.uz*, 18 Aug. 2023,
daryo.uz/en/2023/08/18/each-physician-in-uzbekistan-serves-over-350-people-on-averag
e. Accessed 17 Feb. 2024.

Eberstadt, Nick, and Albert Szymanski. "The Health Crisis in the USSR: An Exchange."
Www.nybooks.com, 5 Nov. 1981,
www.nybooks.com/articles/1981/11/05/the-health-crisis-in-the-ussr-an-exchange/.

---. "The Health Crisis in the USSR: An Exchange." *Www.nybooks.com*, 5 Nov. 1981,
www.nybooks.com/articles/1981/11/05/the-health-crisis-in-the-ussr-an-exchange/.

Field, M . "Health Personnel in the Soviet Union: Achievements and Problems." *American
Journal of Public Health and the Nations Health*, vol. 56, no. 11, Nov. 1966, pp.
1904–1920, https://doi.org/10.2105/ajph.56.11.1904. Accessed 27 Apr. 2020.

Glass, Roger . "The SANEPID Service in the U.S.S.R.: The Sanitary Epidemiological
(SANEPID) Service of the Soviet Union Is a Network of Public Health Centers
Responsible for Surveillance and Control of Potentially Preventable Diseases." *Public
Health Reports (1974-)*, vol. 91, no. 2, 1976, pp. 154–158, www.jstor.org/stable/4595417.
Accessed 8 Apr. 2024.

"Grey Britain." *UK Parliament*, UK Parliament,
www.parliament.uk/business/publications/research/olympic-britain/population/grey-britai
n.

Heinrich, Andreas. "The Emergence of the Socialist Healthcare Model after the First World
War." *International Impacts on Social Policy*, 2022, pp. 35–46,
https://doi.org/10.1007/978-3-030-86645-7_4.

Izmailova, E. *The System of Epidemic Control in the USSR: Short Essay on Its History*. Institute
for History of Science and Technology, Russian Academy of Science, Moscow, 1996,
horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_7/carton07/010008877.
pdf.

Jakušovaitė, Irayda, et al. "Lithuanian Health Care in Transitional State: Ethical Problems."
BMC Public Health, vol. 5, no. 1, 9 Nov. 2005, https://doi.org/10.1186/1471-2458-5-117.

Mackenbach, Johan P, and Caspar WN Looman. "Life Expectancy and National Income in
Europe, 1900-2008: An Update of Preston's Analysis." *International Journal of
Epidemiology*, vol. 42, no. 4, Aug. 2013, pp. 1100–1110,
academic.oup.com/ije/article/42/4/1100/659306, https://doi.org/10.1093/ije/dyt122.

Macrotrends. "GNI per Capita by Country." *Www.macrotrends.net*, 2023,
www.macrotrends.net/countries/ranking/gni-per-capita.

Macrotrends. "Uzbekistan Healthcare Spending 2000-2024." *Www.macrotrends.net*,
www.macrotrends.net/global-metrics/countries/UZB/uzbekistan/healthcare-spending.

"Monthly Salary of Doctors in Uzbekistan Is around $125." *Kun.uz*, 2018, kun.uz/en/42570003.

"On Denationalization and Privatization." *Lex.uz*, lex.uz/docs/4402899.

Sheiman, I. "Rocky Road from the Semashko to a New Health Model." *Bulletin of the World Health Organization*, vol. 91, no. 5, 1 May 2013, pp. 320–321, https://doi.org/10.2471/blt.13.030513.

"Tashkent Pediatric Medical Institute Entrance Scores, Pass Scores and Test Results for 2023." *Abt.uz*, 2023, abt.uz/university/toshkent-pediatriya-tibbiyot-instituti.

"What Are the 10 Most Common Diseases?" *Health Service Navigator*, www.myhsn.co.uk/top-tip/what-are-the-10-most-common-diseases.

World Bank. "Current Health Expenditure per Capita (Current US$) | Data." *Worldbank.org*, 2019, data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD.

---. "Physicians (per 1,000 People) | Data." *Worldbank.org*, 2019, data.worldbank.org/indicator/SH.MED.PHYS.ZS.

---. "World Bank Open Data." *World Bank Open Data*, 2024, data.worldbank.org/indicator/SP.DYN.LE00.IN?end=1990&locations=US-RU&start=1960&view=chart. Accessed 8 Apr. 2024.

World Population Review. "Best Healthcare in the World 2023." *World Population Review*, 2023, worldpopulationreview.com/country-rankings/best-healthcare-in-the-world.

Interpretation of the U.S. in the Cross-Strait Relations leading South Korea with inevitable decisions By Eungkyu Kang

Abstract

  The conflict between China and Taiwan or Cross-Strait Relations has been gaining more attention in recent days. However, the conflict between the two nations expanded to a worldwide problem as the United States of America joined in to prevent China from getting too much authority over Asia. Ironically this has left South Korea in a position where they are desired or even threatened by each side as China is the biggest trading partner at the moment and the U.S. is the second biggest trading partner as well as military alliance. Although it is inevitable for South Korea to face the aftermath of choosing either side, it is assumed that South Korea should side with the U.S. considering the number of consequences in the long term.

Introduction

  In recent years, China and Taiwan's Cross-Strait relations have been a major issue in East Asia. The term cross-strait relations refers to the crossing of political, military, economic, social, and cultural ties between Taiwan and the People's Republic of China (Harrison), which occurred ever since Taiwan established a distinct government in 1949. Unlike what Taiwan suggests, that it is an independent country with its government, China argues that Taiwan is a part of them and tries to change Taiwan into Hong Kong, which is a country administered by China but can keep its own political and economic systems and offers autonomy. In recent years, the conflict got worse as Taiwan fought to maintain its independent government, and the United States, wary of China, started to be involved in the conflict. Nonetheless, due to this conflict, other regional parties were dragged into the conflict as the two sides tried to work through their political disagreements and historical grudges, South Korea is one of the third-party countries with one of the most important roles as well as facing the worst possible consequences (Hsiao). South Korea's military alliance with the U.S. and its economic dependence on China make it hard to make decisions in this conflict, nonetheless, since South Korea has friendly relations with both sides of the Strait and has the ability to understand and reconcile both sides' position may allow them to act as a mediator as well. This research paper seeks to explain how South Korea should balance its strategic goals with efforts to preserve and strengthen diplomatic connections with both China and the United States and the position itself within such conflict, by examining South Korea's relationship between China and the United States, historically and economically.

Background

  Korea has shared a long history with China since long ago. The Choson dynasty (Joseon dynasty), which is formal Korea, adopted Confucianism and pledged fealty to the Chinese Ming dynasty. Even the succession to the throne of the Choson Dynasty was supported by Chinese emperors. As a result, Chinese power spread throughout the Choson dynasty over the aristocracy and court. Furthermore, Choson rulers even relied on the Ming dynasty for their country's security and asked for its protection against Japanese invasion (Kim). The relationship between South Korea and China continues today as well in different areas such as culture, religion,

economy, and many more. Today, there is no doubt that South Korea and China are one of the biggest trade partners for each other. For example, In 2022, 30 percent of South Korea's total trade was to China and China bought 40 percent of South Korea's total semiconductor exports in 2021 as well (Roy). As South Korea and China shared this relationship for thousands of years and it continues today, it makes it harder for South Korea to go against China in this cross-strait relationship and side with China.

On the other hand, after the U.S. joined the conflict by backing up Taiwan, this made South Korea much harder to make decisions. As many people are aware of it, Korea signed a Defense Treaty with the United States in 1953, after Korea cease-fire the war with North Korea (Henry et al). They established diplomatic relations with the United States in 1949. Currently, The United States is not only important to South Korea militarily but also economically as they are one of the biggest trading partners as well, which will be explained further in the later section.

Interestingly, although the cross-strait relations are between Taiwan and China, tough decisions to be made by South Korea have not much to do with Taiwan, but rather with their relationships with China and the U.S. and their relationships with each side will be examined throughout the next section of the research.

South Korea's economic dependence on China.

As briefly discussed earlier, it could be argued that South Korea is heavily dependent on China for its international trade. South Korea's chip industry, which is one the biggest industries in South Korea, exports its products to China, with a staggering $48.1 billion in integrated circuits exported annually (South Korea). Not just in the chip industry, South Korea's exportations of the energy resources to China are significant as well with cyclic hydrocarbons and refined petroleum bringing in over $11 billion combined. South Korea's economic ties with China blossomed over the past quarter-century, with exports surging from $9.5 billion in 1995 to a staggering $158 billion in 2021, propelled by a robust 11.4% compound annual growth rate. To present how big the numbers are, it is worth it to compare these numbers to South Korea's exportation to other countries as well. South Korea exported $24.5 billion in 1995 to $95.9 billion to the U.S. in 2021, and $17.3 billion to $30.1 billion to Japan in 2021 (South Korea). As it can be observed from the numbers, combined exportations to the U.S. and Japan are not too far from exportations only to China. If one considers the growth rate of the exportations, the dependencies grow even bigger, which shows how South Korea is dependent on China when it comes to international trade.

Although the amount of exportation is significant, one may argue that China may not be able to stop any imports from South Korea as that would bring several consequences to their country, but there was an incident where the Chinese government somewhat threatened South Korea through international trade. In 2016, South Korea had agreed to deploy Terminal High Altitude Area Defense (THAAD) with the United States to defend against any threats from North Korea's missile threat. In the meantime, the Chinese government argued that the THAAD deployment poses a threat to its security, and it is concerned that the deployment could escalate

tensions in the Northeast Asian region and that they strongly suggested South Korea not to deploy THAAD (Lim and Ferguson). However, South Korea proceeded with the THAAD installation, which led the Chinese government to economically threaten South Korea by restricting South Korean tourists from entering China, banning their own tourists to South Korea, and planning to ban any imports from South Korea. As a result, plummeting Chinese tourists in South Korea led them to a total loss of 15.62 billion U.S. dollars from tourist revenue, 10.89 billion U.S. dollars from retail industry damage with 402,000 jobs lost (THAAD Row). This shows how China could be willing and able to implement strong policies if South Korea is to side with the opposition.

Nonetheless, Chinese influence in the international market is already in place. More than 100 international flights and trading ships were suspended due to military exercises conducted by China near the island of Taiwan. This caused major disruptions to flights and trading ships to enter Northeast Asia, including South Korea. As briefly mentioned above, one of the main exportations from South Korea is energy resources, and 70% of the total energy resource exports have to be traveled through the ocean near Taiwan (Kang). It could be assumed that China simply could disrupt or even prevent South Korea from participating in international trade, which may suggest that South Korea should side with China.

The U.S. involvement and its influence on South Korea

To begin with, in 1979, under the One China policy, the United States 'acknowledged' the Chinese position that Taiwan is part of China, however, they did not 'recognize' any Chinese sovereignty over Taiwan (Green, M. J., & Glaser, B. S.). This suggests that the involvement of the U.S. towards cross-strait relations started much earlier than many people are aware of.

The rivalry between the U.S. and China was ongoing for a long time and they used to use more direct policies towards each other. For example, in 2018, President Trump began slapping 25 percent tariffs on a list of about $50 billion in imports from China to prevent their influence in the international market (York). Meanwhile in modern days, as China was somewhat dominating the international trade in Asia, the U.S. started to adopt different and indirect methods to prevent China from growing too many authorities. Taiwan became the most strategically important place to the U.S. for its Indo-Pacific region and also because it manufactures about 70% of the world's semiconductors and about 90% of its chips which China is eager to take over, which forced the U.S. to be more involved within the conflict. President Biden used diplomacy with several Asian countries, promising them economic and security cooperation and bringing them to his side. Despite the long years of the military alliance, South Korea would have been a good option for the U.S. because of its economic stability and its position within the international market.

One of the 'indirect policies' mentioned above is the 'Chip 4 alliance' which the U.S. is promoting to form with Japan, Taiwan, and South Korea (Jung). The United States desired discussions and coordination of policies about supply chain security, worker development, research and development, and semiconductor subsidies between governments and businesses in each nation, but the real agenda is to prevent China from accessing semiconductors. This could seriously damage the roles and influences of China in the international market as they may not be

able to produce many of their products without semiconductors. Unlike Japan and Taiwan which announced their likelihood of joining the alliance almost right after it was suggested in July 2022, South Korea delayed their announcement, which shows how they are aware of the aftermath from China if they are to join the alliance.

Another factor that may suggest that South Korea should side with the U.S. is their military alliance. Their military alliance went way back when North Korea surprisingly invaded South Korea and South Korea was only able to win their country back with support from the U.S.. Even today, there are United States Forces Korea (USFK) located in South Korea and any disagreement with the U.S. or withdrawal of the USFK from South Korea could increase the potential threats from North Korea (who are ironically sided with China) which gives more reason to South Korea to side with the U.S..

Potential consequences of the decision

It would be great if China and Taiwan could resolve this problem peacefully however, it seems unlikely. Two of the most influential audiences are China and the United States and South Korea is sort of placed in the middle and the decision they make could lead to completely different outcomes. It means that South Korea will be facing consequences no matter which side they go with. This section of the research tries to address the possible outcomes of either choice and to determine what would be the best move for South Korea.

If South Korea takes a side with China, then it can continue to have a good economic relationship. South Korea imports 29.1% of its major supply chain commodities from China and an average of 67% of major minerals such as copper, aluminum, and zinc from China as well, which are used in semiconductors and secondary batteries (Lee). On the other hand, South Korea imports natural gas, oil, and agricultural products from the United States, with an average of 10% of its major supply chain commodities from the United States as well, which emphasizes the fact that South Korea is reliable on both sides.

Nonetheless, looking at South Korea's cumulative total exports from January to May 2023, the share of the Chinese market fell to 19.6%, while the share of the US market increased to 18%, which shows that South Korea's dependencies in the international market are slowly starting to slant towards the U.S. (Cho). Also, it was mentioned that South Korea's exports added up to $124.8 billion to China and $115.7 billion to the United States in 2023. Nevertheless, to the U.S., South Korea exported high-value products such as automobiles, auto parts, semiconductors, and computers, while to China, Korea mainly exported intermediate goods and raw materials, with some semiconductors, automobiles, petroleum products, and steel. Therefore, considering what they exported, it could be concluded that maintaining a good relationship with the U.S. may be more beneficial to South Korea.

Additionally, the United States has the global semiconductor market share of 50.8%, followed by South Korea with 18.4%, Japan with 9.2%, and Taiwan with 6.4%, which are all ahead of China (4.8%). Also, in terms of semiconductor production capacity, Taiwan leads with 21.4%, followed by South Korea with 20.4% and Japan with 15.8% which are all ahead of China

(15.3%) (Park). Therefore, China may not be able to just stop any international trade with South Korea as they will need to have access to a strong semiconductor-producing country.

Conclusion

  South Korea has the least to lose when it acts as a mediator between the two sides, in fact, every participant will have the least to lose if any agreements could be made, however, this is highly unlikely to happen. Also, some consequences will be faced by South Korea despite which side they choose to stand with. Anyhow, considering what has been discussed above, in the short term South Korea may face fewer consequences if they choose to side with China as they are currently the biggest trading partner, but, in the long term, it will be more beneficial to side with the U.S. as they are forecasted to become the greatest trading partner as well as China is unlikely to economically threat South Korea.

Works Cited

Cho, Gyewon. "중국 제치고 미국으로…20년 만에 "수출 1위 시장 " [Changes in export market, number one changes from China for the first time in 20 years] www.hani.co.kr/arti/economy/economy_general/1095465.html. Accessed 24 Jan. 2024.

Green, M. J., and Glaser, B. S. (2017, January 13). *What is the U.S. "One China" policy, and why does it matter?* CSIS. https://www.csis.org/analysis/what-us-one-china-policy-and-why-does-it-matter

Harrison, Mark. "Cross-Straits Relations." *The China Story*, 24 Sept. 2012, www.thechinastory.org/yearbooks/yearbook-2012/cross-straits-relations/. https://www.thechinastory.org/yearbooks/yearbook-2012/cross-straits-relations/

Henry, et al. "Contingency Plans: South Korea and the Cross-Strait Security." *Lowy Institute*, 3 May 2021, www.lowyinstitute.org/the-interpreter/contingency-plans-south-korea-and-cross-strait-security.

Hsiao, Russell. "Taiwan and South Korea Enhancing Their Engagement as Chinese Aggression Intensifies." *Global Taiwan Institute*, 20 Sep. 2023, globaltaiwan.org/2023/09/taiwan-and-south-korea-enhancing-their-engagement-as-chinese-aggression-intensifies/.

Jung, Eric. "The "Chip 4 Alliance" and Taiwan–South Korea Relations." *Global Taiwan Institute*, 20 Sept. 2023, globaltaiwan.org/2023/09/the-chip-4-alliance-and-taiwansouth-korea-relations/.

Kang, Junyoung, "양안 관계 위기가 한국에 미치는 영향" [The impact of cross-strait crisis on South Korea], Kyungnam University, Gukdong-research center

Kim, Ilpyong J. "Korea's Relations with China and Japan in the Post-Cold ..." *Korea's Relations with China and Japan in the Post-Cold War Era*, 21 Nov. 1997, ciaotest.cc.columbia.edu/journals/ijoks/v2i1/f_0013360_10856.pdf.

Lee, Yoon Joo. "한국 수입망, "원자재 공급 취약·중국 의존도는 심화."[South Korea's import chain, "raw material supply vulnerable - dependence on China deepens"] 경향신문, 30 June 2022, m.khan.co.kr/economy/economy-general/article/202206301606011#c2b.

Lim, Darren. J., and Ferguson, Victor. "Chinese Economic Coercion during the THAAD Dispute." *The Asan Forum*, 28 Dec. 2019, https://theasanforum.org/chinese-economic-coercion-during-the-thaad-dispute/

Park, Ki-soon. "칩(Chip) 4 동맹과 한국의 선택."[The Chip 4 Alliance and South Korea's Choice] *Economy Chosun.com*, 10 Oct. 2022, economychosun.com/site/data/html_dir/2022/10/10/2022101000022.html.

Roy, D. (n.d.). *South Korea will stay out of a Taiwan Strait war*. – The Diplomat. https://thediplomat.com/2023/03/south-korea-will-stay-out-of-a-taiwan-strait-war/

"South Korea (KOR) Exports, Imports, and Trade Partners." *The Observatory of Economic Complexity*, oec.world/en/profile/country/kor.

"THAAD Row with China Costs S. Korea Dear: Report." *Yonhap News Agency*, 15 Sept. 2017, en.yna.co.kr/view/AEN20170915008300320.

York, Erica. "Tracking the Economic Impact of Tariffs." *Tax Foundation*, 31 July 2023, taxfoundation.org/research/all/federal/tariffs-trump-trade-war/.

Economics Of Triboelectricity By Minh A. To

Abstract

This paper explores the concept behind triboelectric nanogenerators and how variants of the model function. It also dives into all the facets of applications of TENG in some of the biggest and most influential industries in the world, with correlating data and research to back up claims and statistics that prove TENG's worth to the economy and scientific community. Realistically, triboelectricity, despite being on the rise only recently, is becoming more and more of an opportunity window to snatch portions of the economic market for the aforementioned industries, and thus should be considered depending on the context of industry one chooses to rely on when utilizing or considering the potential of TENG.

Introduction

With the fast-growing pace of the world and its industries nowadays and more policies being implemented regarding eco-friendly aspects, greener and more efficient technologies, such as hydroelectric, wind, and sun energy, are being sought out (Markard & Truffer, 2006). In fact, due to the overall progression in production quantity and usage in the industrial era, events like climate change have persisted and created long-term aftereffects, such as melting glaciers, affecting biodiversity, and longer heatwaves. These effects are lengthy enough for the world to turn its head and pay attention to them as a concern. In addition to this, companies of all scales and sizes are also searching for these eco-friendly alternatives to boost their brand image and reputation, now that customers nowadays are more inclined to choose eco-friendly products (Markard & Truffer, 2006). To balance both of these factors is a difficult task, however, as most of the well-known green alternatives are either too unpredictable for some companies or too few in quantity to implement over time (Maradin, 2021), which discourages companies from purchasing these technologies. Thus, TENG presents a viable approach to the conversion of mechanical to electrical energy that overcomes both of these challenges, in addition to its possible application without requiring any battery usage (Harmon et al., 2020). With its unique structure that allows for implementation into smaller electronics, triboelectricity brings a revelation to creating convenient self-powered everyday appliances.

Discussion

1. Working principles

To better grasp the possible influence and enhancements triboelectric nanogenerators are able to bring, a brief summary of the working principles is needed. The powering mechanism behind how triboelectricity operates is its ability to form electrical charges via any variation of contact or rubbing (Peng et al., 2017). Specifically, when any two surfaces come into contact

with no additional pressure exerted, there is a constant interatomic distance throughout the contact area. Thus, when an external force is exerted, at specific points across the contact area between the surfaces, high pressure is experienced which causes the interatomic distance there to be reduced and under a repulsive force between the pressed atoms. This facilitates the transferring of electrons which creates the phenomenon of triboelectricity (Zhou et al., 2020). At its core, there are four available and discovered modes of TENG, namely: (a) vertical contact-separation mode, (b) lateral-sliding mode, (c) single-electrode mode, and (d) freestanding triboelectric-layer mode (A. Ahmed et al., 2019)

The most common variant of TENG is the vertical contact-separation mode (Zhu et al., 2012), in which two electrodes (one suspended above the other) come into contact through a layer of dielectric film that fully covers the grounded electrode. As the two electrodes are under influence via vertically exerted forces, it causes the electrodes to be separated and then in contact repeatedly, creating a flow of charge, thus producing current when connected to an electric circuit.

The lateral-sliding mode is set up similarly to the vertical contact-separation structure (S. Wang et al., 2013). However, the difference lies in the method of contact; as the name suggests, the second mode allows for contact via sliding the electrodes with parallel forces in opposite directions, separated only by the dielectric layer. This leads to the transferring of electrons within the material surfaces, generating triboelectric charges. (Zhu et al., 2012). Furthermore, it is also worth noting that the potential difference fluctuates according to the magnitude of the contact surface area, which is eventually balanced out by the current flow generated.

The next mode of TENG deviates from the previous two in regards to connecting both electrodes, as the single-electrode model only requires one freely moveable electrode with no electrical circuit attached, while the other becomes stationed to the ground. In this alternative, the charges are similarly generated, succeeding the contact between the electrodes as the motion procedure continues, creating a current flow.

The final, but not least important, mode of TENG is the freestanding triboelectric-layer mode, which only necessitates an unrestricted moving part. A model form of this TENG consists of the regular dielectric layer, a couple of congruent electrodes, and the aforementioned movable piece. As the part slides back and forth, switching from one electrode to another, a current is formed through the difference in potential distribution, facilitating electrons to travel from electrode to electrode, thus creating the desired electrical output (Niu et al., 2014b).

2. Economics of TENG

One of this research paper's main objectives is to dive deeper into the intricacies behind the economic environment surrounding the concept of TENG. In one specific paper regarding the assessment of techno-economic effects derived from triboelectric nanogenerators, two modules of TENG were constructed to show different structures in practicality to be experimented upon. Both are almost similar in their applications but different in efficiency and variant of free-standing mode (sliding vs. rotating). These two models were then examined in regard to the

level of capital investment required to generate a presumed production capacity of 100 MW every year. The calculations led to the former of the two being valued at $7 million USD at 50% conversion efficiency, while the latter at 24% efficiency was, in correlation, at an estimated $14 million USD (A. Ahmed et al., 2017). Compared to other alternative forms of renewable energy harvesting such as solar farms (ranging around the $100 million USD mark for a 100 MW production area) (Solar, 2023; MSc & MSc, 2023) or a wind farm of the same production quantity (approximately $130-175 million USD of installation cost) (Guard, 2023) (*The Economics of Wind Power*, 2011), triboelectricity is significantly cheaper to construct, albeit with a much lesser and simple structure than entire farms.

Future potential driving factors of lower costs include using waste material for the electrode, therefore enabling a metal-free TENG. (Li et al., 2021), advances in generator designs (Gui et al., 2022),

3. Applications in healthcare:

Healthcare has always been one of the forefront industries of the world, mainly due to mankind's obsession with being able to prolong life expectancies (Wang et al., 2021). Functioning as a self-powered system, TENGs have a vast potential for a variety of biomedical and healthcare applications, including but not limited to (Kamilya & Park, 2022) (Xia et al., 2020):

- sensing applications
- endocardiac monitoring and treatment
- neuromodulation
- regenerative medicine
- communication
- safety
- drug delivery

a. Sensing applications:

Sensory purposes can be divided into a range of categories. TENG, for instance, can help to sense body movement for functional monitoring, pulse detection for wearables, proper exercise monitoring, respiration sensing, and physiological sensing that can hint at a person's emotional state (Kamilya & Park, 2022). TENG has also been used to power oxyhemoglobin saturation monitoring (Chen et al., 2019). Another useful approach is gait detection, in which little TENG structures made from copper and rubber layers are input into insoles for tracking purposes, proving to be a viable option for rehabilitation (Shabbir et al., 2021). TENG applications can also offer a simple solution for sleep monitoring both through breathing and movement sensing. Stretchability and the ability to machine wash the sensors are particularly desirable properties for physiological monitoring. (Xia et al., 2020)

b. **Endocardiac monitoring and treatment**:

Considering how cardiovascular anomalies are considered to be one of the most lethal causes of death in the current day age (Mathers et al., 2009), TENG provides an approach that allows for smaller devices to be implemented in monitoring processes. In particular, miniature TENG-powered biosensors can be coated in bio-compatible material to provide monitoring and pacemaking to the cardiac cells. (Xia et al., 2020).

c. **Neuromodulation**:

TENG is able to act as an electrical supply for neuromodulation, a method of therapy used to help regulate bodily functions by simulating and sending out manmade nervous signals, has been demonstrated in animal models for vagal nerve stimulation, and muscle rehabilitation or stimulation (Xia et al., 2020).

d. **Regenerative medicine**:

Stimulation of fibroblast cells has achieved faster healing in animal models. In one of the studies supporting this, a TENG model had been an accelerator of wound healing, akin to an electrical bandage, where electricity had been generated from the movement of skin cells in the affected area (Long et al., 2018), Other potential applications include cell differentiation to neuronal cells and hair regeneration that have been demonstrated in vitro. (Xia et al., 2020)

e. **Communication**:

Communication via non-verbal methods has been explored through the approach of combining motion sensors and signals to convey information. For instance, a self-powered motion sensor could capture gestures of the hand and enable live transcription of messages. (Xia et al., 2020).

f. **Safety**:

TENG devices have been suggested as safety devices for divers to detect drowning and set up an alert system, or for detecting falls or other potentially dangerous situations for the public. A waterproof TENG system based on ferrofluid usage was tested on situations involving drowning, and results show distinguishable readings on the sensors between the presence and non-presence of a drowning scenario (Xia et al., 2020)

g. **Drug delivery**:

Drug delivery in medicinal practices has been implemented but requires an external power source to begin the procedures. TENG offers new drug delivery methods for cancer therapy with no necessary external power source that has been demonstrated in vitro, a model presented by Ouyang et al. to produce an on-demand transdermal system. (Xia et al., 2020)

4. Applications in agriculture

Considering how traditional means and methods involved in agriculture are commonly under threat from natural disasters and other weather/climate obstacles (Cao et al., 2022), the use of TENGs can prove beneficial to modernizing these systems. Given their sustainability and small size to convenience, triboelectric nanogenerators can be implemented in contexts of agricultural use, such as a leaf-based TENG that harvests energy and self-powered sensors (Luo et al., 2023). These uses can range from temperature sensors, humidity level identifiers, and light intensity meters, among other environmental factors relative to a productive understanding of beneficial agriculture planning (Cao et al., 2022).

a. Wind energy harvesting

Triboelectric nanogenerators, specifically those in rotating or vibrating modes, have been implemented in significant numbers throughout the area of farming for wind energy (Dai et al., 2022). A model of the vibrating structure for TENG can be placed in windy locations, where an airflow duct leads wind to vibrate a contact electrode film, causing it to separate and touch a fixed membrane film inside the duct (Yang et al., 2013). A similar approach could also be taken with the wheel-rotation structure, utilizing the horizontal sliding mode within the rotor (Zhang et al., 2021).

b. Water energy harvesting

TENG models can cultivate hydro-powered electricity in both rainfall and flowing states of water. Rainy weather can become more beneficial in agriculture uses extending beyond a natural watering source for crops and plants, such as electrification from solid-liquid contact and static electric induction from contact between rainwater and TENG material (Lin et al, 2014). Although water flow is a tad more difficult to harness energy from due to the humid circumstances of common water flow areas (Dai et al., 2022), the stability of implemented TENG models can be enhanced by developing corrosion resistance through applying protection coating (Jiang et al., 2021).

c. Boosting crop growth and sensing

Agriculture information regarding the environment where crops are cultivated, specifically in greenhouse habitats, requires data collection through various types of sensors, including but not limited to temperature, humidity, soil acidity, etc. Triboelectricity becomes a viable option to power such devices, as works have included TENG systems utilizing the film covering on most greenhouses as a pre-installed triboelectrification layer, thus introducing a variant of the typical plant-growing infrastructure (H. Wang, Zhang, et al., 2021). Additionally, within greenhouses, TENG structures can also be implemented within the crop mulch and be mechanically operated via people stepping on the mulch, providing a layer of protection for crop roots while also enhancing germination rates via seed stimulation through electricity (Li et al., 2019) (Q. Li et al., 2021).

d. **Water purification**

Water is essential in sustaining the forms of life existing on Earth, and contamination from bacteria and viruses can cause detrimental effects on human health and biodiversity. One widespread resolution to this issue has been the experimentation of ozone disinfection in water treatment (Marcé et al., 2016), and a self-powered version of ozonation with TENG applications has been tested successfully as a sufficient high-voltage water purifier (Lei et al., 2021). Additionally, triboelectric structures implemented in pathogen sterilizing have also gone through trial for water cleaning, such as a self-powered filtration system with TENG that utilizes electroporation to clear microbial threats (Cho et al., 2021).

e. **Air purification**

Air quality is a critical factor when it comes to monitoring the development of crops and animals in the farming industry, a matter that can be improved upon with the utility of wide-scale air purification (Dai et al., 2022). Triboelectricity nanogenerators can contribute to making these purification systems simpler while being a high-voltage source (Lei et al., 2020), by releasing negative air ions, inactivation of airborne microorganisms, and eliminating particle-sized airborne matter (Dai et al., 2022).

5. Applications in smart cities

Smart cities are referred to as the integration of a multitude of sensors to gather data regarding the environment, activity, and status of the people and infrastructure present (*Smart Cities*, 2022). With this in mind, TENG can be integrated into various sensors within smart home and architecture systems. Another aspect to consider in creating an efficient and ideal smart city environment is spreading the prevalence of telecommunications, particularly 5G technology, IoT, and big data (Wang et al., 2022). As of 2021, 54% of the world's population has migrated into cities (Zhang, 2016), which calls for significant development in the latest technology to meet the constantly rising demand and standard of what is considered the norm in technology for societal use.

a. **Smart homes**

Smart homes, in particular, have recently gained significant amounts of traction due to their conceived ease of access/accessibility for regular everyday functions (Cao et al., 2022). A common use for triboelectricity in this context is to harness mechanical energy from human activity within the household using a TENG model made from plastic waste (Graham et al., 2021); in other words, an application that contributes to recycling aims from the waste stream while utilizing an alternative energy harnessing method. Another household implementation of TENG is self-powered utilities like doorbells and light switches which take a partial load off the house's general electric circuit (Hao et al., 2020). When integrated into the floor, TENG can detect the movement of humans walking around, which can even be beneficial for dancers

looking to create visual representations through the movement of their feet within studios (Cao et al., 2022). Studies have also shown TENG being used with alternative electric fields to be used for turning windows opaque or transparent, allowing a higher privacy magnitude for any smart house (Wang et al., 2020) (Yeh et al., 2015). Furthermore, the development of access control panels self-powered by TENG modules has been explored, reaching out to indoor and outdoor approaches similar to door locking, with modules set aside for control circuits and password inputs (Qiu et al., 2020).

b. **Smart transportation**

Smart transportation is also an important aspect for smart cities to be as seamless and convenient as technologically possible while ensuring the safety and well-being of citizens. Specifically, in the area of monitoring driver behavior, in which cost-efficient TENG-powered sensors are used to track instances in normal car driving activity such as blinking, accelerating, and braking, to be used in categorizing that specific driver behavior into conclusions like fatigue, impulsive, or regular (Meng et al., 2018). Other TENG systems have been implemented in evaluating fatigued or irregular driving behavior such as tracking miscellaneous actions like neck rotation and yawning (Lu et al., 2020), safety belts where body motion is tracked while turning on the road (Feng et al., 2019), as well as the tracing of steering wheel rotation (Yang et al., 2021). Traffic safety and congestion is also an explored area for nanogenerators, where distance sensors in a transmitter system have been placed to detect traffic volume, thereby updating real-time information to a 5G cloud, allowing drivers to plan their routes ahead to avoid conflicting areas (Zhang et al., 2016).

6. **Triboelectricity with AI synergy and AI**

AI has seen a tremendously widespread rise in popularity, specifically with the mass usage of chatbot services like ChatGPT and Claude.ai. Regardless, the true potential of AI remains untapped, such as that of machine learning, but the development of works and inventions that integrate AI and human-machine interactions to create functional and up-to-date intelligent systems (Cao et al., 2022). With this in mind, this section explores the various aspects of artificial intelligence and its synergy within human-machine interactions in everyday life that TENG may assist in terms of cost, efficiency, and scalability.

a. **Machine learning**

Machine learning is a term usually associated with representing the application of artificial intelligence when the topic is discussed, no matter the expertise. However, if correctly used, it allows devices in technology to detect "human traits" that are usually difficult for programmed devices to track and infer from (Cao et al., 2022). One example of this is the diverse range of handwriting unrestricted by humanity's population size, where a triboelectricity-powered handwriting pad successfully tracked and defined three separate languages' writing styles with significantly positive accuracy (Zhang et al., 2020), working

dependently on TENG's capability to detect external influencing forces (Cao et al., 2022). By advancing on the character illustration input via character recognition TENGs, a neural network can be applied to analyze the direct input of handwriting and character inscription (Tcho et al., 2020). In the same token, smart TENG keyboards have been constructed to analyze typing behavior through an in-depth understanding of keystroke monitoring, thus providing up to a 98.7% success rate in identifying different styles of typing (Wu et al., 2018).

b. **AR/VR implications**

The worldwide acceptance of augmented reality (AR) and virtual reality (VR) technology is in large part due to their mass commercialization through platforms and mediums like social media, gaming, work-related simulations, etc. (Cao et al., 2022). In this area, AR and VR technology rely on tactile sensors that provide users with an immersive experience, largely consisting of audio, visuals, and touch sensory. Thus, TENG-based sensors can be comfortably thin, light, and adaptive to the user's figure, thereby providing a more realistic, extreme experience when using AR/VR (American Association for the Advancement of Science, 2023) (He et al., 2019). Further extension applications of these experiences can range through limb rehabilitation tracking, user identification, motion monitoring for games, etc. (Zhang et al., 2021).

c. **Intelligent sports**

Sports data tracking has seen tremendous progression that correlates to the pace of the latest developed technology and the growing popularity of participating in sports. TENG, in particular, has been utilized in data tracking devices designed for wearing during exercise due to its low maintenance cost, sports-suitable production material like wood, paper, fibers, etc., and its self-sustainable powering nature (Luo et al., 2021). In one specific practical application, smart ski poles and insoles were created for skiers to monitor through a detailed analytics system that tracks joint, hand, and foot movement, pressure displacement, etc. (Yang et al., 2022).

Methods

The paper, in general, consists of a largely significant literature review that serves as the guiding overview of the topic, as well as an understanding of the workings of the triboelectricity concept and market, as well as how triboelectricity fits into those economies. The review itself would consist of in-depth approaches to the wide spectrum of applications in a multitude of industries that TENG can impact positively. There would also be a need for corresponding data and information analysis from research done by credible sources, journals, and companies in the field of triboelectricity and its surrounding economies to back up the observations and statements made within the review.

The types of information and data collected throughout the process of writing this research paper include but are not limited to market size, supply, significant competitors, demand, past/current/future implications of TENG, etc.

In total, after going through over a hundred different websites, journal articles, books, reports, etc., a list of 65 credible sources has been compiled and used throughout the creation of this research paper, in an attempt to diversify viewpoints and approaches to TENG, its implications, and its effects on the economy. These sources vary from credible organizations and companies with extensive research on the topic, as well as proven individuals and scientists that have spent significant efforts on developing their work.

The above research methods are combined in the paper to provide an all-around scope of the effects and potential of triboelectric technology on the economy and daily life, which gives a sensible prospect to readers and interested stakeholders of TENG technology as to what the projections and statistics mean for the future of societal growth and innovation.

Results

This section displays and analyzes data on how well triboelectric nanogenerators can infiltrate a market in several industries, and how significant it may be to the industries' economies.

Table 1 summarizes the findings relative to the industries that TENG can impact economically, their respective market size, how much of each industry's total market could be "captured" and utilized by TENG-based technology, as well as the estimated market value of that serviceable obtainable market (SOM).

Industry	Market Size (USD)	Market reach value for triboelectricity (USD)	% available for "capture"	SOM Estimate (USD)
Smart Agriculture	$11.4 billion	$342 million	10%	$34 million
Biomedical batteries: sensing application	$2.7 billion	$2.7 billion	50%	$1.35 billion
Biomedical: cardiac implantation devices IoT in smart cities (by 2030)	$735 billion	$22.05 billion	20%	$4.41 billion
Batteries replacement in IoT devices (by 2030)	$770 billion	$770 billion	20%	$154 billion

Table 1. *Respective market sizes, potentials in "capturing", estimated market values affected of several TENG-impacted industries*

a. **Smart agriculture**

According to BusinessWire's report on a Global Industry Analytics Inc. book on the smart agricultural market, as of 2022, the estimated market size for the smart agriculture industry is at 11.7 billion US dollars, with projections to double by 2030. Judging by how low-cost TENG models are, it is estimated that its cost will be just under 3%, roughly 342 million USD. Since triboelectricity's main competitor is Lithium-ion batteries or solid-state variants, it is most likely that 10% of the market will be captured based on how recently developed TENGs are, which puts the estimated SOM for smart agriculture at 34 million USD.

b. **Healthcare: biomedical**

In terms of the sensing application in the area, it is estimated that the battery sources for the industry are valued at approximately 2.7 billion USD. Even though there are competitors like Japan's OMRON Healthcare, Inc. and Indiro Global who are prime developers of electrical powering of medical devices such as blood pressure monitors and hospital equipment, TENG still remains a reliable technology that is able to compete to the extent of the full market. Its possible captured percentage of the market, however, would be most suitably estimated at 50% given the significance and popularity of its competitors. (Coherent Market Insights Pvt. Ltd, 2022). In a different area, implemented cardiac devices in healthcare are projected to see huge growth in the market, valued at an estimated 735 billion USD by 2030. Despite this being in large part due to its influence and relationship with the IoT market, it is not to say the healthcare aspect brings a great opportunity to power healthcare devices and appliances, as it provides significantly less downtime while maintaining the same magnitude of security. (Verified Market Research, 2022)

c. **Batteries in IoT**

Another important area, that has also been mentioned throughout this paper, is the IoT battery industry. Its market size is projected to be at 770 billion USD by 2030, and given the mass influence of how TENG could change the landscape of cost-efficient, energy-efficient, and light devices, a 20% estimated market capture is not unreasonable, meaning that triboelectricity alone can affect up to $154 billion of the industry. (Verified Market Research, 2022)

Conclusion

TENG is considered a viable option for a wide range of industries globally, and thus should not be considered lightly in the upcoming years of technological development. Throughout this paper, it can be inferred that the possibilities of TENG-based models are endless within everyday life and commercialized purposes and that its economic effect can prove

groundbreaking to companies and tech giants looking to make significant advancements in the convenience of their products, all while profiting and aiding the environment.

Acknowledgements

Works Cited

Wang, H.; Cheng, J.; Wang, Z. L.; Ji, L.; Wang, Z. L. Triboelectric Nanogenerators for Human-Health Care. *Science Bulletin* **2021**, *66* (5), 490–511. https://doi.org/10.1016/j.scib.2020.10.002.

Ahmed, A. A.; Hassan, I.; El-Kady, M. F.; Iacobellis, V.; Jeong, C. W.; Selvaganapathy, P. R.; Zu, J. W.; Ren, S.; Wang, Q.; Kaner, R. B. Integrated Triboelectric Nanogenerators in the Era of the Internet of Things. *Advanced Science* **2019**, *6* (24), 1802230. https://doi.org/10.1002/advs.201802230.

Data sources to help determine your total addressable market size. https://www.scalepath.io/library/best-market-sizing-data-sources-to-determine-total-addressable-market.

Markard, J.; Truffer, B. The Promotional Impacts of Green Power Products on Renewable Energy Sources: Direct and Indirect Eco-Effects. *Energy Policy* **2006**, *34* (3), 306–321. https://doi.org/10.1016/j.enpol.2004.08.005.

Jackson, R. *The effects of climate change*. Climate Change: Vital Signs of the Planet. https://climate.nasa.gov/effects/.

View of advantages and disadvantages of renewable energy sources utilization. https://econjournals.com/index.php/ijeep/article/view/11027/5802.

Maradin, D. ADVANTAGES AND DISADVANTAGES OF RENEWABLE ENERGY SOURCES UTILIZATION. *International Journal of Energy Economics and Policy* **2021**, *11* (3), 176–183. https://doi.org/10.32479/ijeep.11027.

Harmon, W.; Bamgboje, D.; Guo, H.; Hu, T.; Wang, Z. L. Self-Driven Power Management System for Triboelectric Nanogenerators. *Nano Energy* **2020**, *71*, 104642. https://doi.org/10.1016/j.nanoen.2020.104642.

Peng, J.; Kang, S. D.; Snyder, G. J. Optimization Principles and the Figure of Merit for Triboelectric Generators. *Science Advances* **2017**, *3* (12). https://doi.org/10.1126/sciadv.aap8576.

Zhu, G.; Pan, C.; Guo, W.; Chen, C.-Y.; Zhou, Y.; Yu, R.; Wang, Z. L. Triboelectric-Generator-Driven Pulse Electrodeposition for Micropatterning. *Nano Letters* **2012**, *12* (9), 4960–4965. https://doi.org/10.1021/nl302560k.

Wang, S.; Lin, L.; Xie, Y.; Jing, Q.; Niu, S.; Wang, Z. L. Sliding-Triboelectric Nanogenerators Based on In-Plane Charge-Separation Mechanism. *Nano Letters* **2013**, *13* (5), 2226–2233. https://doi.org/10.1021/nl400738p.

Niu, S.; Liu, Y.; Wang, S.; Lin, L.; Zhou, Y.; Hu, Y.; Wang, Z. L. Theoretical Investigation and Structural Optimization of Single-Electrode Triboelectric Nanogenerators. *Advanced Functional Materials* **2014**, *24* (22), 3332–3340. https://doi.org/10.1002/adfm.201303799.

Ahmed, A.; Hassan, I.; Ibn-Mohammed, T.; Mostafa, H.; Reaney, I. M.; Koh, L.; Zu, J. W.; Wang, Z. L. Environmental Life Cycle Assessment and Techno-Economic Analysis of

Triboelectric Nanogenerators. *Energy and Environmental Science* **2017**, *10* (3), 653–671. https://doi.org/10.1039/c7ee00158d.

Solar, C. *How Much Investment Do You Need For A Solar Farm? | Coldwell Solar*. Coldwell Solar. https://coldwellsolar.com/commercial-solar-blog/how-much-investment-do-you-need-for-a-solar-farm/.

MSc, K. T.; MSc, K. T. *Solar Farm Cost Investment unveiled: True Cost of building*. Energy storage blog. https://howtostoreelectricity.com/solar-farm-cost/.

Guard, W. *Wind Turbine Cost: Worth The Million-Dollar Price In 2022?*. Weather Guard Lightning Tech. https://weatherguardwind.com/how-much-does-wind-turbine-cost-worth-it/.

The economics of wind power. - ANS / Nuclear Newswire. https://www.ans.org/news/article-638/the-economics-of-wind-power/#:~:text=Cost%20of%20wind%20farms%3A,year%20(1%2C750%2F15).

Cao, X.; Xiong, Y.; Sun, J.; Xie, X.; Sun, Q.; Wang, Z. L. Multidiscipline Applications of Triboelectric Nanogenerators for the Intelligent Era of Internet of Things. *Nano-micro Letters* **2022**, *15* (1). https://doi.org/10.1007/s40820-022-00981-8.

Wang, W.; Pang, J.; Su, J.; Li, F.; Li, Q.; Wang, X.; Wang, J.; Ibarlucea, B.; Liu, X.; Li, Y.; Zhou, W.; Wang, K.; Han, Q.; Liu, L.; Zang, R.; Rümmeli, M. H.; Li, Y.; Liu, H.; Han, H.; Cuniberti, G. Applications of Nanogenerators for Biomedical Engineering and Healthcare Systems. *InfoMat* **2021**, *4* (2). https://doi.org/10.1002/inf2.12262.

Mathers, C.; Boerma, T.; Fat, D. M. Global and Regional Causes of Death. *British Medical Bulletin* **2009**, *92* (1), 7–32. https://doi.org/10.1093/bmb/ldp028.

Shabbir, I.; Rubab, N.; Kim, T. W.; Kim, S. W. Healthcare Management Applications Based on Triboelectric Nanogenerators. *APL Materials* **2021**, *9* (6), 060703. https://doi.org/10.1063/5.0052605.

Xu, C.; Zeng, F.; Wu, D.; Wang, P.; Yin, X.; Jia, B. Nerve Stimulation by Triboelectric Nanogenerator Based on Nanofibrous Membrane for Spinal Cord Injury. *Frontiers in Chemistry* **2022**, *10*. https://doi.org/10.3389/fchem.2022.941065.

Long, Y.; Wu, H.; Li, J.; Yao, G.; Bai, Y.; Ni, D.; Gibson, A.; Lan, X.; Jiang, Y.; Cai, W.; Wang, X. Effective Wound Healing Enabled by Discrete Alternative Electric Fields from Wearable Nanogenerators. *ACS Nano* **2018**, *12* (12), 12533–12540. https://doi.org/10.1021/acsnano.8b07038.

Luo, Y.; Cao, X.; Wang, Z. L. Self-Powered Smart Agriculture Sensing Using Triboelectric Nanogenerators Based on Living Plant Leaves. *Nano Energy* **2023**, *107*, 108097. https://doi.org/10.1016/j.nanoen.2022.108097.

Smart Cities. https://education.nationalgeographic.org/resource/smart-cities/.

Dai, S.; Li, X.; Jiang, C.; Ping, J.; Ying, Y. Triboelectric Nanogenerators for Smart Agriculture. *InfoMat* **2022**, *5* (2). https://doi.org/10.1002/inf2.12391.

Yang, Y.; Zhu, G.; Zhang, H.; Chen, J.; Zhong, X.; Lin, Z.-H.; Su, Y.; Bai, P.; Wen, X.; Wang, Z. L. Triboelectric Nanogenerator for Harvesting Wind Energy and as Self-Powered Wind Vector Sensor System. *ACS Nano* **2013**, *7* (10), 9461–9468. https://doi.org/10.1021/nn4043157.

Zhang, B.; Zhang, S.; Li, W.; Gao, Q.; Zhao, D.; Wang, Z. L.; Cheng, T. Self-Powered Sensing for Smart Agriculture by Electromagnetic–Triboelectric Hybrid Generator. *ACS Nano* **2021**, *15* (12), 20278–20286. https://doi.org/10.1021/acsnano.1c08417.

Lin, Z.-H.; Cheng, G.; Lee, S.-M.; Pradel, K. C.; Wang, Z. L. Harvesting Water Drop Energy by a Sequential Contact-Electrification and Electrostatic-Induction Process. *Advanced Materials* **2014**, *26* (27), 4690–4696. https://doi.org/10.1002/adma.201400373.

Jiang, C.; Li, X.; Ying, Y.; Ping, J. Fluorinated Graphene‑Enabled Durable Triboelectric Coating for Water Energy Harvesting. *Small* **2021**, *17* (8), 2007805. https://doi.org/10.1002/smll.202007805.

Wang, H.; Zhang, M.; Yang, Z.; Wang, Z.; Liu, X.; Lu, Y.; Ji, L.; Wang, Z. L.; Cheng, J. Energy from Greenhouse Plastic Films. *Nano Energy* **2021**, *89*, 106328. https://doi.org/10.1016/j.nanoen.2021.106328.

Li, Z.-G.; Gou, H.-Q.; Li, R. Electrical Stimulation Boosts Seed Germination, Seedling Growth, and Thermotolerance Improvement in Maize (*Zea Mays* L.). *Plant Signaling & Behavior* **2019**, *14* (12), 1681101. https://doi.org/10.1080/15592324.2019.1681101.

Li, Q.; Liu, W.; Yang, H.; He, W.; Li, L.; Wu, M.; Zhang, X.; Xi, Y.; Hu, C.; Wang, Z. L. Ultra-Stability High-Voltage Triboelectric Nanogenerator Designed by Ternary Dielectric Triboelectrification with Partial Soft-Contact and Non-Contact Mode. *Nano Energy* **2021**, *90*, 106585. https://doi.org/10.1016/j.nanoen.2021.106585.

Zhou, L.; Liu, D.; Wang, J.; Wang, Z. L. Triboelectric Nanogenerators: Fundamental Physics and Potential Applications. *Friction* **2020**, *8* (3), 481–506. https://doi.org/10.1007/s40544-020-0390-3.

Ahmed, A.; Hassan, I.; El‑Kady, M. F.; Radhi, A.; Jeong, C. K.; Selvaganapathy, P. R.; Zu, J. W.; Ren, S.; Wang, Q.; Kaner, R. B. Integrated Triboelectric Nanogenerators in the Era of the Internet of Things. *Advanced Science* **2019**, *6* (24), 1802230. https://doi.org/10.1002/advs.201802230.

Marcé, M.; Domenjoud, B.; Esplugas, S.; Baig, S. Ozonation Treatment of Urban Primary and Biotreated Wastewaters: Impacts and Modeling. *Chemical Engineering Journal* **2016**, *283*, 768–777. https://doi.org/10.1016/j.cej.2015.07.073.

Lei, R.; Shi, Y.; Wang, X.; Tao, X.; Zhai, H.; Chen, X. Water Purification System Based on Self-Powered Ozone Production. *Nano Energy* **2021**, *88*, 106230. https://doi.org/10.1016/j.nanoen.2021.106230.

Cho, S.; Hanif, Z.; Yun, Y.; Khan, Z. A.; Jang, S.; Ra, Y.; Lin, Z.; La, M.; Park, S. J.; Choi, D. Triboelectrification-Driven Microbial Inactivation in a Conductive Cellulose Filter for Affordable, Portable, and Efficient Water Sterilization. *Nano Energy* **2021**, *88*, 106228. https://doi.org/10.1016/j.nanoen.2021.106228.

Cheek, E.; Guercio, V.; Shrubsole, C.; Dimitroulopoulou, C. Portable Air Purification: Review of Impacts on Indoor Air Quality and Health. *Science of the Total Environment* **2021**, *766*, 142585. https://doi.org/10.1016/j.scitotenv.2020.142585.

Lei, R.; Shi, Y.; Ding, Y.; Nie, J.; Li, S.; Wang, F.; Zhai, H.; Chen, X.; Wang, Z. L. Sustainable High-Voltage Source Based on Triboelectric Nanogenerator with a Charge Accumulation Strategy. *Energy and Environmental Science* **2020**, *13* (7), 2178–2190. https://doi.org/10.1039/d0ee01236j.

Graham, S. A.; Chandrarathna, S. C.; Patnam, H.; Manchi, P.; Lee, J.; Yu, J. S. Harsh Environment–Tolerant and Robust Triboelectric Nanogenerators for Mechanical-Energy Harvesting, Sensing, and Energy Storage in a Smart Home. *Nano Energy* **2021**, *80*, 105547. https://doi.org/10.1016/j.nanoen.2020.105547.

Hao, S.; Jiao, J.; Chen, Y.; Wang, Z. L.; Cao, X. Natural Wood-Based Triboelectric Nanogenerator as Self-Powered Sensing for Smart Homes and Floors. *Nano Energy* **2020**, *75*, 104957. https://doi.org/10.1016/j.nanoen.2020.104957

Wang, J.; Meng, C.; Gu, Q.; Tseng, M. C.; Tang, S. T.; Kwok, H. S.; Cheng, J.; Zi, Y. Normally Transparent Tribo-Induced Smart Window. *ACS Nano* **2020**, *14* (3), 3630–3639. https://doi.org/10.1021/acsnano.0c00107.

Yeh, M.; Lin, L.; Yang, P. K.; Wang, Z. L. Motion-Driven Electrochromic Reactions for Self-Powered Smart Window System. *ACS Nano* **2015**, *9* (5), 4757–4765. https://doi.org/10.1021/acsnano.5b00706.

Qiu, C.; Wu, F.; Lee, C.; Yuce, M. R. Self-Powered Control Interface Based on Gray Code with Hybrid Triboelectric and Photovoltaics Energy Harvesting for IoT Smart Home and Access Control Applications. *Nano Energy* **2020**, *70*, 104456. https://doi.org/10.1016/j.nanoen.2020.104456.

Meng, X.; Qian, C.; Jiang, X.; Fang, Z.; Chen, X.; Li, S.; Li, C.; Sun, C.; Wang, W.; Wang, Z. L. Triboelectric Nanogenerator as a Highly Sensitive Self-Powered Sensor for Driver Behavior Monitoring. *Nano Energy* **2018**, *51*, 721–727. https://doi.org/10.1016/j.nanoen.2018.07.026.

Lu, X.; Zheng, L.; Zhang, H.; Wang, W.; Wang, Z. L.; Sun, C. Stretchable, Transparent Triboelectric Nanogenerator as a Highly Sensitive Self-Powered Sensor for Driver Fatigue and Distraction Monitoring. *Nano Energy* **2020**, *78*, 105359. https://doi.org/10.1016/j.nanoen.2020.105359.

Feng, Y.; Huang, X.; Liu, S.; Guo, W.; Li, Y.; Wu, H. A Self-Powered Smart Safety Belt Enabled by Triboelectric Nanogenerators for Driving Status Monitoring. *Nano Energy* **2019**, *62*, 197–204. https://doi.org/10.1016/j.nanoen.2019.05.043.

Yang, X.; Yang, W.; Yu, X.; Li, H.; Cheng, T.; Lu, X.; Wang, Z. L. Real-Time Monitoring System of Automobile Driver Status and Intelligent Fatigue Warning Based on Triboelectric Nanogenerator. *ACS Nano* **2021**, *15* (4), 7271–7278. https://doi.org/10.1021/acsnano.1c00536.

Wang, H.; Fu, J.; Wang, J.; Su, L.; Zi, Y. Tribophotonics: An Emerging Self-Powered Wireless Solution toward Smart City. *Nano Energy* **2022**, *97*, 107196. https://doi.org/10.1016/j.nanoen.2022.107196.

Zhang, X. Q. The Trends, Promises and Challenges of Urbanisation in the World. *Habitat International* **2016**, *54*, 241–252. https://doi.org/10.1016/j.habitatint.2015.11.018.

Zhang, B.; Chen, J.; Jin, L.; Deng, W.; Zhang, L.; Zhang, H.; Zhu, M.; Yang, W.; Wang, Z. L. Rotating-Disk-Based Hybridized Electromagnetic–Triboelectric Nanogenerator for Sustainably Powering Wireless Traffic Volume Sensors. *ACS Nano* **2016**, *10* (6), 6241–6247. https://doi.org/10.1021/acsnano.6b02384.

Zhang, W.; Deng, L.; Yang, L.; Yang, P.; Diao, D.; Wang, P.; Wang, Z. L. Multilanguage-Handwriting Self-Powered Recognition Based on Triboelectric Nanogenerator Enabled Machine Learning. *Nano Energy* **2020**, *77*, 105174. https://doi.org/10.1016/j.nanoen.2020.105174.

Tcho, I.; Kim, W.; Choi, Y. A Self-Powered Character Recognition Device Based on a Triboelectric Nanogenerator. *Nano Energy* **2020**, *70*, 104534. https://doi.org/10.1016/j.nanoen.2020.104534.

Wu, C.; Ding, W.; Liu, R.; Wang, J.; Wang, A. C.; Wang, J.; Li, S.; Zi, Y.; Wang, Z. L. Keystroke Dynamics Enabled Authentication and Identification Using Triboelectric Nanogenerator Array. *Materials Today* **2018**, *21* (3), 216–222. https://doi.org/10.1016/j.mattod.2018.01.006.

American Association for the Advancement of Science. *Self-powered textile for wearable electronics by hybridizing fiber-shaped nanogenerators, solar cells, and supercapacitors*. Science Advances. https://www.science.org/doi/10.1126/sciadv.1600097.

He, T.; Shi, Q.; Wang, H.; Wen, F.; Chen, T.; Ouyang, J.; Lee, C. Beyond Energy Harvesting - Multi-Functional Triboelectric Nanosensors on a Textile. *Nano Energy* **2019**, *57*, 338–352. https://doi.org/10.1016/j.nanoen.2018.12.032.

He, T.; Shi, Q.; Wang, H.; Wen, F.; Chen, T.; Ouyang, J.; Lee, C. Beyond Energy Harvesting - Multi-Functional Triboelectric Nanosensors on a Textile. *Nano Energy* **2019**, *57*, 338–352. https://doi.org/10.1016/j.nanoen.2018.12.032.

Zhang, Q.; Jin, T.; Cai, J.; Xu, L.; He, T.; Wang, T.; Tian, Y.; Li, L.; Peng, Y.; Lee, C. Wearable Triboelectric Sensors Enabled Gait Analysis and Waist Motion Capture for IoT‑Based Smart Healthcare Applications. *Advanced Science* **2021**, *9* (4), 2103694. https://doi.org/10.1002/advs.202103694.

Luo, J.; Gao, W.; Wang, Z. L. The Triboelectric Nanogenerator as an Innovative Technology toward Intelligent Sports. *Advanced Materials* **2021**, *33* (17), 2004178. https://doi.org/10.1002/adma.202004178.

Yang, Y.; Hou, X.; Geng, W.; Mu, J.; Zhang, L.; Wang, X.; He, J.; Xiong, J.; Chou, X. Human Movement Monitoring and Behavior Recognition for Intelligent Sports Using Customizable and Flexible Triboelectric Nanogenerator. *Science China-technological Sciences* **2022**, *65* (4), 826–836. https://doi.org/10.1007/s11431-021-1984-9.

BusinessWire. *Global Smart Agriculture Strategic Analysis Report 2023: A $25+ Billion Market by 2030 - Ongoing Shift Towards Precision Agriculture Instigates Opportunities - ResearchAndMarkets.com*. BusinessWire. https://www.businesswire.com/news/home/20230908107421/en/Global-Smart-Agriculture-Strategic-Analysis-Report-2023-A-25-Billion-Market-by-2030---Ongoing-Shift-Towards-Precision-Agriculture-Instigates-Opportunities---ResearchAndMarkets.com.

Global Industry Analysts Inc. *Smart Agriculture - Global Strategic Business Report*; Global Industry Analysts Inc., 2023.

Coherent Market Insights Pvt. Ltd. Global Medical Batteries Market to Surpass US$ 4,471.56 Million by 2030, Says Coherent Market Insights (CMI). *GlobeNewswire News Room*. July 12, 2022. https://www.globenewswire.com/news-release/2022/07/12/2478238/0/en/Global-Medical-Batteries-Market-to-Surpass-US-4-471-56-Million-by-2030-Says-Coherent-Market-Insights-CMI.html.

Verified Market Research. *Global IoT In Smart Cities Market Size By Offering (Solution, Services), By Application (Smart Transportation, Smart Building), By Geographic Scope And Forecast*; Verified Market Research, 2022

Improving Player Efficiency Rating in Basketball through Machine Learning By Raghav Seshadri

Abstract

This paper explores the intersection of advanced statistical methodologies and basketball with a focus on improving the Player Efficiency Rating (PER) metric. This research delves into three distinct AI models: Lasso Regression, Random Forest Regression, and Neural Networks. These models, each with unique capabilities, allow for more accurate PER ratings which helps teams and coaches to make informed decisions about player rotations and substitutions.

Introduction

Player Efficiency Rating (PER) is a widely used metric in basketball analytics for assessing a player's overall performance. Traditional PER metrics have primarily focused on offensive statistics such as points per game (ppg) and assists per game (apg), overlooking critical defensive contributions that can significantly impact a player's value to the team. This paper poses an innovative approach to improve the PER metric by integrating additional metrics. This research aims to provide more accurate and comprehensive results, particularly in terms of a player's defensive contributions, by adjusting weightage through various Machine Learning (ML) models. The final results will contribute to improving the accuracy of awards given in the NBA, potentially reshaping the league's effectiveness.

Background

Player Efficiency Rating (PER) is a fundamental metric widely used in basketball analytics to evaluate a player's overall performance to impact the game. John Hollinger introduced PER in the early 2000s, providing a single numerical value that summarizes a player's statistical contributions. He enabled various comparisons between players and teams and is still a very commonly used metric today.

$$
\begin{aligned}
PER = \frac{1}{MP} & \left[3P + \frac{2}{3} \cdot AST + \left(2 - factor \cdot \frac{team\_AST}{team\_FG} \right) \cdot FG \right. \\
& + \left(FT \cdot 0.5 \cdot \left(1 + \left(1 - \frac{team\_AST}{team\_FG} \right) + \frac{2}{3} \cdot \frac{team\_AST}{team\_FG} \right) \right) \\
& - VOP \cdot TOV - VOP \cdot DRB\% \cdot (FGA - FG) \\
& - VOP \cdot 0.44 \cdot (0.44 + 0.56 \cdot DRB\%) \cdot (FTA - FT) \\
& + VOP \cdot (1 - DRB\%) \cdot (TRB - ORB) + VOP \cdot DRB\% \cdot ORB \\
& + VOP \cdot STL + VOP \cdot DRB\% \cdot BLK \\
& \left. - PF \cdot \left(\frac{lg\_FT}{lg\_PF} - 0.44 \cdot \frac{lg\_FTA}{lg\_PF} \cdot VOP \right) \right]
\end{aligned} \tag{1}
$$

• PER: Player Efficiency Rating
• MP: Minutes played by the player
• 3P: Total number of three-point field goals made
• AST: Total number of assists

- FG: Total number of field goals made
- FT: Total number of free throws made
- ORB: Total number of offensive rebounds
- DRB: Total number of defensive rebounds
- STL: Total number of steals
- BLK: Total number of blocks
- PF: Total number of personal fouls
- FGA: Total number of field goals attempted
- The factor of 2 3 is a constant
- Team AST: Team's total assists
- Team FG: Team's total field goals made

As mentioned earlier, PER assesses a player's efficiency on the basketball court. A higher PER rating generally indicates that a player is more efficient while a lower PER suggests a less productive player. Coaches, technical staff, and analysts use PER to evaluate a player's contributions to a team which they can use to strategize team formations and make critical decisions. The traditional PER metric created by John Hollinger heavily emphasized offensive statistics like points per game (ppg), assists, and shooting efficiency. While these metrics are essential, they fail to account for a player's defensive prowess, which significantly influences a team's success. This limitation has led to insights from analysts proposing modifications to the traditional PER calculation. Many analysts have suggested adjusting the weights of individual statistical components within the PER formula to better reflect a player's true impact. For instance, some studies have given less importance to scoring based on the time period, arguing that scoring has become easier in recent years. Others have criticized the methodology of the formula, claiming it doesn't adhere to standard research practices [1]. On top of that, basketball analysts have highlighted the need to consider the team's performance when calculating PER. Some have advocated for incorporating team-based metrics such as team assists and team field goals to account for a player's influence on team success beyond individual statistics. To improve upon PER, this research paper proposes an approach that incorporates advanced defensive statistics and adjusts their weights using Artificial Intelligence models. Using AI algorithms such as Neural Networks (using PyTorch), LASSO regression, and Random Forest Regression, this study aims to determine the optimal weightage for each statistical component, accounting for both offensive and defensive contributions.

Data Preprocessing and Web Scraping

The dataset used in this research was collected through web scraping from the NBA 2022-2023 season statistics page on basketball reference. The scraped data includes essential attributes such as "Player", "Tm", "G", "MP", "PqTS", "FG", "FGA", "FG%", "3P", "3PA", "3P%", "2P", "2PA", "2P%", "eFG%", "FT", "FTA", "FT%", "ORB", "DRB", "TOV", "PF", "PTS", "AST", "TRB", "STL", and "BLK". This dataset captures both offensive and defensive statistics which forms the foundation for the research. Prior to analysis, a rigorous data

preprocessing phase was conducted to ensure data quality and completeness. Missing values were changed to '0' or the mean value, depending on the situation. The result was a clean and robust dataset ready for the application of machine learning models.

Machine Learning Models

The Lasso Regression model is a linear regression technique that introduces L1 regularization, encouraging the model to select a subset of the most influential features while penalizing others. In this case, Lasso Regression is applied to adjust the weightage of statistical components within the PER formula such as blocks, steals, and rebounds. The Lasso Regression model is generally implemented through the scikit-learn library in Python. It's trained on historical NBA player data, with scaled PER values from 0 to 100 used as the target variable. The L1 regularization term helps identify the most relevant features and their respective coefficients, thus determining the adjusted weightage for each component. The Lasso Regression model generates a histogram illustrating the distribution of scaled PER values for all players in the dataset. This histogram allows for an assessment of the model's ability to assign accurate weights to individual statistics, particularly defensive contributions.

The Random Forest model is an ensemble learning method that combines the predictions of multiple decision tree models. It is well-suited for both classification and regression tasks, making it great for enhancing the accuracy of the PER metric. The Random Forest model, like the Lasso Regression model, is implemented using the scikit-learn library in Python. Historical NBA player data has also been utilized to train the model. The Random Forest algorithm aggregates predictions from multiple decision trees, enabling the evaluation of the adjusted weightage of statistical components within the PER formula. The Random Forest model produces a histogram that overlays the predicted PER values and the actual PER values for each player in the dataset. This visualization allows for the identification of areas where the model aligns with the actual metric and areas where further refinement is needed.

Neural networks are a class of machine-learning models inspired by the structure and function of the human brain. In this research, the PyTorch framework is leveraged to design and train a neural network capable of optimizing the weightage of PER components. Using PyTorch, a neural network architecture is constructed to the task of adjusting PER weights. The model is trained on a broad dataset of NBA player statistics, and its deep learning capabilities allow for intricate feature transformations and weight adjustments. Similar to the Lasso Regression and Random Forest models, the Neural Network model generates a histogram depicting the distribution of scaled PER values. This histogram reveals the neural network's capacity to fine-tune weights, particularly in relation to defensive contributions.

Evaluation Metrics

To evaluate the performance of the machine learning models and the effectiveness of the adjusted PER metric, several key evaluation metrics are employed, including:

• R-squared (R²) Value: This metric measures the proportion of variance in the scaled PER that is predictable by the models. Higher R^2 values indicate a better fit to the data.

• Mean Squared Error (MSE): This metric measures the amount of error in statistical models. A higher MSE score shows that the model is more inaccurate whereas a lower MSE score exhibits a stronger and more accurate model.

• Histogram Overlap: In the case of the Random Forest model, the degree of overlap between predicted and actual PER values on the histogram is assessed. Overlapping regions signify accurate predictions, while non overlapping areas indicate areas for improvement.

Results: **Lasso Regression**
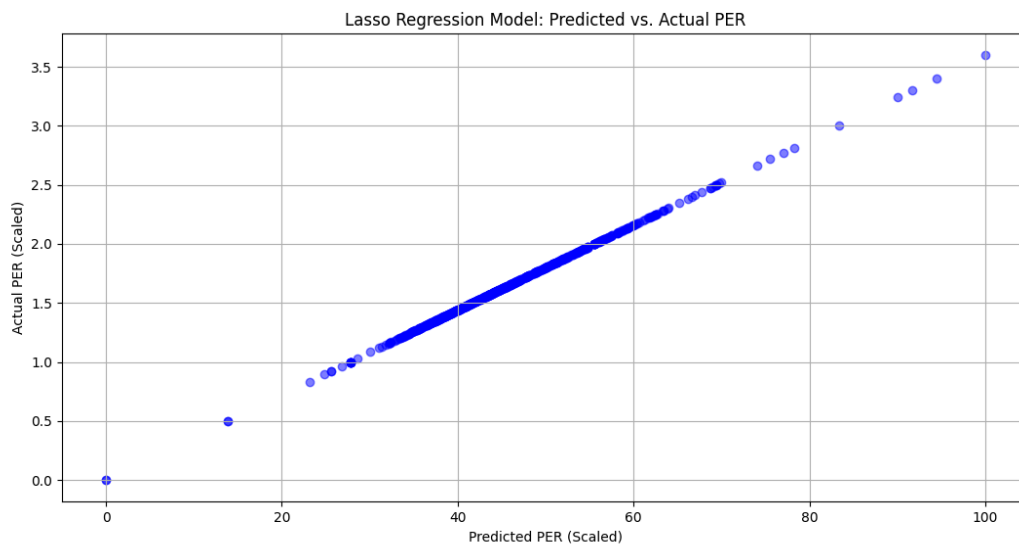
Figure 1: Histogram of Predicted PER using Neural Networks

The histogram in Figure 1 presents the distribution of scaled predicted Player Efficiency Rating (PER) values generated by the Lasso Regression Model. This 5 histogram visually represents the model's predictions and offers insights into its performance. The Lasso Regression Model, employed to optimize the weights of individual statistical components within the Player Efficiency Rating (PER) formula, has provided valuable insights into the distribution of scaled predicted PER values. This section explores the key findings and implications of the Lasso Regression Model's performance.

• Histogram Analysis: The histogram displayed in Figure 2 illustrates the distribution of scaled predicted PER values generated by the Lasso Regression Model. This histogram serves as a visual representation of the model's predictions and offers critical insights into its effectiveness.
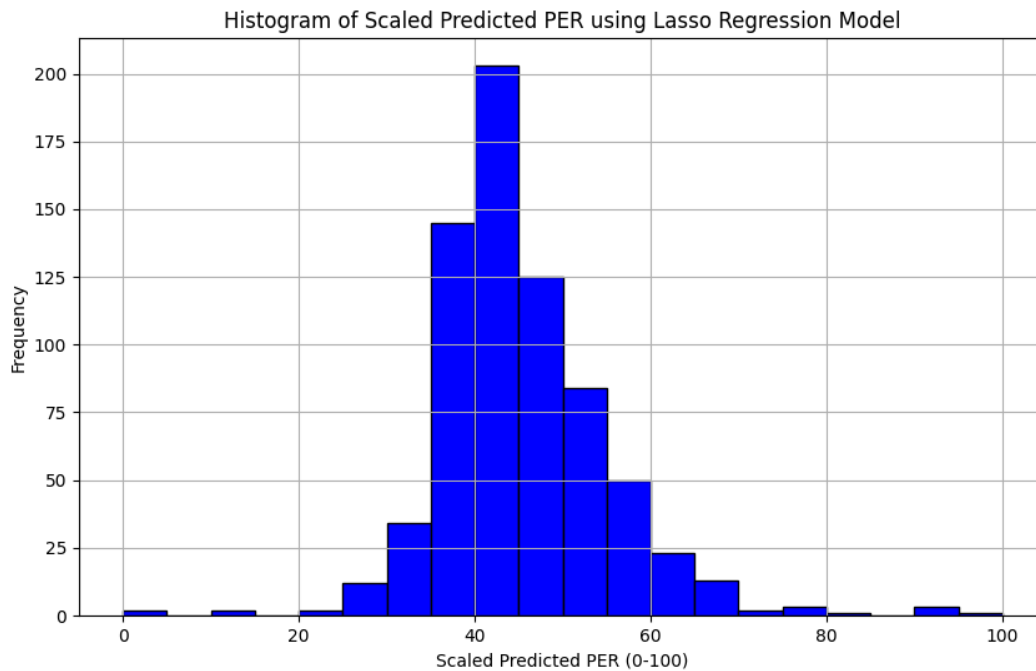
Figure 2: Histogram of Scaled Predicted PER using Lasso Regression Model

The histogram in Figure 2 depicts the distribution of scaled predicted PER values generated by the Lasso Regression Model. The presence of a bell-shaped curve indicates that the model's predictions cluster around a central point, resembling a normal distribution. This suggests that the Lasso Regression Model provides balanced and accurate predictions, although further validation is required.

 • Bell-Shaped Curve: One notable characteristic of the histogram is the presence of a bell-shaped curve, which closely resembles a normal distribution. This pattern suggests that a substantial proportion of the predicted PER values cluster around a central point, mirroring the shape of a typical normal distribution curve. In statistical terms, this observation implies that the Lasso Regression Model's predictions exhibit a central tendency, possibly corresponding to the average player efficiency within the dataset.

 • Balanced Predictions: The normal distribution of scaled predicted PER values implies that the Lasso Regression Model provides balanced predictions. This balance indicates that the model neither consistently overestimates nor underestimates player efficiency. Instead, it produces predictions that are symmetrically distributed around the central tendency, resulting in a well-balanced histogram.

 • Model Effectiveness: The presence of the bell-shaped curve in the histogram is a promising indicator of the Lasso Regression Model's effectiveness. It suggests that the model captures underlying patterns in the data, aligning with the expected distribution of player efficiency. This is a crucial step in improving the accuracy of the PER metric, as it demonstrates

the model's ability to generate predictions that reflect player performance characteristics present in the dataset.

• Validation and Further Assessment: While the bell-shaped curve is encouraging, a comprehensive evaluation is necessary to validate the model's predictive accuracy rigorously. This assessment should involve comparisons with actual player performance data to determine how closely the model's predictions align with reality. Additionally, additional metrics, such as the R-squared value, should be considered to quantify the model's predictive power. The R-squared value for this dataset was around 0.65, which is pretty reasonable and accurate for most real-life predictions. This is reflected in the bell curve in Figure 1.

In conclusion, the observation of a bell-shaped curve in the histogram of scaled predicted PER values underscores the potential of the Lasso Regression Model as a tool for enhancing the accuracy of player efficiency prediction in basketball analytics. This distribution pattern indicates that the model's predictions align with the inherent characteristics of player performance in the dataset. Further validation and analysis are required to ascertain the model's predictive accuracy comprehensively, but this initial observation is promising for the advancement of PER metrics in basketball analytics.

Random Forest Model:
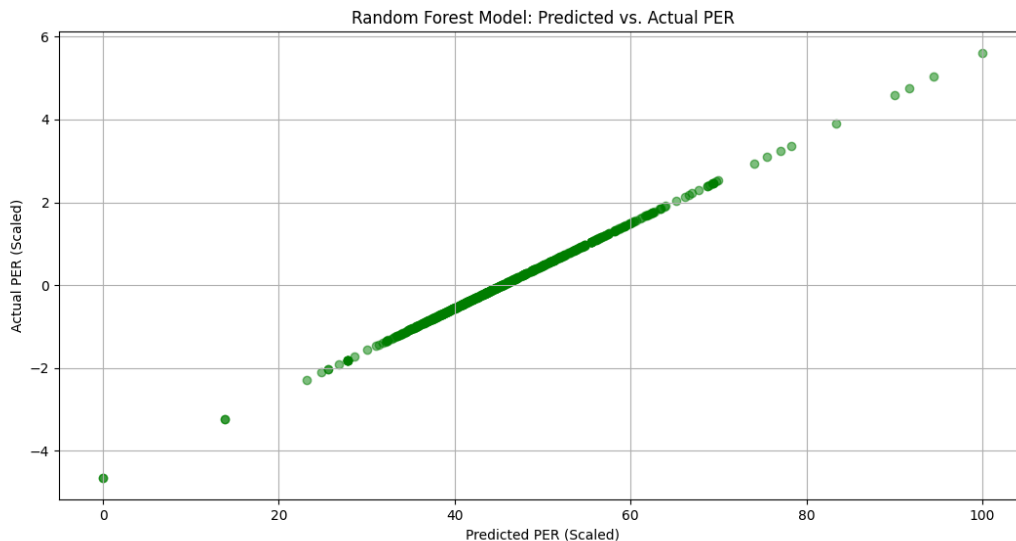
Figure 3: Histogram of Predicted PER using Neural Networks

Figure 3 displays a histogram that compares the distribution of actual PER values with those predicted by the Random Forest Regression Model. The model's performance is evaluated based on the Mean Squared Error (MSE) and the alignment of predicted and actual PER values. The Random Forest Regressor model was employed to predict Player Efficiency Rating (PER) for NBA players. In assessing the model's performance, the Mean Squared Error (MSE) was

calculated. The MSE provides a quantitative measure of how well the model's predictions match the actual PER values.

  • MSE Value: The Mean Squared Error obtained from the model was 255.7421. A lower MSE indicates that the model's predictions closely align with the true PER values. In this case, it's hard to tell if the MSE is high or low because the metric is relative to the study. There isn't anything to compare it to, but based on the histogram itself, it is accurate to say that it was pretty accurate because most of the predicted and actual PER values were overlapping in order to create that purple color. (See Figure 2)

  A histogram was generated to visually compare the distribution of actual PER values with the PER values predicted by the Random Forest model.

  • Histogram Visualization: The histogram itself was bi-modal along with a shift left. (See Figure 2)

  • Alignment with Actual Data: The histogram, for the most part, had the shade of purple which showed that the orange and blue (predicted and actual) PER's were overlapping, proving accuracy. There were a few outliers, however, because the predicted PER seemed to overestimate the actual PER on a few occasions. Also, there was a gap in PER data values around the 45-55 PER range.

  The Random Forest Regressor demonstrated robustness in predicting PER values, effectively capturing variations and trends within the dataset.

  • Robust Predictions: Throughout the entire 70-100 PER range, the model was able to correctly predict the actual PER values based on many variables such as different weights of statistics, new statistics altogether, and many more. While the Random Forest model exhibited strong predictive capabilities, it's important to identify areas with discrepancies between actual and predicted values.

  • Identifying Discrepancies: Throughout the 15-70 PER range, the model often overshot the actual PER values. This can be due to a number of factors such as 3-point shooting inconsistency, fouls, and free throws.

  • Model Enhancement: In this model, the weights of defensive statistics were a bit too high which may have skewed the data. Changing the weights to more offensive-based statistics could help even out the weights, but testing the data with other models to check could truly prove as the only definitive answer.
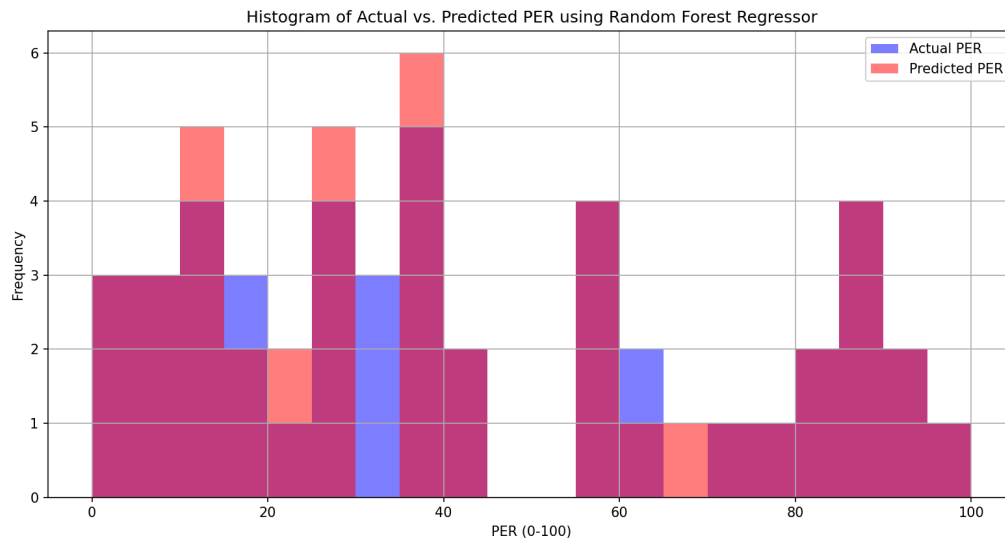
Figure 4: Histogram of Actual vs. Predicted PER using Random Forest Regression

The histogram in Figure 4 illustrates the distribution of predicted PER values generated by the Random Forest Regression Model. The model's performance is evaluated through the MSE value, which indicates the accuracy of its predictions. While the model demonstrates robustness, discrepancies between predicted and actual values suggest areas for improvement. In summary, the Random Forest Regressor model exhibited promise in predicting Player Efficiency Rating (PER) for NBA players. Its performance, as evaluated by the Mean Squared Error and histogram analysis, indicated that the model captures the essence of player efficiency. However, areas of divergence between actual and predicted values suggest opportunities for further research and model refinement. By conducting a thorough examination of the model's performance, your paper contributes valuable insights to the enhancement of the PER metric in basketball analytics.

Neural Network:

Figure 5 presents a histogram showcasing the distribution of scaled predicted PER values generated by the Neural Network Model. This visual representation helps assess the model's performance in predicting Player Efficiency Rating (PER) and indicates its ability to capture underlying data patterns.
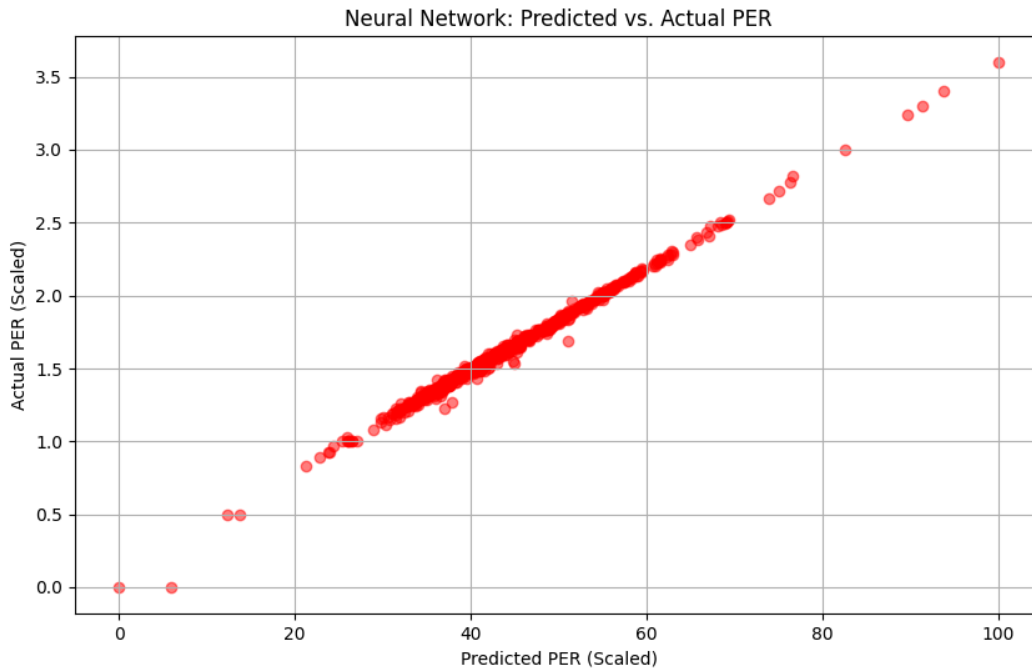
Figure 5: Histogram of Predicted PER using Neural Networks

• Overview: In this section, we present the findings and evaluation results of the Neural Network (PyTorch) model for predicting Player Efficiency Rating (PER). This model was developed to improve the accuracy of PER calculations in the context of basketball analytics. Similar to the other models in this study, the Neural Network model was trained and evaluated on a broad dataset containing various player statistics.

• Model Architecture: The Neural Network model employed in this research comprises three fully connected (dense) layers. The input layer is designed to accommodate the number of features present in the dataset. Two hidden layers consist of 128 and 64 neurons, respectively, facilitating feature transformation and pattern recognition. The output layer comprises a single neuron, responsible for predicting the scaled PER.

• Data Preprocessing: Data preprocessing played a crucial role in preparing the dataset for model training. Missing values were systematically addressed by imputing them with feature means, ensuring data integrity. Further, the numeric features underwent standardization to have a mean of 0 and a standard deviation of 1, making them suitable for neural network training.

• Training and Evaluation: The Neural Network model was trained using the Mean Squared Error (MSE) loss function and optimized with the Adam optimizer. The training process extended over 1000 epochs, allowing the model to adjust its weights and learn the underlying patterns in the data. Monitoring the loss during training revealed a consistent decrease, indicating successful learning.

• Histogram of Predicted PER: The histogram in Figure 3 illustrates the distribution of scaled predicted PER values. The x-axis represents the scaled PER values within the 0-100 range, while the y-axis displays the corresponding frequency. The histogram's bell-shaped curve signifies the 10 model's predictive accuracy, with its predictions closely centered around actual PER values. This suggests that the model captures essential patterns in the data, leading to accurate predictions.

• Top 30 Players: To assess the model's predictive performance further, the top 30 players were ranked based on their predicted PER values. These players, with the highest predicted PER scores, are expected to have a significant impact on the game. This ranking provides valuable insights for teams and analysts, aiding in player assessments and strategic decisions. The model outputted various high-ranking defensive players in the top 30 players. Some of these players included Draymond Green, Rudy Gobert, and Karl Anthony Towns. They were given similar PER ratings to players at the guard spots that many fans, analysts, and coaches argued they should be similar in skill to. There was the opposite, however, where players who shot high-volume three-pointers such as Trae Young (that were ranked "higher than they should have" on the normal PER metric), were now falling towards the 30-40 scaled PER ranges.

All in all, the Neural Network (PyTorch) model exhibits promising predictive capabilities for Player Efficiency Rating (PER). Its ability to generate a bell-shaped histogram of predicted PER values indicates that it effectively captures the underlying data patterns, particularly around central values. This suggests that the model has substantial potential to enhance the accuracy of PER evaluations in basketball analytics.

Nevertheless, comprehensive evaluation, validation against real-world performance data, and comparisons with other models are essential steps to thoroughly assess the model's effectiveness in improving PER calculations. Integration of domain-specific knowledge and expert insights can further fine-tune the model for practical applications in the NBA. The findings presented in this study underscore the significance of machine learning, particularly neural networks, in advancing the field of basketball analytics. By providing more accurate player performance assessments, such models contribute to informed decision-making and enhanced player evaluations. The histogram in Figure 6 illustrates the distribution of predicted PER values generated by the Neural Network Model using the PyTorch framework. The presence of a bell-shaped curve suggests that the model accurately captures central tendencies in player performance, reflecting its potential to enhance PER evaluations.
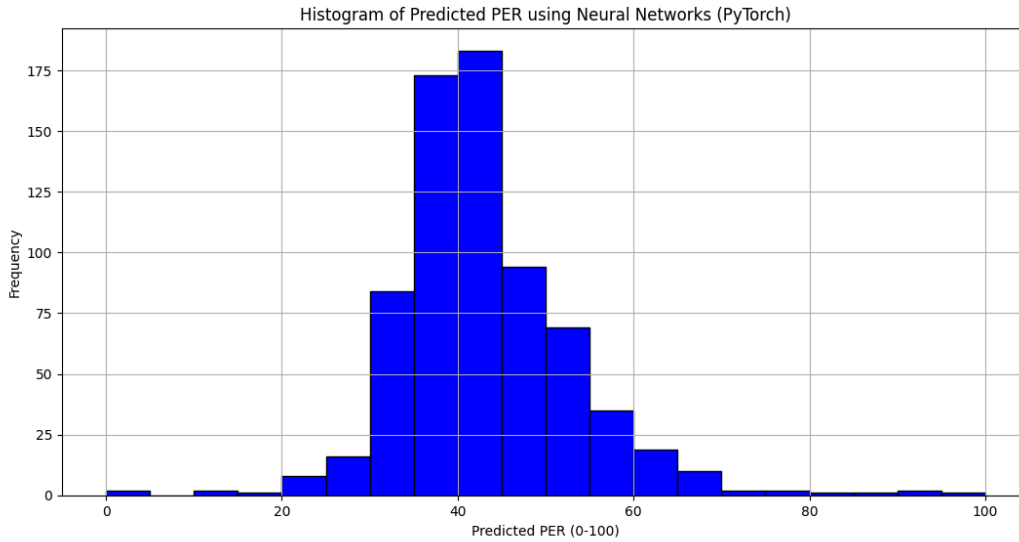
Figure 6: Histogram of Predicted PER using Neural Networks

Mean Squared Error (MSE) Accuracy Test:

Model	Mean Squared Error (MSE)
Lasso Regression	2002.7282
Neural Network	355.8390
Random Forest Regression	255.7241

Lasso Regression (MSE: 2002.7282): The MSE for the Lasso Regression model indicates how well this model fits the data. In this case, an MSE of 2002.7282 suggests that the Lasso Regression model has a higher level of error when predicting Player Efficiency Rating (PER) values. A higher MSE implies that the model's predictions deviate significantly from the actual values, indicating reduced accuracy.

Neural Network (MSE: 355.8390): The MSE for the Neural Network model reflects the model's performance in predicting PER values. With an MSE of 355.8390, the Neural Network exhibits a moderate level of error in its predictions. While it may provide more accurate predictions compared to Lasso Regression, there is still room for improvement in reducing prediction errors.

Random Forest (MSE: 255.7241): The MSE associated with the Random Forest model suggests how well this model performs in estimating PER values. A lower MSE value of 255.7241 indicates that the Random Forest model is relatively accurate in its predictions

compared to the other models. It represents a lower level of error and, therefore, higher predictive accuracy.

In summary, the MSE values provide insights into the accuracy of each model's predictions. A lower MSE indicates a closer fit to the actual data and, hence, a more accurate model. Therefore, the Random Forest model appears to be the most accurate among the three models considered, followed by the Neural Network, with Lasso Regression showing the highest prediction error.

Discussion

In this study, the aim was to enhance the Player Efficiency Rating (PER) metric by incorporating advanced statistical methodologies, including Lasso Regression, Random Forest Regression, and Neural Networks. Each of these models aimed to optimize the weightage of individual statistical components within the PER formula and provide a more comprehensive assessment of player performance, including defensive contributions.

Lasso Regression

The Lasso Regression Model demonstrated its potential in improving PER calculations. The observation of a bell-shaped curve in the histogram of scaled predicted PER values is an encouraging sign. This distribution suggests that the model effectively captures underlying patterns in player performance, closely mirroring the central tendencies in the dataset. However, comprehensive validation and further analysis are essential to establish its predictive accuracy rigorously.

Random Forest Regression

The Random Forest Regression Model showcased robustness in predicting PER values, effectively capturing variations and trends within the dataset. The Mean Squared Error (MSE) value of 255.7421 indicates the model's ability to align predicted and actual PER values, with a noticeable concentration of predictions within the correct range. Nevertheless, discrepancies between predicted and actual values highlight areas for improvement, especially in cases where the model overestimated PER.

Neural Network

The Neural Network (PyTorch) model exhibited promising predictive capabilities for Player Efficiency Rating. Its histogram of scaled predicted PER values formed a bell-shaped curve, indicating that the model effectively captured underlying data patterns. This suggests that the model has substantial potential to enhance PER evaluations in basketball analytics. However, thorough validation and comparison with real-world performance data are necessary to assess its true effectiveness.

Conclusion

Collectively, the findings underscore the importance of incorporating advanced statistical methodologies to refine PER calculations. The models explored in this study provide valuable insights into player performance assessment, particularly in considering defensive contributions. While each model exhibited promising results, the road to enhancing PER metrics in basketball analytics is ongoing. To advance this research further, it is recommended to conduct comprehensive validation against real-world performance data, explore additional machine learning techniques, and integrate domain-specific knowledge. Collaboration with basketball analysts and experts is vital to fine-tune these models and ensure their practical applicability in the larger organizations, even up to the leagues such as the NBA. In conclusion, this study showcases the potential of machine learning models to revolutionize player performance evaluations in basketball. By providing more accurate and comprehensive assessments in some areas and needs for improvements in others, these models empower teams, coaches, and analysts to make informed decisions, ultimately shaping the future of the game.

Works Cited

[1] Josh Gonzales, P. (2020, January 21). Problems with per in the NBA. Medium. https://t.ly/bJ7Hn

[2] Vangelis Sarlis, Christos Tjortjis (2020, May 23). Sports analytics - Evaluation of basketball players and Team Performance. https://t.ly/nuSbE

[3] Hollinger, J. (2003). "Introducing PER." https://tinyurl.com/bballRefpage

[4] E. Turban, R. Sharda, D. Delen, Decision Support and Business Intelligence Systems, Vol. 9, ninth ed., Pearson, 2011.

[5] A. Senderovich, A. Shleyfman, M. Weidlich, A. Gal, To aggregate or to eliminate? optimal model simplification for improved process performance prediction, Inf. Syst. (2018) 1–16.

[6] B. Gerrard, Moneyball and the role of sports analytics: A decision theoretic perspective, in: North American Society for Sport Management Conference,NASSM 2016, 2016, pp. 2010–2012, no. Nassm

The Direction of Genetic Research in Alzheimer's Disease By Sritej Nukala

Abstract

As of 2023, Alzheimer's Disease (AD) affects more than 6 million people in the U.S. alone and more than 55 million people worldwide. Despite almost 120 years of AD research, medical science has yet to find a cure or effective prevention. This paper explores the state of Alzheimer's research and the potential for genetic treatment. Starting by describing the course of Alzheimer's and who is most susceptible. Then, discussing what science has told us about the genetic contributions to the disease. Finally, detailing the direction of current genetic research on how this may help prevent or cure Alzheimer's Disease.

Introduction

Alzheimer's Disease (AD) is a progressive brain disorder regarding the deterioration of brain cells in turn damaging brain functions, including the ability to communicate, the ability to interact with objects, and even the ability to walk. AD is a variant of dementia, a term for defective memory and learning (1). Senile dementia is seen in persons 65 years of age or older, while presenile dementia, or early onset dementia, is seen in patients below the age of 65. Although brain cells begin to deteriorate naturally between the age of 40-50 years, AD accelerates the rate of the decline in brain cells, leading to functional impairments (2).

Brain cells in AD patients deteriorate at abnormal speeds, compared to the average person, due to Tau and Amyloid protein build-ups. Amyloid protein build-ups, also known as plaques, occur when large amounts of this protein accumulate between and around cells in the brain. These build-ups set of immune responses that kill off these plaques and healthy cells. Tau protein build-ups, on the other hand, are caused by abnormal amounts of the Tau protein creating tangles around brain cells. These tangles occur when Tau proteins detach from microtubules and attach to other Tau proteins, creating ropes that knot and tangle with cells (3).

Unhealthy diets, unhealthy body mass indexes, and lack of physical activity are other causes of these protein build-ups (4). Unhealthy lifestyles and genetic factors are the driving causes of AD and related deaths around the world. In a study by Rush Alzheimer Disease Center, it was found that the risk of AD was reduced by 60 percent in people with 4 to 5 healthy lifestyle factors (5). These factors include healthy diets and other healthy lifestyle choices, such as healthy amounts of physical activity. (15)

The symptoms of AD are difficult to catch early in the progression of the Disease. According to The Alzheimer's Association, the early symptoms of AD take around ten years to become noticeable. Patients generally show difficulty in remembering recent events and communicating clearly. As symptoms and time progress, brain functions drastically deteriorate, causing abnormal mood changes and apathy in doing activities they would normally enjoy. Lack of care and treatments heavily affect AD progression due to the inability to ease symptoms.

Without the right care, patients become unable to live safely and are at an elevated risk of physical harm.

The Four As of Alzheimer's Disease

AD primarily damages a section of the brain called the hippocampus, located in the temporal lobe, which organizes/temporarily stores memories and controls the ability to learn and retain new information. When cells in the brain deteriorate from plaques (protein build-ups) the hippocampus becomes unable to do its necessary functions (6). The degeneration of the cells in the hippocampus leads to defective behaviors, which are categorized into 4 groups of AD, known as the 4As of AD. The 4As include apraxia, amnesia, and agnosia, aphasia.

Apraxia is the loss of a patient's ability to interact with many daily-use objects (e.g. silverware, electronic devices, and self-care items). Ideomotor, dressing, and constructional apraxia are the three main subtypes of apraxia. Ideomotor apraxia causes the patient to lose their ability to use limbs, which causes the inability to do things like taking a walk in the park or even getting themselves a glass of water. Dressing apraxia causes the patient to lose the ability to wear clothes, making it almost impossible to go out in public without the help of someone. Constructional apraxia makes it difficult for the patient to create or replicate drawings, or even put pen to paper.

Amnesia prevents patients from creating and/or remembering memories. Retrograde amnesia is the inability to remember older events, while anterograde amnesia is the inability to create new memories or remember more recent events. Amnesia can lead to a mix-up of memories or even the creation of false memories. Patients who suffer from retrograde amnesia are faced with the difficulty of living in present-day situations. Retrograde amnesia causes patients to lose account of recent events, and are left with the memory of only occurrences from before a certain point in their lives. Anterograde amnesia leaves patients with difficulty understanding right vs. wrong. This deeply affects the patient's ability to make decisions as they may be based on a false prior occurrence.

Agnosia makes it difficult for the patient to use their five senses. The subtypes of agnosia include visual, auditory, and tactile agnosia. Each of these subtypes of agnosia deteriorates the ability to use specific senses, making living peacefully and safely difficult. Visual and tactile agnosia deteriorates patients' ability to recognize objects by sight or touch (i.e. utensils), preventing the ability to carry out daily tasks like having a meal. Agnosia can lead to other disorders such as depression and eating disorders, due to the degrading feeling of not understanding how to complete certain tasks. Auditory agnosia results in the inability to recognize the source or the composition of the sound. A patient suffering from auditory agnosia

Aphasia is the patients' loss of their ability to verbally communicate with others, this category does not affect the hippocampus, instead, it mainly damages Wernicke's and Broca's areas of the brain. These parts of the brain are responsible for controlling language comprehension and production. Wernicke's and Broca's are the two subtypes of Aphasia. Broca's Aphasia, among other symptoms, causes a patient to lose their ability to produce language.

Wernicke's Aphasia causes the loss of the ability to create complete sentences, causing the patient to speak with improper grammar and language, as they lose the ability to comprehend language. Aphasia makes life for patients extremely difficult since they are generally unable to communicate their wants and needs to their peers. This also makes it a challenge for patients to receive care comfortably and may, for example, not recognize the sound of thunder, and instead mistake it for something like laughter.

State of Research
Overview of Alzheimer's Genetics

Studies have shown that AD can be a hereditary disease and that a certain chromosome increases the chances of getting Alzheimer's. The APOE-4 allele, of the APOE chromosome, is an allele that 15-25% of the world's population can inherit (7). People 65 and older have been found to be most susceptible to showing symptoms of AD caused by the APOE-4 chromosome. This allele increases the chances of getting Alzheimer's by threefold. APOE-4 creates a lack of glial cells in the brain, which are responsible for supporting and protecting neurons, by disrupting their formation. With the lack of glial cells protecting the brain's neurons, the brain becomes extremely vulnerable to dying cells.

APOE (Apolipoprotein E)

Researchers have discovered the three main alleles of the APOE chromosome: APOE-2, APOE-3, and APOE-4. These alleles differ in terms of their effect on the brain and on AD. APOE is a chromosome involved in creating Apolipoprotein-E. This protein combines with lipids to form lipoproteins, which are responsible for carrying fats and cholesterols into the bloodstream. The build-ups of these fats can deteriorate the functions of neurons, which in turn can result in damaged signals and AD (17).

The APOE-2 allele of the APOE chromosome is found in 5-10% of the human population. This allele works to prevent AD by lowering the levels of amyloid proteins in the brain. One of the main causes of AD is the build-up of this protein (8) which creates plaques on the brain's cells, slowly killing them off and damaging the brain's functions. The e2 allele prevents these plaques from forming. The e3 allele is found in 20-25% of the population and increases the risk of atherosclerosis. Atherosclerosis is a deteriorating disease, which creates plaque build-ups in the bloodstream, thickening the arteries. The build-ups are created by Low-density lipoprotein Cholesterol (LDL-C). Atherosclerosis leads to heavily damaged neurons, creating an everlasting impact on the functions of the brain. This leads to many diseases, mainly AD.

The APOE-4 allele is the main genetic cause of Alzheimer's and has been found in 15-25% of the population, with 2-5% having two copies of this allele. This allele erodes the barrier between the brain and direct blood contact. The blood-brain barrier (BBB), is a structure comprising multiple cells. The most well-noted of the cells that make up the BBB are endothelial cells, which combine to create a cell layer. The endothelial cell layer lines blood vessels and

creates a protective layer from pathogens, making contact with the brain as a whole. When the brain receives direct contact with open blood, these pathogens are able to make direct contact with the brain which rapidly destroys cells. The APOE-4 and APOE-2 allele are separately responsible for maintaining high levels of LDL-C cholesterol. The presence of the APOE-4 allele is the leading issue of AD, as it is able to create and maintain a damaging impact on the brain's communication with the body.

Direction of Research
The Overexpression of Genes

Gene overexpression is a method used to "turn on a specific protein, in terms of increasing the functions and amount of said protein, which can only be functional when the gene is turned on. When a gene is overexpressed, a large quantity of the gene is flooded into the body. This causes an overload of the resources required by the gene and/or protein receptor, which prevents the gene from doing its overall functions and decreasing or eliminating the function of the gene (9). The overexpression of a gene can also degrade the production of cytokines, allowing for reduced inflammation levels (10).

Neuroinflammation is an immune response in the brain and/or spinal cord contributed by cells of the peripheral nervous system, which damages the functions of the central nervous system. Neuroinflammation is caused by cytokines and chemokines (20), part of the body's secondary messenger system. Cytokines are responsible for signaling molecules, while chemokines induce cell migration. Cytokines and chemokines work as a whole to create an inflammatory reaction, in response to pathogens, and can even maintain cell homeostasis (18). Regarding neuroinflammation, the secondary messenger system receives signals from toll-like receptors (TLRs) in order to adapt to or deplete the presence of pathogens (19). Amyloid beta protein deposits create a mass concentration of the protein, which creates tangles. Microglial cell receptors inside of the brain recognize these misfolds of amyloid proteins as pathogens, and trigger an inflammatory reaction. Neuroinflammation can result in the death of cells and neurons, resulting in a long range of damage to the brain's functions.

The APOE-4 allele is responsible for causing neuroinflammation which leaves a permanently damaging effect on the brain's functions. The APOE-4 genotype is also responsible for the cerebrovasculature's impairment, damaging the blood flow and blood vessels in the brain. With the reduction of the APOE-4 protein, a reduction of neuroinflammation and alleviation of Tau and Amyloid Protein build-ups occur (16). Particularly, in a study conducted by Lee and colleagues (2022) at the Mayo Clinic Department of Neuroscience, it was found that the overexpression of the APOE receptor, low-density lipoprotein receptor (LDLR), can be an effective method to reduce the presence of APOE-4. The LDLR protein is a receptor responsible for binding to APOE-4, giving APOE-4 its abilities to erode the blood-brain barrier and maintain LDL-C in blood pathways. The overexpression of LDLR-related protein 1 (LRP1), which metabolizes Amyloid Proteins, regulates the endocytosis of Tau proteins, and can maintain APOE-4 levels in the brain can reduce the risk of AD by 25% (11). Endocytosis is the process in

which a cell, through protein channels, takes in outside materials that act as nutrients for the cell. The endocytosis of Tau proteins allows for the overall abundance and spreading of the protein inside the body. The overexpression of the receptor can be an effective way to reduce AD, but sorely results in the increase of Amyloid Proteins, which in turn causes a great risk of damage to organ functions (e.g, heart, liver, kidneys), and also increases the risk of inflammatory responses due to the abundance of misfolds in proteins. Conversely, the overexpression of LDLR as a whole can result in a 50-90% reduction of the risk of AD. Tests conducted on APP/PSI mice (12) have found that the reduction of LDLR can impair the aggregation of Tau proteins, reducing build-ups.

Conclusion

Although AD has created a huge impact, whether it be the widespread deaths across the globe or the harrowing experiences AD patients and their loved ones go through on a daily basis, there is a promising future ahead. Research has been focused on the genetic progression of AD, implementing the APOE-4 allele, to globally limit the spread of the disease as a whole, before further treating the complications current patients experience. First, preventing AD through genetics ensures that future generations will not live in a world with the current issue. The depletion of the APOE-4 allele and related receptors ensures that AD can be abolished from our society, not just through genetics, but even with current patients. The APOE-4 allele spreads through generations and is triggered by health complications. In a world where the APOE-4 doesn't exist, AD can be prevented in a much more undemanding method.

Current AD patients live through daily struggles of living a life balanced with the limitations AD places on them and the pressure put on them by medications, peers, and family. Given this assurance that the future will hold a full-time prevention to AD gives hope to the entirety of humanity.

Works Cited

Francois Boller, Margaret M. Forbes. (1998). History of dementia and dementia in history: An overview. *Journal of Neurological Sciences,* 158(2), 125-133.

Miyoshi K. What is 'early onset dementia'? Psychogeriatrics. 2009 Jun;9(2):67-72. doi: 10.1111/j.1479-8301.2009.00274.x. PMID: 19604328.

Bloom GS. Amyloid-β and Tau: The Trigger and Bullet in Alzheimer Disease Pathogenesis. *JAMA Neurol.* 2014;71(4):505–508. doi:10.1001/jamaneurol.2013.5847

Anthony G. Pacholko, Caitlin A. Wotton, Lane K. Bekar; Poor Diet, Stress, and Inactivity Converge to Form a "Perfect Storm" That Drives Alzheimer's Disease Pathogenesis. *Neurodegener Dis* 27 November 2019; 19 (2): 60–77. https://doi.org/10.1159/000503451

Besser, Lilah M. MSPH*; Gill, Dawn P. PhD*,†,‡; Monsell, Sarah E. MS*; Brenowitz, Willa MPH*; Meranus, Dana H. MPH*; Kukull, Walter PhD*; Gustafson, Deborah R. PhD§, ∥ ,¶. Body Mass Index, Weight Change, and Clinical Progression in Mild Cognitive Impairment and Alzheimer's Disease. Alzheimer Disease & Associated Disorders 28(1):p 36-43, January–March 2014. | DOI: 10.1097/WAD.0000000000000005

Rao YL, Ganaraja B, Murlimanju BV, Joy T, Krishnamurthy A, Agrawal A. Hippocampus and its involvement in Alzheimer's disease: a review. 3 Biotech. 2022 Feb;12(2):55. doi: 10.1007/s13205-022-03123-4. Epub 2022 Feb 1. PMID: 35116217; PMCID: PMC8807768.

Gharbi-Meliani, A., Dugravot, A., Sabia, S. *et al.* The association of *APOE* ε4 with cognitive function over the adult life course and incidence of dementia: 20 years follow-up of the Whitehall II study. *Alz Res Therapy* 13, 5 (2021). https://doi.org/10.1186/s13195-020-00740-0

https://www.news-medical.net/news/20221005/Decline-in-specific-protein-levels-linked-to-Alzheimere28099s-disease-not-buildup-of-amyloid-plaques.aspx#:~:text=Previous%20research%20from%20the%20team,likely%20to%20have%20cognitive%20impairment.

Gregory Prelich, Gene Overexpression: Uses, Mechanisms, and Interpretation, *Genetics*, Volume 190, Issue 3, 1 March 2012, Pages 841–854, https://doi.org/10.1534/genetics.111.136911

Shinohara, M., Tachibana, M., Kanekiyo, T., & Bu, G. (2017). Role of LRP1 in the pathogenesis of Alzheimer's disease: evidence from clinical and preclinical studies. *Journal of lipid research, 58*(7), 1267–1281.

Dwight C. German, Omar Nelson, Fen Liang, Chang Lin Liang, Dora Games. (2005). The PDAPP Mouse Model of Alzheimer's Disease: Locus Coeruleus Neuronal Shrinkage. *The Journal of Comparative Neurology,* 492: 469-476. U.S. Department of Health and Human Services. (n.d.). *Alzheimer's disease fact sheet*. National Institute on Aging.

Dhana K, Evans DA, Rajan KB, Bennett DA, Morris MC. Healthy lifestyle and the risk of Alzheimer dementia: Findings from 2 longitudinal studies. Neurology. 2020 Jul 28;95(4):e374-e383. doi: 10.1212/WNL.0000000000009816. Epub 2020 Jun 17. PMID: 32554763; PMCID: PMC7455318.

Yonghe L., Jesse M., Chia-Chen L., Guojun B. (2022). ApoE4 reduction: An emerging and promising therapeutic strategy for Alzheimer's Disease. *Neurobiology of Aging,* 115: 20-28 Angela R Garcia, Caleb Finch, Margaret Gatz, Thomas Kraft, Daniel Eid Rodriguez, Daniel Cummings, Mia Charifson, Kenneth Buetow, Bret A Beheim, Hooman Allayee, Gregory S Thomas, Jonathan Stieglitz, Michael D Gurven, Hillard Kaplan, Benjamin C Trumble (2021) APOE4 is associated with elevated blood lipids and lower levels of innate immune biomarkers in a tropical Amerindian subsistence population eLife 10:e68231. https://doi.org/

Geeta Ramesh, Andrew G. MacLean, Mario T. Philipp, "Cytokines and Chemokines at the Crossroads of Neuroinflammation, Neurodegeneration, and Neuropathic Pain", *Mediators of Inflammation*, vol. 2013, Article ID 480739, 20 pages, 2013 https://doi.org/10.1155/2013/480739

Sameer AS, Nissar S. Toll-like Receptors (TLRs): Structure, Functions, Signaling, and Role of Their Polymorphisms in Colorectal Cancer Susceptibility. Biomed Res Int. 2021 Sep 12;2021:1157023. doi: 10.1155/2021/1157023. PMID: 34552981; PMCID:PMC8452412.

Chen K, Bao Z, Tang P, Gong W, Yoshimura T, Wang JM. Chemokines in homeostasis and diseases. Cell Mol Immunol. 2018 Apr;15(4):324-334. doi: 10.1038/cmi.2017.134. Epub 2018 Jan 29. PMID: 29375126; PMCID: PMC6052829.

How British Misrule Lead to the Partition of India By Aaryan Sultania

The year was 1947. South Asia was in chaos. In villages throughout the subcontinent, communal violence was at its peak. Previously warm communities turned against each other (Begum). Organized military groups massacred local religious groups ("India: Partition"). Even people far away from the violence, engulfed by fear, left everything behind for safety (Mal). Some changed their religion and identities to avoid persecution (Kukkal). Thousands of women were raped, and millions of families were permanently separated. This was the devastation caused by the partition of India. Previously, India was ruled by the colonial British Empire. During and after World War II, a strong independence movement from within India was gaining more and more traction. Yet, when India was granted independence, it was divided into two states - a Muslim-majority Pakistan and a Hindu-majority India. People flocked to the side of the border where they would be in the majority, while others attacked minorities within their communities. Most historians credit the start of the violence to "Direct Action Day," also known as the Great Calcutta Killings. On August 16th, 1946, leaders from the Muslim League, the organization that claimed to stand for Muslim rights, called for a separate state for Muslims. In particular, Ali Jinnah, who gained massive popularity throughout the Muslim demographic (Phillips), inspired "direct action" for Pakistan, resulting in riots that left 4,000 dead. Throughout the partition, it is estimated that around one million people were killed, and 14 to 15 million were displaced from their homes.

The bloodshed and devastation caused by the partition of 1947 were caused by the British government's abhorrent ruling because of their divisive policies during the 19th and 20th centuries that amplified religious conflict and their poor implementation of the partition.

Britain has a long history of forcibly maintaining control in India. It was always clear that the British rulers of India saw Indians as sub-human. British officials feared "native contamination" (Wolpert 4). The best example of their desire to maintain control was the repression of the Sepoy Mutiny, where Indian soldiers, tired of their poor treatment, revolted against the British East India Company. The rebellion was started when soldiers heard rumors about cartridges being greased with the fat of animals they were religiously forbidden to eat, though British officials had stated they had no intention "to interfere with the religion of the natives" ("The Mutinies in India - Question" 1394).

In the aftermath of the mutiny, the British Raj, a government directly ruled by the British government, was established. During the British government's regime, the cultural gap between the British and Indians widened. Whereas before the takeover of the British government from the British East India Company, the British had respect and understanding for Indian culture, it was replaced by suspicion and fear (Wolpert 5) during the Raj. Many policies enacted by this new government were often racist (Howarth 4) and ignorant of the pre-existing culture of the residents.

During this gradual solidification of British rule, a new movement of Indian nationalism emerged against it. Instead of being unified, two separate movements materialized, led by the

Indian National Congress and the Muslim League (Wolpert 12-13). This comes as no surprise, as the British government's poor ruling led to religious dissent spreading throughout India, partially due to their deficient understanding of the cultural situation in the area.

Ever since the Sepoy mutiny, Britain had sought greater control over the subcontinent of India. They achieved this by capitalizing on differences between Indians, namely religion. "Divide and Rule" became a prominent policy within the British Raj (Stewart 49). Many officials in the British government endorsed this policy, with Lord Elphinstone, a colonial administrator, writing "Divide et impera was the old Roman motto, and it should be ours." (Stewart 54).

The policy of "Divide and Rule" became increasingly evident throughout the British Raj. Many British politicians were in favor of separating Indian armies by religion, and major armies in India were reorganized after the Sepoy mutiny (Stewart 49). The government began categorizing Indians separately by religion (Roy 1:20-1:35), and many of their policies were directed at inflaming conflict between Hindus and Muslims. An example includes the first Bengal partition (Wolpert 16-17), which stirred resentment among many Bengali Hindus and resulted in protests around India.

One common refutation of the argument that British rule was divisive is that religious tension between Hindus and Muslims had already existed centuries before British colonialism. Verghese states that the origins of conflict between Hindus and Muslims date back to the 11th century, during the first Muslim invasions of India. He emphasizes that the British are not mainly responsible for the conflict between religious groups in India, and urges people to look beyond Western influence to understand the history of nations. While religious tension was widespread throughout Hindu-Muslim confrontations, during periods of peace, relations were much more tolerant. (Talbot 720). Separate Hindu-Muslim identities formed around a broad range of differences, such as linguistic or cultural dissimilarities, alongside religion. (Talbot 721). These separate identities that resulted in the violence of the partition were indeed formed by the pre-existing conflict between Hindus and Muslims, but it is undeniable that British rule had a definite impact on relations.

Another example of British misrule that impacted religious relations was the Indian Councils Act of 1909, ("Indian Councils Act, 1909"). This act was initially intended to include Indians in the government. However, a highly damaging feature of this act was its separation of Hindu and Muslim voters in the election process.

The government of India consisted of councils of representatives elected by voters who were divided by religion and other social divisions ("Government of the Raj 1858-1914"). This act resulted in Hindus and Muslims feeling more and more separate during the remainder of the Raj. When the independence movement began to gain more and more traction, many Muslims felt that the dissent caused by the partition was "too deep to repair" (Roy 2:13-2:19). They ultimately began to call for a separate nation for the Muslims.

From the rearrangements of armies, the first Bengal partition, and the separation of religious groups in government, it is clear that the British Raj resulted in the already tense religious groups being brought to a near-breaking point. In 1917, vast crowds of Hindus attacked

Muslims in dozens of villages in the region of Bihar, leaving at least 41 dead. In 1924, Muslim residents of a Muslim-majority region massacred 155 Hindus. (Claude) Their destructive policies inflamed conflicts from the past and resulted in the fragmentation of the independence movement.

Though it is clear that British rule led to the massive magnification of tensions between religious groups in South Asia, the most abominable part of their rule was the implementation of the partition itself.

The border drawn by the Boundary Committee (see Appendix A and B) in charge of dividing South Asia was prepared with inaccurate census data and little knowledge of the land, fleshed out in only five weeks (Roy 2:49-257). People on the "wrong" side of the border were often subject to appalling violence. For example, a Hindu woman named Leela Mamtani was born in a city in current-day Pakistan. In 1947, violence against her family rose, with their house being pelted with stones all night. As the attacks got worse, their family decided to flee to India. In the port city of Karachi, their family was robbed of everything they owned.

The violence caused by the partition was most prominent in places near the border, particularly Punjab. Punjab was one of the provinces divided by the Indian-Pakistani border into West and East Punjab (see Appendix C). It was also one of the few provinces with another significant religious minority, Sikhs. The most radical Sikhs, who were in favor of keeping the province unified as a Sikh majority state, participated in the violence. Across the border that ran through the province, Muslims would travel en masse to the Pakistani side, and non-Muslims would travel en masse to the Indian side. ("India: Partition")

One Sikh who went through this ordeal was Sher Singh Kukkal. Kukkal was born in West Punjab, now part of Pakistan. In 1947, his family was warned of attacks on his home by Muslim friends, and they left everything behind, unaware that they would never come back. He describes the sight of dead bodies in the towns that were attacked, which still haunts him to this day. (Kukkal)

The turmoil caused near the Indo-Pak borders could have been averted had the British implemented partition correctly. As mentioned prior, the border separating the two countries was very poorly thought out. In addition, The British Government also withdrew from the sub-continent in a rushed manner. Lord Mountbatten, India's last Viceroy, attempted to leave India as soon as possible. British armies pulled out of India as soon as Independence was announced, leaving the responsibility of maintaining law and order in the turbulent situation to armies that they divided and turned against each other. The hurried decision also allowed the people on the "wrong" side of the border to be subject to the previously described violence. A much more sensible solution would have been to maintain troops in South Asia to provide safety to those stranded in places where they are the minority, waiting until both countries stabilized to leave. Most historians agree that Lord Mountbatten's hasty withdrawal from South Asia was "the major reasoning behind the chaos that was Partition" (Tetlow).

The hasty erection of a border and the messy withdrawal from India were some of the main problems with how the partition was put in place. Another major problem with the partition

was with the princely states. The princely states were regions within the British Raj that were governed by Indian monarchs, known as Maharajas, and remained autonomous under British rule. (Roy 1:09) When India and Pakistan were granted independence, the princely states were required to choose which of the two countries to join and give up their autonomy. This resulted in numerous problems for citizens of former princely states even today. One of the most well-known examples of this is the Kashmir dispute. Kashmir was formerly a princely state that was governed by a Hindu prince. However, the majority of its citizens were Muslim. The Maharaja of Kashmir decided to join India, despite numerous attempts from the Muslim League to convince him otherwise (Ganguly 79). Pakistan, believing that the Muslim Majority state should be given to them, invaded Kashmir, and an armed conflict known as the First Indo-Pak War of 1947 broke out.

This is only the first of three wars fought over the region, with two others in 1965 and 1999. The Fourth Indo-Pak War occurred during a period when both nations had nuclear weapons, introducing the threat of nuclear annihilation. Both nations were driven to develop nuclear weapons out of their bitter rivalry against each other, which was undoubtedly started by the partition. India's High Commissioner in London notes this, stating that the Congress will always view the Muslim League as traitors to India ("India-Pakistan relations").

Since 1948, both countries have agreed on a ceasefire line that evolved into a line of control after 1971. ("Kashmir profile - Timeline") More importantly, the effects of the conflict still plague citizens today. In 1989, militant groups of pro-Pakistani extremists started the Kashmir Insurgency, which is an ongoing conflict within the region right now. There were 20,000 deaths including governmental, insurgent, and civilian casualties (Ganguly 76-77) in the seven years following 1989. The haphazard handling of Kashmir has led to a lasting impact that affects people today.

Violence was also particularly pronounced in the eastern border between India and Pakistan. The border that separated India and Pakistan also split Pakistan into two regions, West Pakistan and East Pakistan. Like with Punjab in the Western Border, the violence among the local Bengali people skyrocketed. Yet the worst of the violence did not occur during the partition, but 24 years afterwards as a direct result of it. There had always been a political and cultural split between West and East Pakistan. "West Pakistan was deemed to be the more predominant, governing side. Accordingly, East Pakistan was exploited for resources, money, and labor to support West Pakistan." (Kundu). Pakistani government officials viewed the Bengali people as "undesirable" and a barrier to creating an Islamic state. In 1970, massive natural disasters struck East Pakistan, and officials in West Pakistan were seen as "neglectful" towards the situation of the Bengali people. ("Bangladesh (East Pakistan), 1971") This caused the Bengali independence movement to flourish in popularity, and the pro-Independence Awami League won the following elections.

The start of genocide was an event known as "Operation Starlight" on March 25, 1971, meant to curb the growing Independence movement by assassinating independence activists and intellectuals. The operation quickly evolved into an 8 month genocide, with estimates for deaths

ranging from 300,000 to 3 million. Hundreds of thousands of women where also raped, and Hindu women were particular targets of the violence. In addition, several sources also claim that Bengali forces were also responsible for a large part of the violence, stating that the Bengali independence movement was always armed, and "revenge killings" were committed against the non-Bengali population in East Pakistan. (Bose). The Bengali Genocide was also the trigger for the Third Indo-Pak War of 1971.

It becomes apparent why the Bengali Genocide was a result of the partition when considering the nature of the violence. Once again, religious minorities in the state that was designated to the opposite religion were heavily persecuted. In addition, the British government failed to take into account the opinions of the Bangladeshi people who wished to have their own state, and did not examine the consequences of grouping them in with the rest of Pakistan.

On the 15th of September, 1947, a telegram was sent to the Commonwealth Relations Officer by the High Commissioner for the United Kingdom. In the telegram, notice is taken of the surge in violence occurring in India ("Communal Disturbances"). Within a month of India's and Pakistan's independence, the situation had completely deteriorated into chaos. Yet, this was already foreseen by many, including the British government itself. During the Secretary of State's comments on India policy for the British Ambassador in Washington, he noted the possibility that the communal situation in India would likely decline ("Risks of Partition").

The British government was aware of the potential consequences. Yet instead of patiently withdrawing from India, they retreated hastily and sloppily, resulting in hundreds of thousands of deaths and millions of lives being scarred.

The partition had a major lasting impact on civilians that still exists today. It marked a turning point in Indian history, transforming the political atmosphere to be highly charged and tense. The partition marked the surge in nationalism across the subcontinent, and greatly shaped diplomatic relations. All the effects of the partition can be traced to be a byproduct of British rule in India, from the dissent spread during the Raj to the bloodshed caused by their sudden withdrawal from India.

Appendix A
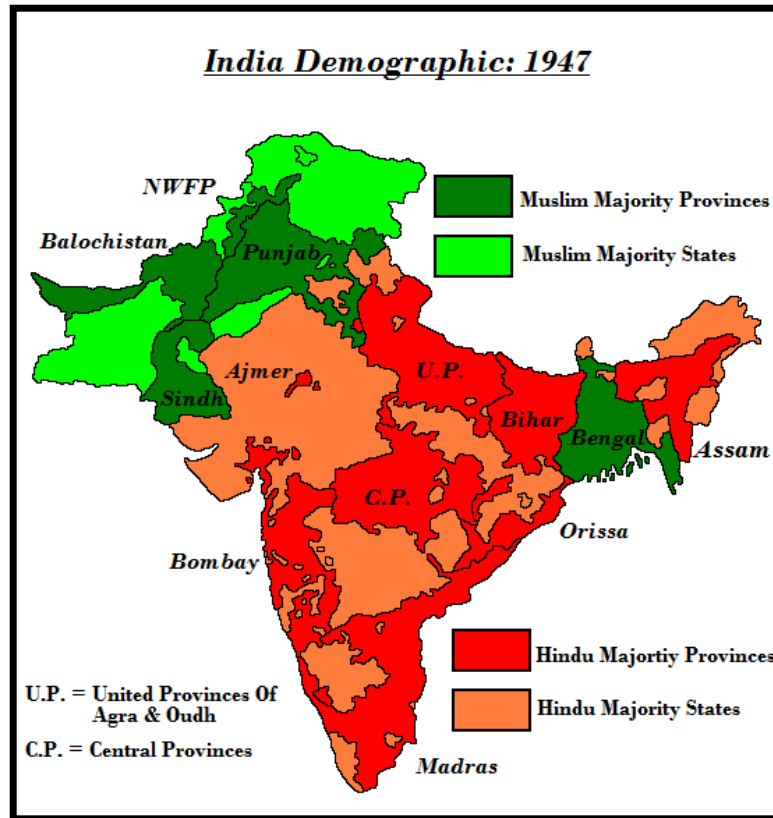
This is a map depicting the location of religious communities in India. ("HINDUISM: India – Timeline of History")

Appendix B
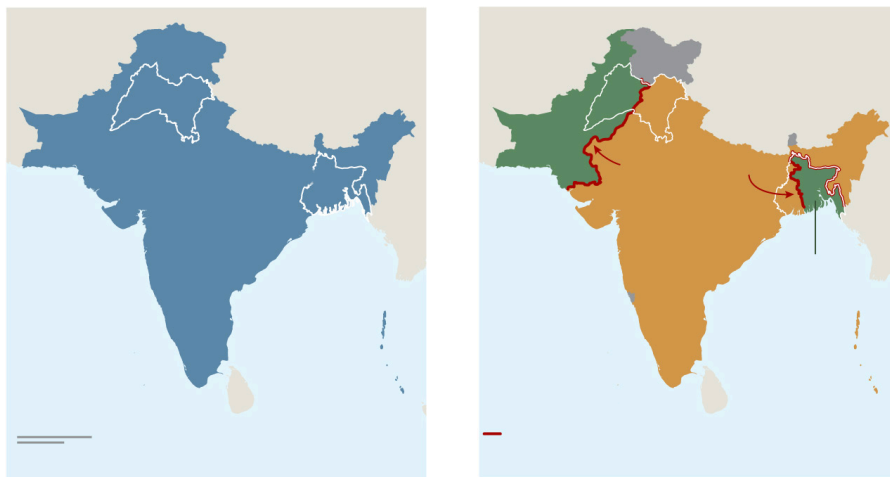
On the left is a map of British raj with the outlined states showing provinces that will be divided in the future. On the right is a map of the Radcliffe line in Red. (Wardley)

Appendix C
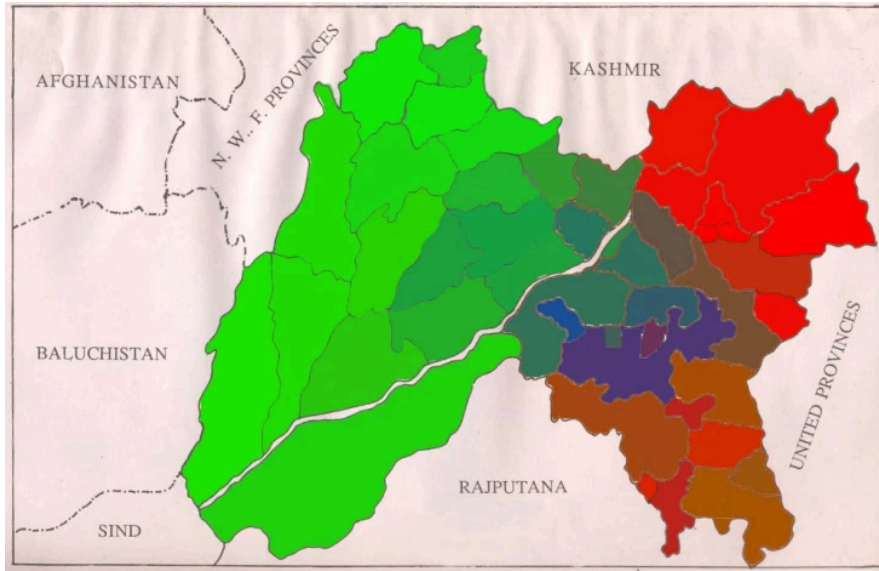
This is a map showing religious communities in Punjab 1947, where green represents Muslims, blue represents Sikhs, and red represents Hindus. ("How Did Partition Change the Religious Map in Punjab?")

Works Cited

"Bangladesh (East Pakistan), 1971." *Gendercide*, www.gendercide.org/case_bangladesh.html.
    Accessed 17 Jan. 2024.

Begum, Taj. "Oral History with Taj Begum, 2017 February 6." Interview by Fakhra Hassan and
    Mankanwal Sachdev. *1947 Partition Archive*, Stanford, 6 Feb. 2017,
    exhibits.stanford.edu/1947-partition/catalog/wb507sk3243. Accessed 2 Oct. 2023.

Bose, Sarmila. "Analysis of Civil War in East Pakistan in 1971." *Economy and Political Weekly*,
    8 Oct. 2005,
    web.archive.org/web/20070301084941/http://www.epw.org.in/showArticles.php?root=20
    05&leaf=10&filename=9223&filetype=html. Accessed 17 Jan. 2024.

Claude, Markovits. "India from 1900 to 1947." *SciencesPo*, 6 Nov. 2007,
    www.sciencespo.fr/mass-violence-war-massacre-resistance/en/document/india-1900-194
    7. Accessed 2 Oct. 2023.

"Communal Disturbances." 15 Sept. 1947. *The Nationals Archive*, United Kingdom,
    webarchive.nationalarchives.gov.uk/ukgwa/+/https://www.nationalarchives.gov.uk/educat
    ion/resources/the-road-to-partition/communal-disturbances/. Accessed 5 Oct. 2023.

"Establishment of All India Muslim League." *Story of Pakistan*, 1 June 2003,
    storyofpakistan.com/establishment-of-all-india-muslim-league/. Accessed 2 Oct. 2023.

Ganguly, Šumit. "Explaining the Kashmir Insurgency: Political Mobilization and Institutional
    Decay." *International Security*, vol. 21, no. 2, 1996, pp. 76-107. *JSTOR*,
    https://doi.org/10.2307/2539071. Accessed 15 Jan. 2024.

"Government of the Raj." *UK Parliment*,
    www.parliament.uk/about/living-heritage/evolutionofparliament/legislativescrutiny/parlia
    ment-and-empire/parliament-and-the-american-colonies-before-1765/government-of-the-
    raj-1858-1914/. Accessed 28 Dec. 2023.

"HINDUISM: India – Timeline of History." *The Truth Source*,
    thetruthsource.org/hinduism-timeline-of-indias-history/. Accessed 23 Jan. 2024.

Howarth, Whitney. "1857 Indian Uprising." *OER Project*,
    www.oerproject.com/-/media/WHP/PDF/Unit5/WHP-1750-5-3-3-Read---1857-Indian-U
    prising---950L.pdf. Accessed 29 Dec. 2023.

"How Did Partition Change the Religious Map in Punjab?" *South Asia Blog*, 3 Jan. 2014,
    southasiablog.wordpress.com/2014/01/03/religious-map-of-punjab-before-partition/.
    Accessed 23 Jan. 2024.

"Indian Councils Act, 1909." 25 May 1909. *Constitution of India*,
    www.constitutionofindia.net/historical-constitution/indian-councils-act-1909/. Accessed
    29 Dec. 2023.

"India-Pakistan Relations." 20 Oct. 1947. *The Nationals Archive*, United Kingdom,
    webarchive.nationalarchives.gov.uk/ukgwa/+/https://www.nationalarchives.gov.uk/educat
    ion/resources/the-road-to-partition/india-pakistan-relations/. Accessed 5 Nov. 2023.

"India: Partition." *Mass Atrocity Endings*, Tufts University, 7 Aug. 2015,
    sites.tufts.edu/atrocityendings/2015/08/07/india-partition/#:~:text=For%20advocates%20
    of%20partition%2C%20communal,localized%20majorities%20in%20some%20cases.
    Accessed 5 Oct. 2023.

"Kashmir profile - Timeline." *BBC News*, Aug. 2019,
    www.bbc.com/news/world-south-asia-16069078. Accessed 16 Jan. 2024.

Kukkal, Sher Singh. "Oral History with Sher Singh Kukkal, 2014 February 6." Interview by
    Prakhar Joshi. *1947 Partition Archive*, Stanford, 6 Feb. 2014,
    exhibits.stanford.edu/1947-partition/catalog/jn737zw7918. Accessed 5 Nov. 2023.

Kundu, Kimtee. "The Past has yet to Leave the Present: Genocide in Bangladesh." *Harvard
    International Review*, Harvard University, 1 Feb. 2023,
    hir.harvard.edu/the-past-has-yet-to-leave-the-present-genocide-in-bangladesh/. Accessed
    17 Jan. 2024.

Mal, Kesho. "Oral History with Kesho Mal, 2016 October 15." Interview by Fakhra Hassan.
    1947 Partition Archive, Stanford, 15 Oct. 2016,
    exhibits.stanford.edu/1947-partition/catalog/yc495ry4797. Accessed 5 Nov. 2023.

Mamtani, Leela. "Oral History with Leela Mamtani, 2014 January 29." Interview by Prakhar
    Joshi. *1947 Partition Archive*, Stanford, 29 Jan. 2014,
    exhibits.stanford.edu/1947-partition/catalog/cc041bc4311. Accessed 4 Oct. 2023.

"The Mutinies In India—Question." 9 June 1857. *UK Parliament*,
    hansard.parliament.uk/Lords/1857-06-09/debates/05718b89-8ade-49e9-8174-33366cb78
    42d/TheMutiniesInIndia%E2%80%94Question?highlight=india%20religion#contribution
    -a00b132d-d89f-4ef3-91e6-23901f416ba9. Accessed 29 Dec. 2023.

Phillips, Sean. "Why Was British India Partitioned in 1947? Considering the Role of Muhammad
    Ali Jinnah." *Faculty of History*, University of Oxford,
    www.history.ox.ac.uk/why-was-british-india-partitioned-in-1947-considering-the-role-of-
    muhammad-ali-0. Accessed 5 Oct. 2023.

"Risks of partition." 19 Feb. 1947. *The Nationals Archive*,
    webarchive.nationalarchives.gov.uk/ukgwa/+/https://www.nationalarchives.gov.uk/educat
    ion/resources/the-road-to-partition/risks-partition/. Accessed 8 Nov. 2023.

Stewart, Neil. "Divide and Rule: British Policy in Indian History." *Science & Society*, vol. 15, no.
    1, 1951, pp. 49-57. *JSTOR*, www.jstor.org/stable/40400043. Accessed 1 Jan. 2024.

Talbot, Cynthia. "Inscribing the Other, Inscribing the Self: Hindu-Muslim Identities in
    Pre-Colonial India." *Comparative Studies in Society and History*, vol. 37, no. 4, 1995, pp.
    692-722. *JSTOR*, www.jstor.org/stable/179206. Accessed 2 Jan. 2024.

TED-Ed, host. "Why Was India Split into Two Countries? - Haimanti Roy." *Ted-Ed*, 21 June
    2021. *YouTube*, www.youtube.com/watch?v=DrcCTgwbsjc.

Tetlow, Anna. "70 Years On: What Happened When The British Army Left India." *Forces.net*, 14
    Apr. 2017, www.forces.net/news/70-years-what-happened-when-british-army-left-india.
    Accessed 15 Jan. 2024.

Verghese, Ajay. "Did Hindu-Muslim conflicts in India really start with British rule?" *Scroll.in*, 5
     July 2018,
          scroll.in/article/880832/did-hindu-muslim-conflicts-in-india-really-start-with-british-rule.
          Accessed 2 Jan. 2024.

Wardley, Rosemary. *75 years after Partition: These maps show how the British split India*. 2022.
     National Geographic, 9 Aug. 2022,
          www.nationalgeographic.com/history/article/these-maps-show-how-the-british-split-india
          . Accessed 18 Jan. 2024.

Wolpert, Stanley A.. "British raj." Encyclopedia Britannica, 6 Oct. 2023,
          https://www.britannica.com/event/British-raj. Accessed 8 November 2023.

To what extent was Douglas MacArthur's firing as the UN commander justifiable? By Soobin Ryu

Section 1 – Identification and Evaluation of Sources

"Il s'agit d'une déclaration tout à fait extraordinaire de la part d'un commandant militaire des Nations unies, qui engage sa propre responsabilité. Il s'agissait d'un acte qui ignorait totalement toutes les directives visant à s'abstenir de toute déclaration sur la politique étrangère. C'était un défi ouvert à mes ordres en tant que président et commandant en chef. Il s'agissait d'un défi à l'autorité du président en vertu de la Constitution. Il a également bafoué la politique des Nations unies"[1]

Cette enquête explore la question de recherche suivante : "To what extent was Douglas MacArthur's firing justifiable?" L'une des sources choisies est un extrait des *Mémoires de Harry S. Truman, volume 2: Années d'épreuve et d'es*poir. Cette source est pertinente car elle montre l'une des raisons du renvoi de Douglas MacArthur par la voix du président américain de l'époque: la insubordination envers le président américain et son administration.

L'origine est un extrait du mémoire publié en 1956 par Harry S. Truman aux États-Unis. La valeur d'origine est qu'elle est écrite par Truman, le président des États-Unis pendant la guerre de Corée, elle donne un aperçu de la raison de sa propre prise de décision et de son contexte. La limite de l'origine est qu'il s'agit d'un mémoire publié après la guerre de Corée, en 1956, ainsi d'une réminiscence personnelle de ses souvenirs. Il se peut qu'elle ne soit pas exacte puisque la mémoire peut être altéré après longtemps.

L'objectif est de justifier ses actions auprès public et de partager sa perspective sur sa prise de décision. La valeur de l'objectif est que, puisqu'il partage son perspective, il parle des défis auxquels il a été confronté, en particulier l'insubordination de MacArthur. La limite de l'objectif est qu'étant donné qu'il essayait de justifier ses actions, il pourrait y avoir quelques exagérations, ce qui est en faveur de ses actions et de ses pensées.

Une valeur de contenu est qu'il explique ses frustrations et son perspective sur l'insubordination de MacArthur comme un acte de "défi ouvert."[2]Il suggère que MacArthur a ignoré "toute les directives"[3] et a défié "ordres en tant que président et commandant en chef."[4] Cependant, la limite du contenu est qu'il n'indique pas explicitement les actions d'insubordination menées par MacArthur, de sorte qu'il n'y a pas de preuve de son insubordination.

Section 2 – Investigation (1002 words)

During the Korean War, Douglas MacArthur, the UN commander was fired by the Truman administration for his statement about bombing China. The Korean War (June 1950- July 1953) was a proxy war during the Cold War between the two superpowers: the Soviet and the US. Truman believed that MacArthur's views on the Korean Peninsula went directly against the UN's mission statement in restoring peace on the peninsula and that it was a direct insubordination toward the President of U.S, which would inevitably create a political

disturbance. However, MacArthur believed that using nuclear weapons was the only way to diminish threat from the Chinese as they were the major aid to the communist forces. Ultimately, Douglas MacArthur's firing can be seen as justifiable when considering the political balance of the US; yet the manner which it occurred suggests that it was unjustifiable.

To begin with, the firing of the UN commander, Douglas MacArthur, was justifiable because of his disobedience to the UN's mission statement regarding Korea. As the UN commander he had the responsibility in following the UN's rules and goals, which was not successful in the eyes of the Truman administration. While MacArthur wanted to extend the war in trying to demolish and end the Chinese and North Korean troops, the Truman administration didn't want to overspend on Asian soil and ultimately avoid any factors triggering another world war. Such view is prominent in Stuek's research that "U.S. officials in Washington did not trust MacArthur with broadened authority"[5] and that "they feared that he would use a new directive to justify action beyond Korea that was not necessary, thus needlessly expanding the conflict."[6]

Furthermore, not only did Douglas MacArthur go against the UN's primary goals, but his continuous insubordination also extended to an "open defiance"[7] of Truman's "orders as president and the Commander in Chief,"[8] which he states "…was a challenge to the authority of the president under the Constitution." [9] Not only did Truman regard MacArthur's insubordination as an offense, but Morrison also stated that they "are incline to think that the major danger is MacArthur's rashness and political responsibility, rather than massive air attack from outside Korea."[10] H.W Brand states that he "thinks the enduring legacy is that Truman took a great political risk, and he did it immediately to prevent World War III, but also to prove the principle that civilian elected officials are above military officials, however grand and decorated they may be," [11] which backs up Truman's need in stopping MacArthur's continuous insubordination. Such is evident following the success of Operation Chromite, where "MacArthur consequently ignored order to obtain prior approval and ordered that Seoul be formally restored to the South Korean government on September 29, 1950."[12] This came to a climax in his last statement, where MacArthur stated that "Within the area of my authority as the military commander, however, it would be needless to say that I stand ready at any time to confer in the field with the commander-in-chief of enemy forces in the earnest effort to find military means … of the political objectives of the United States in Korea"[13] which inferred a provocative attack on China to comply with the Allies' orders, or face war. Therefore, it could be seen that MacArthur's constant defiance against the higher orders ultimately justified his firing, as it may have created a disturbance and weakening of the US political status.

On the other hand, some disagree with the extent of MacArthur's firing; rather suggesting that the justification was not wholly valid. This is evident as his previous success in Japan during US's occupation was widely recognized in drastically raising Japan's status in the global world and its economy by implementing orders which were also insubordinations to a certain extent. However, Truman did not make him accountable for his defiance against his constitution which makes it incomprehensible why he fired him for his insubordination in Korea. As Scheller states, "from 1948-1950, MacArthur consistently criticized prefers and

delayed their implementation. Although this is not a serious breach of the chain of command, it still was an insubordination and potentially caused him to defy orders again not only during the occupation of Japan, but also in the Korean War."[14] Thus, this conflict and between the Truman administration and MacArthur was continuous throughout the progression of both the Japanese and Korean campaigns, but irregularly, MacArthur was only condemned for the latter. This questions the justification and timing that MacArthur was fired.

Moreover, MacArthur's firing remains controversial because of his numerous strategic and military successes. In the Battle of Inchon, although many were against his attack because of the uncertainty of winning as he admits "that Inchon is a 5000 to 1 gamble,"[15] he had strong beliefs that he will win, as he states, " but I am used to taking such odds. We shall land at Inchon and I shall crush them!"[16] As one source states, "MacArthur's Korean retreat was one of his most successful feat of arms."[17] Such view is prominent in MacArthur's own memoir, in which he speaks about his "resentment towards the Truman administration"[18] after receiving a letter from the JCS "that expressed doubt over the Inchon operation."[19] MacArthur also claimed that his views on the conduct of the war was not given proper attention and that he was given "restrictions on military operations,"[20] which shows the substantial disconnection between the two. His ability as the UN commander is undeniable, therefore the Truman administration should have had more trust in him and his orders as the UN commander.

In conclusion, there are some doubts regarding the firing of Douglas MacArthur as the UN commander during the Korean War because of his successes and the timing of his firing, it was legitimate because of his constant disobedience to the UN's mission statement and his insubordination towards President Truman and his administration. Considering the severe risk in damaging Truman's political regime, he had the right to fire him even if he hadn't previously since MacArthur's insubordination was escalating to an irrefutable extent.

Section 3 – Reflection (192 words)
Pendant mon enquête, j'ai appris qu'une oeuvre d'historien comportait de nombreux défis. C'était difficile d'incorporer des nombreuses sources a cause de la variété des sources sur ce sujet. L'une des méthodes que j'ai utilisé a consisté à trouver une source externe principale et une source interne principale auxquelles je puisse faire référence dans mon essai. J'ai appris que, quoique les sites Web étaient utiles pour compléter les connaissances de base et comprendre mes arguments, ils n'étaient pas assez détaillés pour donner une vue d'ensemble du sujet. Lors de la recherche de nouvelles sources, j'ai eu du mal à trouver des sources impartiales, j'ai donc utilisé cette opportunité pour examiner le licenciement de MacArthur avec deux arguments contrastés. Précisément, j'ai utilisé les citations de MacArthur et les citations de Truman pour vraiment formuler ces arguments. Une autre difficulté a été de trouver des sources fiables. Pour surmonter cela, j'ai veillé à ce que les sites web que j'ai pris en compte soient des sites historiques éducatifs bien connus, à ce que je m'inspire d'enquêtes menées par des doctorants sur ce sujet et à ce que j'utilise un livre publié par un historien renommé

Works Cited

"Battle of Inchon." Wikipedia, June 3, 2023.

https://en.m.wikipedia.org/wiki/Battle_of_Inchon#:~:text=MacArthur%20felt%20that
%20he%20could,Cavalry%20Division%20landing%20at%20Incheon.

Brands, H. W. *The general vs. the president: MacArthur and Truman at the brink of Nuclear War*. New York: Anchor Books, a division of Penguin Random House LLC, 2017.

"The Firing of MacArthur." The Firing of MacArthur | Harry S. Truman. Accessed June 9, 2023. https://www.trumanlibrary.gov/education/presidential-inquiries/firing macarthur.

The Great Republic. "Memoirs: Year of Decisions and Years of Trial and Hope by Harry S. Truman, Kansas City Edition, 1955-56." The Great Republic. Accessed June 9, 2023. https://www.great-republic.com/products/memoirs-year-of-decisions-and-years-of-trial and-hope-by-harry-s-truman-kansas-city-edition-1955-
56#:~:text=In%20his%20memoirs%2C%20Truman%20provides,climate%20as%20a%20new%20president.

"History of the Korean War." United Nations Command > History > 1950-1953: Korean War (Active Conflict). Accessed June 9, 2023. https://www.unc.mil/History/1950-1953-Korean-War-Active
Conflict/#:~:text=June%2027%2C%201950%3A%20United%20Nations,peace%20on%20the%20Korean%20Peninsula.

Mueller, Luke G. Defying the United States: General Douglas MacArthur. Accessed June 8, 2023.
https://digitalcommons.iwu.edu/cgi/viewcontent.cgi?article=1051&context=history_ho nproj.

"Relief of Douglas MacArthur." Wikipedia, May 10, 2023.

https://en.m.wikipedia.org/wiki/Relief_of_Douglas_MacArthur.

Stueck, William, Jack L. Snyder, and Richard H. Ullman. *The Korean War: An international history*. Princeton University Press, 1997.

Soobin Ryu June 9th 2023 History IA

Truman, Harry S. *Memoirs. years of trial and hope*. New York: The New American Library, 1965.

The Intriguing Correlation Between Financial Investment and Formula 1 Racing Performance By Bowen Yao

Authors Biography

Bowen Yao is a Junior high school student attending St. Michael's College school in Toronto, Canada. He is a 3 year Honour Roll student and a Basilian Scholar for his highest academic achievements in his grade. He aspires to study in the field of finance and economics at University and has achieved finalist and semi-finalist in the Model Entrepreneur High School Competition and Wharton Global Investment Competition. He is an avid athlete in fencing and has great interests in Formula 1 racing and the NBA.

Abstract

This paper examines the intriguing correlation between financial investments and the performance in Formula 1 motorsport racing, underscored by prominent athlete Lewis Hamilton's leave from Mercedes Petronas to Scuderia Ferrari beginning in 2024. Using the data from 1994 to 2010, this paper identifies a clear link between financial allocation to F1 teams and their success in races. Overall, the paper reveals that teams backed by significant investments from their parent companies, such as Daimler for Mercedes and Ferrar for Scuderia Ferrari, tend to secure a leading position in the F1 Constructors' Championship. The research further extends to operational spending in respective teams. This includes updating the newest technologies to augment their cars' performance. The paper outlines the critical margin of Advantage held by Mercedes over Red Bull, mainly attributed to their significantly high expenditure, proving the causation in investment and performance. The research goes into depth by evaluating racers' salaries and their performance metrics, suggesting a pattern where higher earning aligns with a more preferable result. Sponsorship investments are also mentioned and have proven to play a pivotal role, with well-sponsored teams typically finishing higher each season. In summary, the paper argues that financial investment is a critical determinant of a team's capacity for dominance in Formula 1 racing. While driver skill is essential, the financial contributions explain its influence on performance, offering insights into the broader implications of financial strategies in high-stakes competitive sports.

Keywords: Investment, Formula 1, Performance, Mercedes-Petronas, Lewis Hamilton, Correlation, Championship, investment

Introduction

The Formula One (F1) racing world was astonished in the early days of February 2024, when seven-time world champion Lewis Hamilton announced his decision to leave with Mercedes Petronas to Scuderia Ferrari after 11 years. This abrupt news was proclaimed to be one of Hamilton's "hardest decisions", but is still unclear to fans what the motives behind this leave are. Ever since he left, numerous conspiracy theories have been spread across social platforms, with numerous controversies around social media claims about what led to his leave. However, it

was claimed that Hamilton left since "he no longer believed [Mercedes Petronas] could deliver a car that can stop Red Bull's juggernaut" (Srivastava 2024). It's apparent that the seven-time world champion wants to win not merely with his skill, but also with the most advanced racing cars invented, but how is it that different racing teams can manufacture completely different racing cars throughout Formula 1 racing? Many people characterize F1 racing as a science fair, with the best technologies and science in aerodynamics and engines to win the final price, but often the most money spent on a science project usually leads to the best outcomes. Through examining the investments in F1 racing teams, it is seen that similar to science fairs, team investment, and team expenses all contribute to a more preferable outcome in performance.

Research Question

An F1 race ultimately comes down to a thousandth of a second, or 0.001 seconds. Therefore, a minuscule faster speed, even 0.00001km/h in speed, may decide first and second place. As per financial investment, exploring the relationship between the amount of money invested and their subsequent performances in races can create a correlation. This research will investigate the confounding impact of how financial investment influences the performance of Formula 1 racing teams.

F1 Team Worth

Before examining the impacts of team performances brought by financial investments, it's essential to understand each team's worth. To examine how investment affects performance, a higher team worth often signifies revenue, investments, brand value, performance success, and more. As of 2023, Red Bull racing is currently valued at $2.6 billion, Mercedes at $3.8 billion, Ferrari at $3.9 billion, Mclaren at approximately $2.2 billion, Alpine at $1.4 billion, Aston Martin at $1.3 billion, AlphaTauri at $1.1 billion, Alfa Romeo at $900 million, Haas at $780 million, and Williams at $725 million (Mitchelle).

Influence of Financial Investments on F1 Team Performance

The success of the F1 racing team is significantly influenced by the team's investments from their car manufacturers and parent companies. Although racing is the most expensive sport globally, the F1 racing teams are not publicly listed to be invested on stock exchanges. As a result, the biggest investors and supporters of respective teams are attributed to the parent companies, as the performance boosts brand image. In 2019, Mercedes' parent company, Daimler, invested $80 million into the team to help them in the Constructors Championship (Srinivasan 2023). This investment directly affected the team's performance; in that very year, Mercedes-AMG Petronas earned first place in the season. This money and performance causation can also be seen in Ferrari S.p.A., where Ferrari, the parent, also invested more than $400 million each year in formulating the dominating, and most valuable Ferrari team today.

Furthermore, with Charles Leclerc and Sebastian Vettel placing 3 and 4th, there's no doubt that more investments lead to a stronger team and better overall performance.

Haas Fl Team Principal, Guenther Steiner, stated that even a $100 million investment won't get them closer to Mercedes (Chauhan 2023), and looking at the 2022 performance of HAAS, the team only ranked 8th (RacingNews365 2022) out of 10 F1 racing teams, earning only 37 points in the entire season. Without disclosing the investment amount, it is unquestionable that the team did not earn as much investment to put them on the stage to compete with major F1 teams such as Mercedes and Ferrari.

Furthermore, F1 teams with notable car brands receive more investments. Mercedes and Ferrari in this case, with a notable car manufacturer brand funding the teams, evidently received more funding in their teams. On the other hand, teams such as Haas, Kicker, and Alpha Tauri without a notable or strong car manufacturer or company do not receive as much investment. Overall, teams funded by a well-known and established parent company are pivotal when evaluating the success of these teams.

Technological Investments and Their Impact on F1 Team Performance

A major contribution to team results is individual team spending in inventing technologies. Looking at the fierce rivalry between Mercedes Petronas and Red Bull racing, in 2018, Mercedes-AMG Petronas "was a minuscule 0.058% quicker than Red Bull on average throughout the season. Over a typical 90-second lap, that's an advantage of just five-hundredths of a second" (Will, 2024). Although 0.058% seems minuscule, this resulted in Lewis Hamilton and Mercedes-AMG Petronas achieving first standing in the 2018 season, but this cost more than $400 million in operating spending in that season, with only a total profit of $5 million. This team consists of 950 workers who spent the fewest dollars per point earned is mainly attributed to Lewis Hamilton. His teammate Valtteri Bottas spend $0.61 million for each of the team's 655 points (Jacobs, 2018). This $400 million operating expense led to Mercedes ranking first in terms of team spending in the season, and these costs mainly consist of tires, DRSs, and countless technologies in buying the race car. Behind Mercedes lays Red Bull, which spent $310 million: $181.1 million on team operation, of which 5.7 million dollars were poured into Investment in new production machinery, new hardware and track equipment. On the other hand (Sylt, 2022). Despite earning the same amount of profit; $5 million, Mercedes-AMG outspent Red Bull by more than $90 million. It is striking to note that for Mercedes to gain a mere 1% faster speed than RedBull, the team must invest over $1.5 billion into the development of these vehicles. However, due to these huge contracts in monetary spending, Mercedes did beat Red Bull in the season, highlighting how a higher number in investment can lead to a direct boost in performance even by just a minuscule number.

Research and Development investments in F1 cars can highlight the key correlation between monetary expense and the outcome of each team. While the respective team's investments in technology play a major role in affecting the outcome of the team's performance, the specific allocation of various technologies can further influence the outcome. Throughout the

84 years of developing the fastest racing cars in Formula 1 Racing, aerodynamics testing, material science, data analytics, fins, and DRS have always been the leading sciences pushing the bounds of human technology. Among these advanced technological tests and sciences, the engine has always been the most expensive and invested compartment in F1 cars. Undoubtedly, the engines used in F1 assert their dominance as one of the most important pieces of equipment, extremely sophisticated and a huge factor in improving the speed and performance of the car. Ever since 2014, the FIA set the rules that the engine must be a four-stoke, hybrid, V6 engine with a displacement of 1.6 litres and a turbocharger to boost the power output (with an 80mm bore and 53mm stroke). The turbocharger forces more air into the engine, which results in more power. This is achieved by using exhaust gasses to spin a turbine, which powers a compressor that forces more air into the engine (Gururaj 2023). Although all engines in Formula 1 are hybrid V6 engines, it becomes evident that a direct correlation between cars' performances with more expensive engines than that of racing cars from prior years. According to Sportsnet, Unsurprisingly, the engine is the most expensive component. A singular turbocharged 1.6-litre V6 engine is worth approximately $10.5m (€130.3m), with teams allowed to use three of them throughout the season". In 2023, the fastest F1 speed recorded was 366 km/h in the Las Vegas Grand Prix by Ferrari SF-23 driver Carlos Sainz (Fans 2023). In contrast, if compared to the top speed in 2013, Felipe Massa's Williams-Mercedes topped 342 km/h (Motorsports 2014), compared with the fastest V8 engine. This small yet significant difference of 24 km/h faster marks the evolution of the F1 engine. Throughout the years of developing and refining these articulate metals, investments in science do appear to boost the performance of F1 race car speeds.

Salary and Performance Correlation in Formula 1 Racing

In the sports world, racer performance is a key indicator of their respective salaries, especially in Formula 1 racing. These million-dollar contracts are not only a reflection of the athlete's prowess on the course, but also a significant factor when evaluating their performances in every season. In the sports world, Michal Savio has identified a direct impact between player salary and player performance in the NFL and NBA franchises. Through evaluating the perceptions of "the better they should perform. If players fail to do that, they are accused of "giving up" or "not caring about winning." This perception is amplified when it involves contracts that include guaranteed money" (Savio). Similar to how employees work harder to get a raise, players yearn for higher salaries to enhance their performance. Overall, Michael found that in the NBA, after a player signs a new contract, this usually boosts their performance, as in the examples of Anthony Davis and many other players. Overall, it can be understood through this research that salary may not be based on the performance of an athlete, but the performance is a result of their salary and earnings. This causation is well reflected in the Formula 1 racing world, where players with higher pay tend to achieve the best outcome.

In the 2024 season, Forbes's top-paid athlete Max Verstappen ranks first out of the 20 racers with a commanding salary of $70 million (Longman). This pinnacle salary ranking is well

reflected in his performance, with a total of 575 points in the 2023 season, significantly outranking his second-place teammate Sergio Pérez - who is fourth in salaries ranking earning a total of $34 (Longman, 2024) million - by 290 points. The salary-performance correlation extends to other notable racers, most notably seven times world champion Lewis Hamilton, earning a total of $45 (Longman, 2024) million in 2024. Hamilton's salary ranked him third amongst the top earners, but his direct performance correlation: a total of 234 points in 2023, suggests his ability to grapple with exceptional outcomes. Looking at the lower end of the salary spectrum, the last five racers reveal a pertinent contrast, with their annual earnings fluctuating between $1-3 million (Longman, 2024): 70 times less than Verstappen's, corresponding with their lower performance ranking. This pattern reveals a strong link between financial rewards and competitive success in Formula 1 Racing.
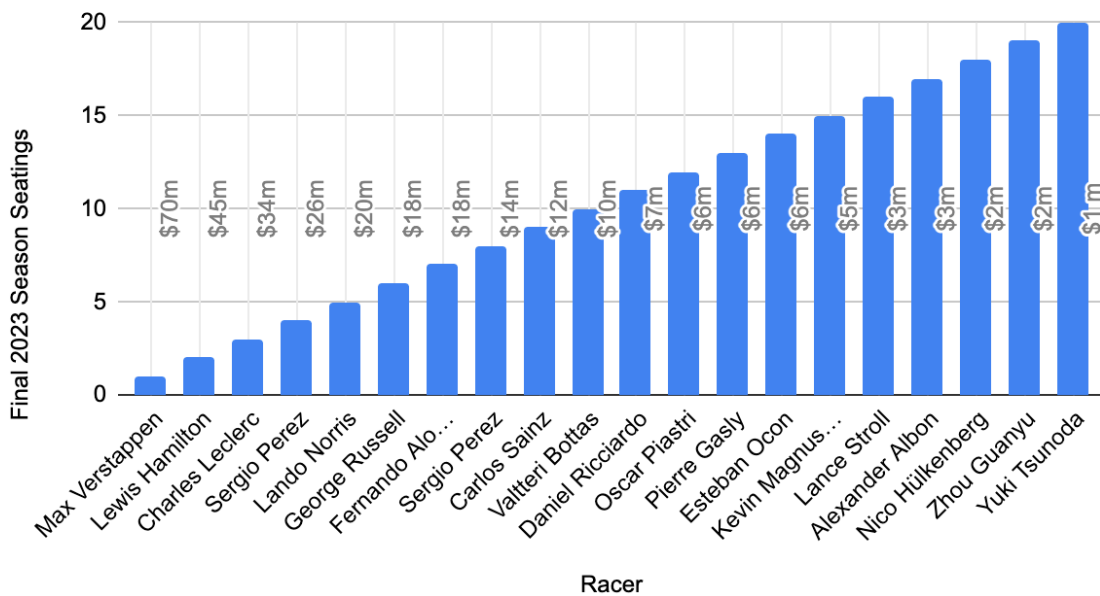
Fig 1: Racers ranked from left to right based on performance and their indicated salary

Sponsorship and Team Performance in Formula 1 Racing

Sponsorship investments in Formula 1 racing teams have augmented the overall results of each team. According to data statistics on the NFL, researchers found that stocks returning to the sponsoring firms are affected by the outcomes of games played. Overall, the mean difference between returns after a win and after a loss of the home team is 56 basis points for regular season games and 92 basis points for post-season elimination games. Evidence suggests that this effect is partially driven by investor sentiment (Alhada 8). Prominent sports scientist Suffyan A. Alhadad adds by stating, "There is a strong link between team performance and sponsors' realized brand exposure and the price paid" (Alhada 3). Unlike any sport, sponsorships generate the largest revenue in Formula 1 racing. However, sponsorships direct money from investors, and

sponsors' monetary input gives them the right to control stakes. Despite the different ways of investing (Investing and sponsoring), the money stored in Formula 1 racing has also led to quality results. Often, the teams with the most sponsors are the teams with the best outcomes:

F1 Teams Sponsorship amount
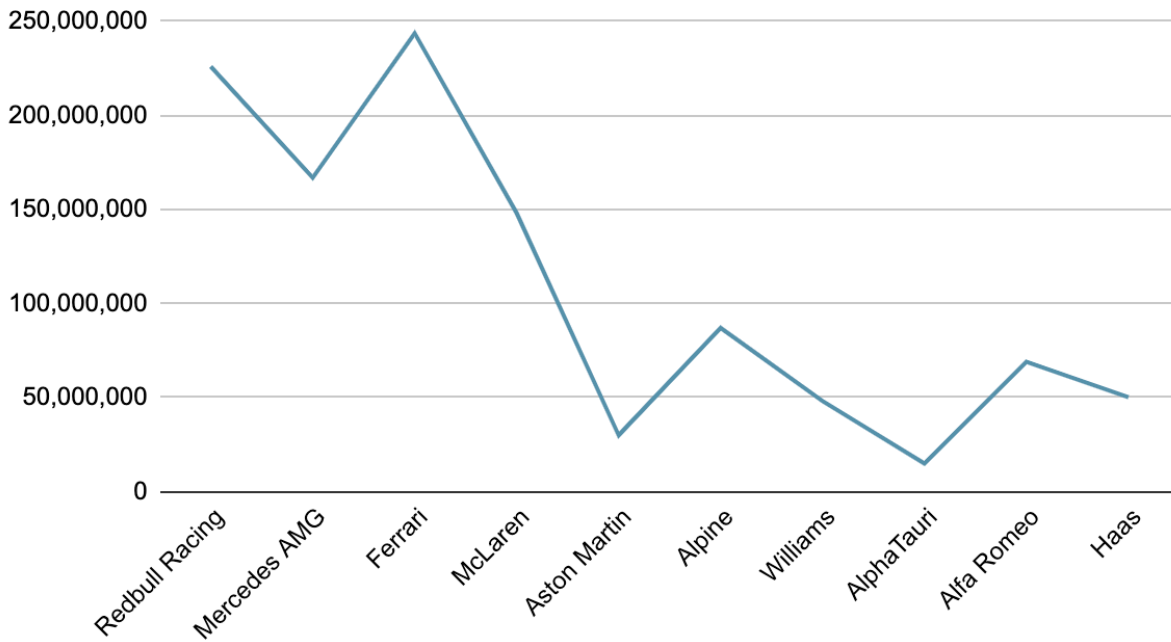
Fig 2: F1 racing teams ranked from left to right based on performance and their Sponsorship in 2023

      In the graph, the teams identified in the x-axis are the final team seatings in the 2023 Formula 1 racing season, and the y-intercept is each team's respective sponsorship received. Redbull Racing and Ferrari – $226 (Admin 2023) and $243 (Admin 2023) million – both with the highest sponsorship invested, finished first and fourth in the season. In comparison, Alpha Tauri and Haas are racing, with only $15 and $20 million worth of sponsorships finished last and third-last throughout the entire season (Admin 2023). This difference of more than $225 million has displayed a significantly higher ranking throughout the season, showing how there is a direct correlation between financial investment and the very performance of Formula 1 teams.

Sponsorship Brands and Team Performance in Formula 1 Racing
      With flashy and filled sticker images of brands on F1 race cars, these sponsors are no jokes. In 2024, F1 announced their biggest sponsors: Oracle, Aramco, Petronas, Stake, and Bybit. Extravagant brands such as Rolex – luxurious brands which target richer individuals – highlight the financial significance of these costly races. However, the sponsor brands can also disclose stark evidence of investing and performance.

TOP 5 EXTERNAL SPONSORS OF F1 TEAMS IN 2024

CLASSIFICATION	SPONSOR NAME	TEAM	AMOUNT +/- IN $
1.	Oracle	Red Bull Racing	90 million
2.	Aramco	Aston Martin	75 million
3.	Petronas	Mercedes	70 million
4.	Stake	Stake F1 Team	50 million
5.	Bybit	Red Bull Racing	40 million

Fig 3: Top 5 Sponsors of F1 Teams in 2024 (Mitchell)

The mass sponsorships to the fastest teams do not end in 2023; evidently, the biggest team sponsorships in 2024 mainly went to the teams with the best performances. To evaluate how more successful brands will sponsor more successful teams, market cap is essential to rank the company sizes. Amongst the list, Aramco has a market cap of $1.933 trillion Oracle at $315.97 billion, Petronas at $7.46 billion, Bybit at $9.46 billion, and Stake at $1.21 billion (Arranged from greatest to least). These stats show the top 5 sponsors and the teams sponsored also are the top 4 teams in the final ranking in the 2023 season (Red Bull being sponsored twice). Bigger companies favour better teams. This is evident not only within F1 but also in numerous other professional sports discussed earlier in the research. On the lower spectrum of the performance ranking, Haas F1's biggest sponsor is   MoneyGram (Legge), who paid the team only $20 million in 2023 (Brittle). Moreover, MoneyGram's Market cap is only around $1.07 (Legge) billion, less than all the companies listed in the table above. These data show a tight correlation between richer companies sponsoring stronger teams to broadcast their brand, while smaller companies – companies who pay less in sponsorships – tend to favour weaker teams.

Pit stops

Runners typically keep a consistent pace in a marathon to maximize their energy. However, if a certain runner has to stop to refill water, use the washroom, or twist their ankle, they just forfeit minutes, or even seconds, putting them behind their competitors. In Formula 1, pit stops are mandatory events within a race. After driving into a pitstop, teams engage in quick maintenance, change of tyres, mechanical repairs or adjustments and many other actions necessary during the race (Daphnecavadias). However, this mandatory and seemingly

advantageous occurrence might put certain teams at a disadvantage, similar to running a marathon.

On April 21, 2024, the Formula 1 Grand Prix was held at the Shanghai International Circuit in Shanghai, China. With Chinese fans' home race Zhou Guan Yu, the first ever Chinese person to compete in F1, competing, much spotlight and attention were put onto this amateur driver. However, with this attention, many Chinese fans discover the extensive long time wasted in Zhou's pit stops. As Max Verstappen, the eventual champion of this race, only spends a total of 44.76 seconds in the pit, Zhou's team Kick Sauber Ferarri spends a time of 1:22.24 minutes (Formula 1 Results). This stark contrast of more than 30 seconds puts Zhou at a significant disadvantage. Specifically, with 322km/h, this 38 seconds puts Zhou behind Max by more than 3.3km.

Although pit times can vary due to many causes, such as the skillfulness of mechanics, a major factor is how rich a team is. Looking back at the race, even Chinese commentator, Pan Yong Yong, later states that this gap between the two F1 teams is simply because Red Bull is richer than Kick. Although pit stops may seem reasonable, a well-timed pit stop can help a driver overtake or defend from another driver (Mavericks). This raises a question: how can the financial status of racing teams affect the pit stop times for an F1 team?

In Formula 1 racing, not only is there a champion for the fastest racer, but also an award dedicated to the fastest pit stop times. With a faster pit time, respective teams will earn more points which contributes to their final season seeding. So far in 2024, Red Bull is the leading team in terms of the fastest pit with almost 180 points, while Sauber (Zhou's team) earned a sum of 0 points, the lowest among the teams. As the richest F1 team, Red Bull happens to be the fastest team in pit time, while less funded teams including Kick, Haas, and Williams, consume the most amount in pits.
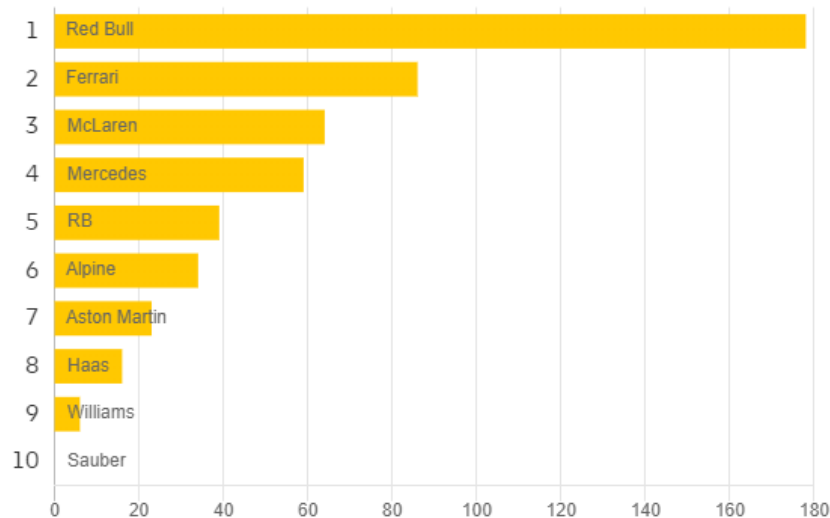
Fig 4: 2024 Season F1 team ranking based on points earned in Pit Stop (DHL Award)

Knowing that Red Bull, Mercedes, and Ferrari are some of the most affluent teams, the chart reflects a causation effect. Comparing Mercedes (a rich team) and Haas(a relatively poor team), a stark difference is present. Inspecting the chart below, Sauber takes significantly longer than Mercedes in every single Gran Prix so far this season. These differences sum up to a total of 34.3 seconds, quite literally putting Haas more than 3 kilometres of difference behind Mercedes
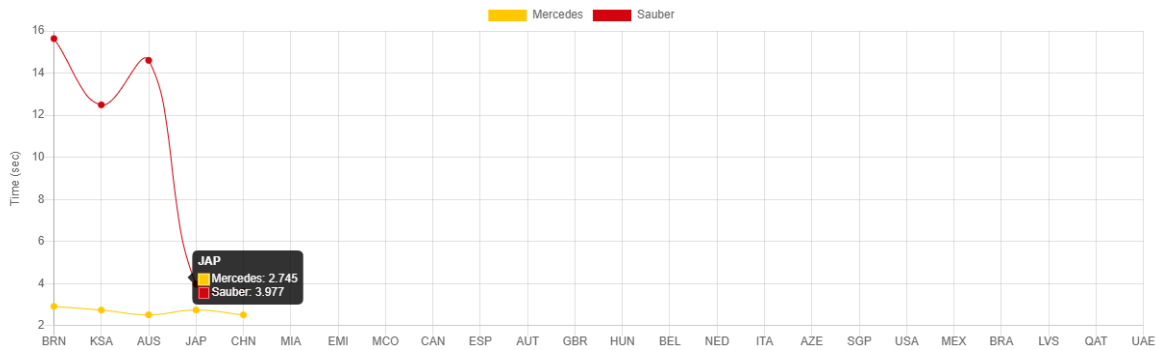
Fig 5: Mercedes's Pit time Vs Sauber Ferrari's Pit time in the 2024 season (DHL Award)

Although the race car itself plays a pivotal role in determining the final placement, the amount of time exhausted in pit stops more literally illustrates how wealthier teams can have a direct impact on their outcome. Whereas the richest teams develop the fastest pit times, the poorest teams usually have greater disadvantages in their pit stops, revealing how higher investment can lead to faster pit times.

Conclusion

Overall, the analysis presented in this research paper unequivocally highlighted the strong correlation and causation between financial investment and the performances of Formula 1 racing teams. Investigating the strategic infusion of capital in various forms such as direct team investment, technological development, or sponsorship investments, consistently yields a competitive edge on the race track. The cases of Mercedes-AMG Petronas and Scuderia Ferrari alongside victorious racers like Max Verstappen and Lewis Hamilton, underscore the notion that financial contributions can critically affect the success of teams and drives in this high-stakes sport. Discounting talents and strategical planning's pivotal role, the evidence illustrated in this research suggests that the monetary subsidy of a team significantly influences its capacity to innovate, excel, and ultimately dominate in the fast-paced world of Formula 1 racing. This financial-performance link not merely illuminates the successful dynamics in motorsport racing, but also reflects on a broader theme of investment and return, resonating with the patterns observed in various competitive sectors where innovation and excellence become a paramount role in reaching first.

Works Cited

Admin, K. (2023, June 26). *Top Ten current sponsor partners of Scuderia Ferrari*. Sportcal.
https://www.sportcal.com/data-insights/top-10-sponsor-partners-scuderia-ferrari/

Alhada, Suffyan. "Researchgate | Find and Share Research." *Study on Sports Sponsorship Effectiveness*, 14 Feb. 2019, www.researchgate.net/profile/Sakinah_Alhadad. Accessed 13 May 2024.

Brittle, Cian. "Haas F1 Unveils 'US$20m-a-Year' Title Sponsorship with MoneyGram." *BlackBook Motorsport*, 29 Nov. 2023,
www.blackbookmotorsport.com/news/haas-f1-moneygram-title-sponsor-us-grand-prix-22/#:~:text=Financial%20terms%20of%20the%20deal,the%20Haas%20Formula%20One%20team. Accessed 13 May 2024.

Chauhan, D. (2023, August 9). *$100,000,000 investment not enough to beat F1 big boys Mercedes, states Haas Boss Guenther Steiner*. Sportskeeda.
https://www.sportskeeda.com/f1/100-000-000-investment-enough-beat-f1-big-boys-mercedes-states-haas-boss-guenther-steiner

Daphnecavadias. "A Thorough Analysis of The Pit Stop Strategy in Formula 1." *Statathlon*, 15 Sept. 2023,
statathlon.com/analysis-of-the-pit-stop-strategy-in-f1/#:~:text=In%20F1%2C%20a%20pit%20stop,connected%20to%20the%20main%20track. Accessed 13 May 2024.

"DHL Fastest Pit Stop Award." *DHL InMotion*, 5 May 2024,
inmotion.dhl/en/formula-1/fastest-pit-stop-award. Accessed 13 May 2024.

Fans, S. (2023, November 21). *Top speeds from 2023 F1 Las Vegas GP: Carlos Sainz reached 366 km/h!* Scuderia Fans.
https://scuderiafans.com/top-speeds-from-2023-f1-las-vegas-gp-carlos-sainz-reached-366km-h/#:~:text=During%20the%20Las%20Vegas%20Grand,by%20Bottas%20in%20Mexico%202016.

Gururaj, T. (2023, May 16). *Formula One: The science, engineering, and innovation behind the speed*. Formula One: The science, engineering, and innovation behind the speed.
https://interestingengineering.com/innovation/formula-one-f1-racing-speed-engine-power

Jacobs, C. (2018, December 28). *Top 3 Formula 1 teams spent over $1.1 billion in 2018: Report*. The Drive.
https://www.thedrive.com/accelerator/25691/top-3-formula-1-teams-spent-over-1-1-billion-in-2018-report

Legge, Jake Boxall. *Magnussen: "Great" Title Sponsor Has Changed Haas F1 Situation*, 22 Aug. 2023,
www.motorsport.com/f1/news/magnussen-great-title-sponsor-has-changed-haas-f1-situation/10510175/. Accessed 13 May 2024.

Longman, W. (2024, March 21). *F1 driver salaries: How much do Formula 1 drivers earn?* Motorsport Tickets Blog.
https://motorsporttickets.com/blog/f1-driver-salaries-how-much-formula-1-drivers-earn/

Mavericks, F1. "The Importance of Pit Stops in Formula One Racing." *LinkedIn*, 4 Apr. 2023, www.linkedin.com/pulse/importance-pit-stops-formula-one-racing-formula1hubahmedab ad#:~:text=A%20well%2Dtimed%20pit%20stop,affect%20their%20pace%20and%20stra tegy. Accessed 13 May 2024.

Mayne, J. (2024, March 1). *How much does an F1 car cost in 2024? key parts, history of most expensive Formula 1 cars*. Sporting News Canada. https://www.sportingnews.com/ca/formula-1/news/f1-car-cost-key-parts-most-expensive/ sbvxis3e0fveuzxevx56b470#:~:text=A%20singular%20turbocharged%201.6%2Dlitre,(% E2%82%AC663%2C285)%20to%20manufacture.

Mitchell, Rory. "Which Teams Are F1's Most Valuable in 2023?" *RacingNews365*, 19 July 2023, racingnews365.com/which-teams-are-f1s-most-valuable-in-2023. Accessed 12 May 2024.

Motorsport.com. (2014, September 1). *Top speeds at Monza are to be lower than expected*. Motorsport.com: F1 News, MotoGP, NASCAR, Rallying and more. https://www.motorsport.com/f1/news/top-speeds-at-monza-to-be-lower-than-expected/45 6040/

RacingNews365. (2022). F1 standings 2022. https://racingnews365.com/formula-1-standings-2022

"Results." *Formula 1® - The Official F1® Website*, 19 Apr. 2024, www.formula1.com/en/results.html/2024/races/1233/china/pit-stop-summary.html. Accessed 13 May 2024.

Savio, Michael. "The Relationship between Player Salary and Performance in Professional Sports." *LINES*, 13 Nov. 2023, www.lines.com/guides/player-salary-and-performance-in-professional-sports/1617. Accessed 13 May 2024.

Srinivasan, H. (2023, July 5). *Here's how F1 teams and drivers make Millions*. Investopedia. https://www.investopedia.com/the-economics-of-formula-1-here-s-how-f1-teams-and-dri vers-make-millions-7555800

Srivastava, P. (2024, February 2). *Why Ferrari? Lewis Hamilton became a master and man at Mercedes but appeared stuck in recent years*. Hindustan Times. https://www.hindustantimes.com/sports/others/why-ferrari-lewis-hamilton-became-a-mas ter-and-man-at-mercedes-but-appeared-stuck-in-recent-years-101706844199947.html

Sylt, C. (2022, October 12). *Red Bull reveals how much it costs to run an F1 team*. Forbes. https://forbes.com/sites/csylt/2020/01/14/red-bull-reveals-how-much-it-really-costs-to-ru n-an-f1-team/?sh=7679a58277c1

Will Wood, K. C. (2024, February 9). *Analysis: Did Hamilton or Verstappen have the quickest car for their title fight?* RaceFans. https://www.racefans.net/2022/01/17/analysis-did-hamilton-or-verstappen-have-the-quick est-car-for-their-title-fight/#:~:text=Based%20on%20these%20figures%2C%20the,five% 2Dhundredths%20of%20a%20second.

Generational Perspectives on "Feminism" in Relation to Political Party Affiliation and Race By Jacqueline Bodycomb

Abstract

Generational, racial, and political differences shape perceptions of feminism among American women. Results revealed Generation Z embraces feminism, Millennials and Generation X resist labels, while Baby Boomers reject equality. Racial and political disparities highlight the importance of intersectionality. Historical, cultural, and ideological interplay in the feminist discourse creates evolving perspectives.

Literature Review

Feminism regarding intergenerational discussion is a complex and tense issue that is subjected to a substantial amount of attention. For example, recurring characters of the Baby Boomer or the Millennial often appear in media, usually participating in caustic and distorted speeches on their interpretations of "feminism." Thus, the notion of intergenerational feminism conflict seems skewed to mainstream audiences, stunting potentially beneficial discourse (Winch *et al.,* 2016). Moreover, theories surrounding the evolution of feminism from generation to generation, as well as the infamous waves of feminism, have been thoroughly debated and examined over time.

Most of the controversy among generations of women can be found in feminist history (Rampton, 2015). As each generation ages and pushes for equality among the sexes, the definition of feminism becomes different for each (Offen, 2013). Fundamentally, it is crucial to understand the commonly referred to phases of feminism. Due to these generational differences, feminism is often described as being split into waves. The first wave is what most depict as feminism, beginning in 1848 with the first organized movement focused on the voting rights of American women in Seneca Falls, New York (Pruitt, 2022). Subsequently, as feminists were later enlightened by the civil rights movement and protests against the Vietnam War, feminists began the fight against traditional gender roles and sexist discrimination, giving way to the second wave of feminism (Brunell, 1996). While this second wave made noticeable advances for feminists, the movement again evolved as issues such as a lack of women in positions of power and sexual harassment in the workplace were taken on by the third wave of feminists that emerged in the 1990s (Snyder, 2008). In addition, the newest generation to enter the feminist discourse, Generation Z, with their use of modern technology, has consequently set the stage for the fourth wave of feminism that appears more focused on the empowerment of women and intersectionality (Rampton, 2015). Fourth-wave feminism has seen the very real impact of wide-reaching social media movements like #MeToo, Time's Up, and Everyday Sexism (Rampton, 2015). Therefore, feminism has been evolving for the past few generations. However, as others attempt to measure this differentiation among women of all ages, they fail to define a more comprehensive definition of feminism in a modern context. Simultaneously, rarely is it determined how these women define feminism concerning their political party affiliation and race.

To discuss anything surrounding feminism on an intergenerational level, it is essential to first define the term "feminism" in a way that is universal to all feminists and, therefore, includes all women. Ideally, feminism is "the belief in social, economic, and political equality of the sexes" (Burkett & Brunell, 2022, p.1). However, as time progresses and women obtain more social mobility than prior, this definition must become more malleable as "a movement concerned with advancing the position of women through such means as achievement of political, legal, or economic rights equal to those granted to men" (Offen, 1988, p.123). Moreover, it is the concept that women should not be denied opportunities or rights due to their gender, as women and men should be viewed in equal standing. The term "feminism" seems straightforward. It is a movement fighting for gender equality, and its ethicality is undeniable. Nevertheless, some people see the feminist movement as controversial due, partly, to the torrid history of mainstream feminism regarding the exclusion of minority women within the first and second waves (Winch *et al.,* 2016). As feminism grows and changes, we must tweak this definition of feminism to extend to women of color. It is vital to modern feminism to acknowledge that not all women face the same structures of prejudice, and considerably, that is because of race. Women of all races each have a unique history and different experiences surrounding the fight for equality, and thus the notion of gender equivalency should not be depicted as insular. Feminism today has to be more flexible to accommodate this diversity to discontinue the neglect of minority women (Ma, 2015). Feminism is intertwined with extensive changes in time and culture (Aabye-Gayle, 2018).

Similarly to the evolving definition of feminism, the perception of feminism and its implications changed for women from each generation. For women born between 1946 and 1964, or Baby Boomers, feminism is conflicting, as the narratives taught to them as children fail to be reflected in their adult lives. This perception is best explained in *Accidental Feminists,* wherein "baby boomer women are now finding the message they received growing up failed to adjust when the world changed and was not the lives they had" (Caro, 2019, p.72). This juxtaposition between the old-fashioned woman and a more modern reality creates a feeling of frustration with the feminist movement (Abdelmalek, 2019). These resentments are shared by the women of the following generation, Generation X, who feel they were set up for disappointment by the feminist movement as it assured them in childhood that they could "have it all." Thus, women in Generation X carry burdens in a professional context while still feeling solely responsible for more traditional roles such as childcare (Matthew, 2022). Contrastingly, among women born between 1981 and 1996, or Millennials, the views on feminism are quite skewed as 51% would consider themselves "feminists" (Cai & Clement, 2016). The main reason for this divide is the misconception that feminism inherently pits women against their male counterparts that arose in the early 2000s (Weinberger, 2012). In contrast, Millennial women are more likely to feel empowered by the feminist movement than the previous generations, and 87% of Millennial women claim to advocate for gender equality (Cai & Clement, 2016). Therefore, it appears the number of feminists is rising; however, misconceptions surrounding the movement hinder the ability of Millennial women to self-identify as "feminists." In comparison, Generation

Z appears to be embracing feminism as a positive thing, with the notion of gender equality being definite. Most women born between 1997 and 2012 seem confident in demonstrating the power of activism, mainly via social media (Spiers, 2019).

These generational narratives surrounding feminism can be found within different races as well. Minority women, in particular black women, were less likely to be associated with the idea of a "typical" woman, in reality, a white woman, which led to the first and second waves of the feminist movement failing to advocate for women of color (Goodman, 2020). Because of this previous exclusion, many minority women in the Generation X and Baby Boomer generations feel left out of the movement today. In contrast, white women feel represented and comfortable with the label "feminist" (Johnson-Bailey, 2003). However, younger minority women within Generation Z and Millennial generations believe they are included similarly to white women. Thus, they do not share in the discomfort with the feminist movement, instead viewing it as both a positive ideology and empowering (Spiers, 2019; Cai & Clement, 2016).

Race is not the only factor that must be considered when investigating generational perspectives, as political affiliation also plays a huge role. For example, 75% of Democratic and Democratic-leaning women identify with the term "feminist" as opposed to 42% of Republican and Republican-leaning women (Barroso, 2020). This distinction is in part responsible for the generational differences in viewpoint surrounding feminism, as members of Generation X and Baby Boomers are more politically conservative than Millennials on average, with Generation Z being the most left-leaning (Baxter & Warner, 2015).

With this in mind, the history and ever-evolving definition of feminism account partly for the intergenerational divide concerning modern feminism. However, it is essential not to disregard the racial and political components of American women of all generations that play a significant factor in the differentiating perspective surrounding feminism.

Research Inquiry

It can be argued that efforts to consider intersectionality regarding feminism, in particular the tense dynamic between black women in the United States and the feminist movement, both historically and currently, have begun building a presence in modern conversations regarding feminism (Goodman, 2020). However, it is rarely considered whether a racial or political component further agitates these present divides towards intergenerational feminism as a movement or the goal of gender equality; Thus, this gap in literature is what the present research aims to clarify.

Hypotheses

It is hypothesized that:

Generational hypotheses:

1. Women from the Baby Boomer generation have a negative perception of feminism, which will negatively influence their perception of gender equality.
2. Women from the Generation X generation have a negative perception of feminism which

will negatively influence their perception of gender equality.

3. Women from the Millennial generation have a negative perception of feminism; however, their views on gender equality will be positive.
4. Women from the Generation Z generation view both feminism and gender equality as positive.

Race-related hypotheses:

1. White women of all generations view feminism as more positive than minority women within all generations.
2. No difference between the perception of gender equality held by white women and minority women of all generations

Political party affiliation-related hypotheses:

1. Democratic and Democratic-leaning women have a positive perception of feminism which will positively influence their perception of gender equality.
2. Republican and Republican-leaning women have a negative perception of feminism, which will negatively influence their perception of gender equality.

Method

Participants

For five months (October 2022 to February 2023), a sample of 188 females completed a survey titled "Generational Perspectives on Feminism." The survey was composed of three sections: basic demographic information, the *2020 Pew Research Center Social and Demographic Trends Survey,* and the *2016 Washington Post and Kaiser Family Foundation Feminism Survey.* All participation was completed on a volunteer basis. All participants are between 13 to 76 years old, [Mean=35.35] and [Standard Deviation=19.40]. Participants within Generation Z are recruited from Sacred Heart Academy (Hempstead, NY), and women aged 26 to 76 will be recruited from the surrounding area. Participants gave their assent and one parent or guardian gave their consent if the participant is a minor. Of the 188 participants, 85 were within Generation Z (Generation A), 34 were within the Millennial generation (Generation B), 35 were within Generation X (Generation C), and 34 were within the Baby Boomer generation (Generation D). Due to the low quantity of participants within certain race groups, the decision was made to only consider non-Hispanic white, black or African American, and Asian or Asian-American participants from the duration of this study (See Table 1 for race statistics.)

Table 1: Race Statistics

Race	Nassau County	Participants	A	B	C	D
Asian or Asian-American	10.60%	15.40%	51.90%	25.90%	14.80%	7.40%

Black or African American	12.60%	14.40%	9.60%	38.10%	33.30%	19.00%
Hawaiian or Other Pacific Islander	0%	1.10%	0%	0%	100%	0%
Hispanic or Latino	17.10%	8.00%	26.70%	13.30%	20.30%	39.70%
Non-Hispanic or Latino	57.10%	61.09%	43.70%	15.40%	21.60%	19.30%
Other	2.50%	0.01%	50.00%	0%	0%	50.00%

Table 2: Political Affiliation Statistics

Political Affiliation	Participants	A	B	C	D
Democratic	22.87%	55.81%	20.93%	16.28%	6.98%
Democratic-Leaning	30.32%	63.16%	21.05%	3.51%	12.28%
Republican	21.81%	21.43%	9.52%	28.57%	40.48%
Republican-Leaning	21.81%	28.57%	21.43%	33.33%	16.67%

Procedure

The participants completed the survey online via a Google Form at individual computers. After providing proper consent to participate in the survey, participants were then directed to provide demographic information, including their birth year range, racial identity, and their political affiliation. The responses to each question were recorded on Google Sheets, including demographic information and the numerical value of the responses. The data was then analyzed with the Statistical Package for the Social Sciences (SPSS) program. To test what was hypothesized, this study used multiple *t-tests* for two independent means.

Instruments

Title	Author(s)/Date	Purpose and Scale	Sample Questions
Pew Research Center Social &	Barroso, 2020.	Measures participant's perception of feminism.	1. "Empowering". 2. "Outdated" 3. "Inclusive"

Demographic Trends Survey		Responses to 6 items are recorded on 3-point scale (0=No opinion, 1=No, does not describe feminism, 2=Yes, describes feminism).	4. "Polarizing" 5. "Optimistic" 6. "Angry"
Washington Post/Kaiser Family Foundation Feminism Survey (Part A)	Cai & Clement, 2016.	Measures participant's belief in the reputation of 'feminism'/'women's movement'. Responses to 19 items are recorded on 5-point scale (0=No opinion, 1=Very Unfavorable, 2=Unfavorable, 3=Favorable, 4=Very Favorable).	1. In general, do you have a favorable or unfavorable impression of feminism? 2. In general, do you have a favorable or unfavorable impression of the women's movement?
Washington Post/Kaiser Family Foundation Feminism Survey (Part B)	Cai & Clement, 2016.	Measures participant's belief in gender equality. Responses to 4 items are recorded on 3-point scale (0=No opinion, 1=Not true, 2=True).	1. Looks down on women who do not have jobs. 2. Unfairly blames men for women's challenges.

Results–Generations

　　To test the aforementioned hypotheses, several *t-tests* for 2 independent means were conducted. Among the compared Generational groups, significance emerged between Generation Z and Generation X as well as Generation Z and Baby Boomers in both the actual perception of the modern feminist movement (table 3) and how this perception affected the movement at large and their perception of gender equality as an end goal (table 4) with Generation Z largely perceiving the modern feminist movement as positive while simultaneously viewing the concept of gender equality more positively than their older predecessors. In addition, Millennial women perceive current feminism as more positive than Generation X and Baby Boomers (table 3); however, these perceptions influenced Millennials and Generation X similarly, as both generations largely view the concept of gender equality as a positive concept while Millennial women differ from Baby Boomers with Baby Boomers rejecting the concept of equality among the sexes on a political, economic, and social level while Millennials felt more positive about gender equality (table 4). Between Generation Z and Millennial women and Generation X and

Baby Boomers, there was no significant difference concerning feminism (table 3) nor the concept of gender equality (table 4).

Table 3: Results for Generational Comparisons (Section 1)

Groups Compared	T-Values	P-Values	Significance
Generation Z to Millennials	0.53	0.60	not significant at p < .05.
Generation Z to Generation X	4.93	0.0001	significant at p < .05
Generation Z to Baby Boomers	3.87	0.0002	significant at p < .05.
Millennials to Generation X	3.95	0.0002	significant at p < .05.
Millennials to Baby Boomers	3.17	0.002	significant at p < .05.
Generation X to Baby Boomers	-1.29	0.20	not significant at p < .05.

Table 4: Results for Generational Comparisons (Section 2)

Groups Compared	T-Values	P-Values	Significance
Generation Z to Millennials	0.65	0.52	not significant at p < .05.
Generation Z to Generation X	2.60	0.01	significant at p < .05.
Generation Z to Baby Boomers	2.92	0.004	significant at p < .05.
Millennials to Generation X	1.58	0.19	not significant at p < .05.
Millennials to Baby Boomers	2.19	0.03	significant at p < .05.
Generation X to Baby Boomers	0.44	0.66	not significant at p < .05.

Race

A significant difference emerged between black and non-Hispanic white women regarding feminism (Table 5) and the concept of gender equality (Table 6) wherein white women largely regarded feminism and its goal of gender equality as more positive. While a significant difference was present between Asian and black women concerning feminism (Table 5) with the former viewing feminism with a negative perception, the concept of gender equality (Table 6) held no significant difference. Moreover, there was no significant difference between Asian and non-Hispanic white women regarding feminism (Table 5) and the concept of gender equality (Table 6).

Table 5: Results for Racial Comparisons (Section 1)

Groups Compared	T-Values	P-Values	Significance
Asian or Asian-American to Black or African American	2.51	0.02	Significant at p < .05.
Asian or Asian-American to Non-Hispanic White	0.77	0.44	Not significant at p < .05.
Black or African American to Non-Hispanic White	-2.31	0.02	Significant at p < .05.

Table 6: Results for Racial Comparisons (Section 2)

Groups Compared	T-Values	P-Values	Significance
Asian or Asian-American to Black or African American	0.98	0.33	Not significant at p < .05.
Asian or Asian-American to Non-Hispanic White	0.06	0.96	Not significant at p < .05.
Black or African American to Non-Hispanic White	-2.42	0.001	Significant at p < .05.

Political Party Affiliation

Finally, significance was apparent between women who identify as Republican-leaning and Republican, with the former viewing modern feminism as less negative than republican women (Table 7) as well as perceiving the movement as a whole more positively with the goal of gender equality seeming more positive (Table 8). Furthermore, republican-leaning women are more likely to perceive modern feminism as a negative movement than both Democrat-leaning women and Democrats (Table 7) with Republican-leaning women seeing the larger goal for equality as less positive (Table 8). Overall, republican women see feminism, both modern and theoretically, as more negative than all other political affiliations tested (Table 7). Republican women also regard the concept of gender equality more negatively than any other political alignment tested (Table 8). While democrats see modern-day feminism as more positive than democrat-leaning women (Table 7), there was no difference in how this perception affects their view of gender equality and the necessity of the feminist movement at large (Table 8).

Table 7: Results for Political Affiliation Comparisons (Section 1)

Groups Compared	T-Values	P-Values	Significance
Republican-leaning to Republican	2.99	0.004	Significant at p < .05.
Republican-Leaning to Democrat-leaning	-2.41	0 .02	Significant at p < .05.
Republican-Leaning to Democrat	-3.05	0.003	Significant at p < .05.
Republican to Democrat-leaning	-5.90	0.0002	Significant at p < .05.
Republican to Democrat	-6.72	0.0001	Significant at p < .05.
Democrat-leaning to Democrat	-0.74	0.46	Not significant at p < .05.

Table 8: Results for Political Affiliation Comparisons (Section 2)

Groups Compared	T-Values	P-Values	Significance
Republican-leaning to Republican	2.26	0.03	Significant at p < .05.
Republican-Leaning to Democrat-leaning	-2.85	0.005	Significant at p < .05.
Republican-Leaning to Democrat	-4.83	0.006	Significant at p < .05.
Republican to Democrat-leaning	-5.36	0.00001	Significant at p < .05.
Republican to Democrat	-7.32	0.009	Significant at p < .05.
Democrat-leaning to Democrat	-2.20	0.03	Significant at p < .05.

Discussion
Generations

The hypotheses regarding generational perspectives were partly correct considering older generations view feminism and, subsequently, gender equality more negatively than Millennials

and Generation Z women. Moreover, Generation Z largely perceives the modern feminist movement as positive while simultaneously advocating for gender equality, whereas their older predecessors, on average, view modern feminism more negatively while still claiming to be feminists and supporters of equality (Caeiro, 2021). The perceptions of feminism influenced Millennials and Generation X similarly, as both generations largely avoid titling themselves as feminists and view the movement as redundant in the United States (Weinberger, 2012). In contrast, Millennial women differ from Baby Boomers, with Baby Boomers rejecting the concept of equality among the sexes on a political, economic, and social level, while Millennials felt more inclined to champion equality (Abdelmalek, 2019). Additionally, there is no difference of opinion held by the two youngest generations (Generation Z and Millennials) and two oldest generations (Generation X and Baby Boomers) presumably because they are too close in age to fully develop distinctions (Rampton, 2015). However, it may appear as though Generation Z is vastly different from all their predecessors, including Millennial women, through social media, which has allowed Generation Z to more easily appear active in the feminist movement (Spiers, 2019). This is further helped by the prevalence of gender equality within media and the growing opportunities for adolescent women within Generation Z to feel equivalent to their male peers (Weinberger, 2012).

Race

Concerning the proposed hypotheses regarding race, the results were more complex. From the significant difference between the opinions of the feminist movement seen between Asian-American and Black-American women, it is clear that the different cultural significance of gender roles continues to impact the cultural perception of social movements such as the feminist movement (Nash, 2022). Cultural differences between Asian Americans and Black Americans can impact their different perceptions of feminism. In traditional Asian cultures, gender roles are often more strictly defined, and the concept of feminism may be perceived as a threat to these norms (Nash, 2022). Additionally, Asian Americans may be more likely to prioritize family values and the collective good over individual rights, which can affect their understanding and support of feminist ideals such as reproductive rights and gender equality (Nash, 2022). On the other hand, the historical experiences of Black Americans with slavery, segregation, and systemic racism have shaped their perceptions of gender equality and intersectionality (Goodman, 2020). Black women in particular have experienced a unique form of oppression that has led to the development of a distinct form of feminism, one that is often more radical and focused on issues such as Eurocentric beauty standards, economic inequality, and the intersection of race and gender (Johnson-Bailey, 2003). As a result, cultural differences can play a significant role in shaping how Asian Americans and Black Americans perceive and engage with feminism (Nash, 2022). The largest overall difference observed was specifically between non-Hispanic white and black women. Black women, in particular, have such a complex relationship with feminism in the U.S. that their unique experiences and therefore perspectives are different from those of other minority groups, thus further indicating the importance of intersectionality

(Goodman, 2020). Black women have a unique relationship with feminism in the United States because they experience intersectional oppression, where their gender and race intersect to create specific challenges and forms of discrimination that are not experienced by white women or black men (Johnson-Bailey, 2003). This intersectional experience has historically been overlooked and excluded from mainstream feminist movements, which focused primarily on the experiences of white, middle-class women (Johnson-Bailey, 2003). Black women have had to navigate a system that devalues their contributions and perspectives, while also contending with the racism and sexism of mainstream American society at large (Nash, 2022). As a result, black women's experiences have led them to create their own distinct form of feminism that addresses their unique struggles, such as the Combahee River Collective, which highlighted the importance of the intersection of race, class, and gender in shaping women's experiences (Nash, 2022).

Political Party Affiliation

While evaluating the hypotheses regarding political party affiliation, the results indicated that they were, in fact, proven correct. Furthermore, political affiliation is so immensely influential in American feminism because political ideology shapes the way people understand and approach issues related to gender equality (Caeiro, 2021). Political affiliations often align with certain values and priorities, which can affect how individuals engage with feminist activism and the policies they advocate for (Caeiro, 2021). For example, Democrats and Democratic-leaning women tend to prioritize issues such as reproductive rights and equal pay, while Republicans and Republican-leaning women often prioritize traditional gender roles and family values (Bogheiry, Thaha, & Rahmah, 2022). This divide can further exacerbate the intergenerational division regarding feminism and its larger principles, as older generations tend to be more conservative politically (Baxter & Warner, 2015). Moreover, this can lead to different approaches to feminist issues, with Democrats and Democratic-leaning women advocating for policies that protect women's rights and equality, while Republicans and Republican-leaning women may focus on promoting a more traditional view of gender roles and thus perceive the modern feminist movement more negatively (Bogheiry, Thaha, & Rahmah, 2022). Additionally, political affiliation can impact the level of support feminists receive from the government and other institutions, as policies and funding are often influenced by the political climate (Caeiro, 2021). As a result, political affiliation plays a crucial role in shaping the direction and impact of feminist movements in the United States (Caeiro, 2021).

Limitations

The limitation of having to omit some race groups hindered the ability to fully flush out the racial component of my research and would create an insightful study for the future. In addition, my sample was not a fully socioeconomically diverse group due to the location in which participants were found, ultimately causing an underlying influence on the results.

Future Studies

In addition to fully exploring the racial divides among American women's perceptions of feminism, in a future study, this survey could apply to male participants as well. This would be beneficial to understanding men's attitudes towards feminism, as it is often incorrectly perceived as exclusively a women's issue.

Works Cited

Aabye-Gayle, M. (2018, January 9). The feminist generation gap: Is there room for feminism to evolve? *The Body Is Not an Apology*. Retrieved September 12, 2022, from https://thebodyisnotanapology.com/magazine/the-feminist-generation-gap-is-there-room-for-feminism-to-evolve/

Barroso, A. (2021, March 10). 61% of U.S. women say 'feminist' describes them well; many see feminism as empowering, polarizing. *Pew Research Center*. Retrieved September 12, 2022, from https://www.pewresearch.org/fact-tank/2020/07/07/61-of-u-s-women-say-feminist-describes-them-well-many-see-feminism-as-empowering-polarizing/

Baxter, E., & Warner, J. (2015, May 12). Fact sheet: 4 generations of American women. *Center for American Progress*. Retrieved September 12, 2022, from https://www.americanprogress.org/article/fact-sheet-4-generations-of-american-women/

Bindel, J. (2021, September 2). The war between Baby Boomers and Gen Z over feminism is hurting both mothers and daughters. *The Telegraph*. Retrieved September 12, 2022, from https://www.telegraph.co.uk/women/life/war-baby-boomers-gen-z-feminism-hurting-mothers-daughters/

Bogheiry, A., Thaha, M. T., & Rahmah, L. (2022). Feminism and politics: A study on women's representation in the simultaneous regional elections 2018 in Makassar City. *Journal of World Science*, 1(10), 829–843. https://doi.org/10.58344/jws.v1i10.101

Brunell, L. (2019). Feminism - Definition, history, types, waves, examples, & facts. *Encyclopedia Britannica*. Retrieved September 12, 2022, from https://www.britannica.com/topic/feminism

Burkett, E., & Brunell, L. (2022). Feminism - The second wave of feminism. *Encyclopedia Britannica*. Retrieved September 12, 2022, from https://www.britannica.com/topic/feminism/The-second-wave-of-feminism

Caeiro, C. (2021, November). Feminism for the Americas: The making of an international human rights movement. *International Affairs*, *144*(1), 104-107. https://web.p.ebscohost.com/ehost/detail/detail?vid=2&sid=a597c17b-f971-49ee-a246-33d0cf725108%40redis&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#AN=153655799&db=asn

Cai, W., & Clement, S. (2016). What Americans think about feminism today. *The Washington Post*. Retrieved September 12, 2022, from https://www.washingtonpost.com/graphics/national/feminism-project/poll/

Caro, J. (2019, August 22). Female Baby Boomers changed the world - but they're also struggling to keep up. *7NEWS*. Retrieved September 12, 2022, from https://7news.com.au/the-daily-edition/female-baby-boomers-changed-the-world-but-theyre-also-struggling-to-keep-up-c-411329

Goodman, B. (2020). Black Women often ignored by social justice movements. *American Psychological Association*.

https://www.apa.org/news/press/releases/2020/07/black-women-social-justice

Jarvis, B. (2020, June 23). Feminism: the third wave. *National Women's History Museum.* Retrieved September 12, 2022, from https://www.womenshistory.org/exhibits/feminism-third-wave

Johnson-Bailey, J. (2003). Everyday perspectives on feminism: African American women speak out. *Race, Gender & Class Journal, 10*(3), 82-99. https://www.jstor.org/stable/41675089

Ma, A. (2015, March 7). The evolution of feminism. *Harvard Political Review.* Retrieved September 12, 2022, from https://harvardpolitics.com/evolution-feminism/

Marton, S. (2017, April 1). Millennial vs. Baby Boomer feminism: Cross-generational strategies must converge. *HuffPost.* Retrieved September 12, 2022, from https://www.huffpost.com/entry/millennial-vs-baby-boomer_b_9583712

Matthew, E. (2020, April 7). Gen-X women can't 'have it all' after all. *America Magazine.* Retrieved September 12, 2022, from https://www.americamagazine.org/arts-culture/2020/03/20/gen-x-women-cant-have-it-all-after-all

McGuinness, P. P. (2021, March 12). Boomer feminism is not what we need at this transformational moment. *The Sydney Morning Herald.* Retrieved September 12, 2022, from https://www.smh.com.au/national/boomer-feminism-is-not-what-we-need-at-this-transformational-moment-20210312-p57a67.html

Nash, J. (2022). Slow loss: Black feminism and endurance. *Duke University Press, 40*(2), 1-20. https://web.p.ebscohost.com/ehost/detail/detail?vid=5&sid=9f73122c-beff-4d39-a89a-2bda604d65be%40redis&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#AN=157489150&db=asn

Offen, K. (1988, October). Defining feminism: A comparative historical approach. *Journal of Women in Culture and Society, 14*(1), 119–157. https://doi.org/10.1086/494494

Pruitt, S. (2022, March 11). What are the four waves of feminism? *HISTORY.* Retrieved September 12, 2022, from https://www.history.com/news/feminism-four-waves

Rampton, M. (2015). Four waves of feminism. *Pacific University.* Retrieved September 12, 2022, from https://www.pacificu.edu/magazine/four-waves-feminism

Spiers, E. (2019, April 5). Why Generation Z is embracing feminism. *Pacific Standard.* Retrieved September 12, 2022, from https://psmag.com/ideas/why-generation-z-is-embracing-feminism

United States Census Bureau. (2022). U.S. Census Bureau: Nassau County, New York. *Census Bureau QuickFacts.* Retrieved March 30, 2023, from https://www.census.gov/quickfacts/nassaucountynewyork

Weinberger, H. S. T. C. (2012, November 10). Where are all the Millennial feminists? *CNN.* Retrieved September 12, 2022, from https://edition.cnn.com/2012/11/09/living/millennials-feminism

Winch, A., et al. (2016). Why "intergenerational feminist media studies"?. *Feminist Media*

The Application of Small Molecule Drugs: Cancer Therapy By Abhinav simhadri

Abstract

  According to the World Health Organization, Cancer is one of the world's deadliest diseases and is the second leading cause of death in the United States. Cancer has been responsible for almost 10 million deaths worldwide in 2020, with the most common forms of cancer being breast, lung, and colon & rectum cancer. To put into scale just how deadly the disease is, the rate of cancer deaths per year is about 158 per 100,000 men and women. Current traditional cancer therapies include chemotherapy, radiation therapy, and surgery. Although these traditional cancer therapy methods have been somewhat effective over the past decades, they come with serious adverse health effects and have been related to very serious long-term side effects. As a result, over the recent years, targeted cancer therapy using small molecule drugs has become a focus in the medical field of cancer treatment. Small molecule drugs have a very advanced and tunable targeting ability which is effective in passing through cell membranes and reaching their designed intracellular targets. Most of these drugs can be administered orally, and due to their very small size, they are able to pass through a variety of obstacles in order to inhibit certain cancer-related biomolecules. In this review, I provide a summary of several different SMIs (small molecule inhibitors) that can be used in cancer therapy and explain recent advances as well as future outlooks in the field of SMIs for cancer treatment.

Keywords: Small Molecule Drugs, Cancer, inhibitors, molecular, targeted therapy

The Application of Small Molecule Drugs: Cancer Therapy

  Currently, the three forms of therapy for Cancer include surgery, chemotherapy, and radiation therapy. Surgery is fairly straightforward and is used to remove the tumor and nearby tissue during an operation. There are several adverse side effects to cancer surgery which include numbness, lymphedema, appetite loss, swelling, and organ dysfunction (V. Lavanya, M. Adil, N. Ahmed, A. Rishi, S. Jamal, 2014). As for Chemotherapy, drugs are used in order to target and kill the rapidly dividing cancer cells. However, many of these drugs are unable to distinguish the difference between normal cells and cancer cells, which can cause them to target normal cells as well - causing damage to bone marrow, hair follicles, and digestive tracks. This causes the patient, being treated by chemotherapy, to experience adverse effects including diarrhea, fatigue, anemia, alopecia, and nausea, just to list a few. When it comes to radiation therapy, high-energy waves (in the form of radiation) are used to destroy cancer cells. However, similar to the effects of chemotherapy, radiation therapy can cause swelling in tissues, pose harm to epithelial surfaces, and can incur patients to intestinal damage. Many popular, current cancer therapy systems being used in the industry combine the methodologies of chemotherapy and radiation therapy. Because of the many adverse effects posed by current forms of therapy, Cancer Research has been shifted towards the fields of targeted cancer therapy - using the approach of searching for specific molecular targets, which can help slow down or diminish the effects of

cancer on the body and nearby cells. Using targeted cancer therapy methods, research is able to differentiate healthy cells and cancer cells- avoiding any healthy cells being destroyed, and side effects occurring.

When it comes to targeted drug delivery and therapy, there are two types of compounds that can be used: Small Molecule Drugs and Macromolecule drugs (G. Wilkes, 2018). The main difference between the two are size; Macromolecule are about 150,000 Da, while small molecule drugs are less than 500 Da. Due to the small size of these small molecule drugs, they are able to easily and effortlessly traverse through cell membranes, bind to cell receptors or targets, and do the task they were designed to do. When it comes to cancer therapy and targeted drug delivery using these molecules, the two main options used in clinical practice include small molecule agents and monoclonal antibodies (macromolecule).

Scientific Review
Small Molecule Kinase inhibitors

Protein kinase is a type of enzyme which is responsible for catalyzing the transfer of a phosphate group, from ATP to protein residues. Phosphates, in contrast, have the exact opposite function of protein kinase, where they are responsible for removing a phosphate group from a protein. The counter mechanisms between the protein kinase and phosphates are what cause the regulation of protein activity in the body and improve the plasticity of the epigenome. However, when the protein kinase is overexpressed, it messes up this balance- and in turn causes promotion in cell proliferation, survival, and growth. The biochemical reaction that protein kinase is responsible for catalyzing is: $MgATP1{-}+protein{-}O{:}H{\rightarrow}protein{-}O{:}PO32{-}+MgADP+H+$

The protein kinase enzyme supports and carries out many things which have an important role in cell growth, proliferation, and differentiation. Protein Kinase inhibitors have the job of regulating these protein kinases, preventing, and proving therapy for the various disease protein kinases are linked to- including cancer. The Protein Kinase inhibitors are

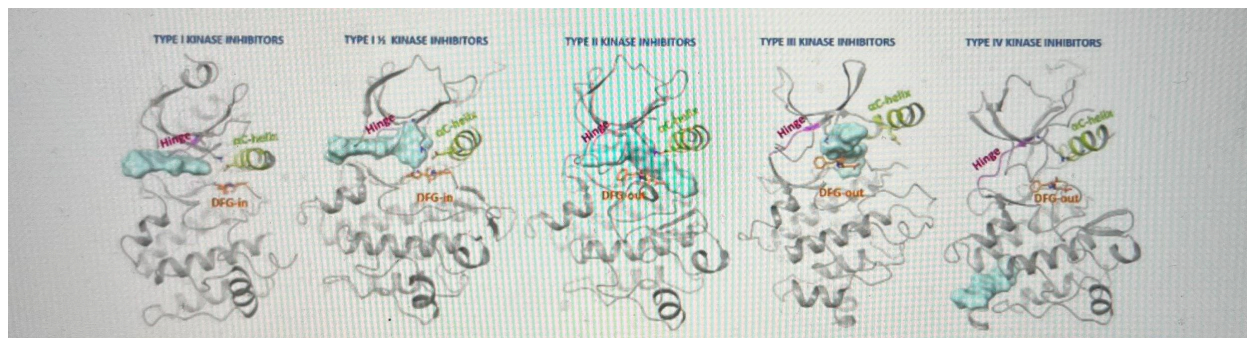classified into six different types, all of which have separate binding locations and functions (See Figure 1).

Figure 1. The structures of the 6 types of kinase inhibitors. The indicator of wether the kinase is active or inactive, is the position of the C-helix together with the DFG motif. The ATP binding gatekeeper and cleft are shown in the structure as well. From Gluza, K., & Dobrzańska, M.

(2016, June 16). New horizons in next-generation small molecule kinase inhibitors. Drug Target Review.

https://www.drugtargetreview.com/article/12269/new-horizons-next-generation-small-molecule-kinase-inhibitors/

RTKs, receptor tyrosine kinases, is one of the most common targets for anti-cancer drugs. Activation of these targets have been linked to the downstream signaling involving pivotal cytoplasmic kinases being activated. In turn, this causes increased cell growth and survival, especially in cancer cells, and is found to contribute to the progression and spreading of cancer. In many cancers, the activation and overexpression of these RTKs leads to promotion in cancer cell growth and survival, contributing to cancer-associated angiogenesis. So, by preventing and regulating these RTKs, we are able to control and manage cancer cell growth. To go more in detail, scientists and researchers have observed that the activation of tyrosine kinase leads to a downstream signaling cascade- which sends a signal through a certain pathway affecting various different growth factor receptors. These growth factor receptors, when activated, can have a big effect on the development and progression of neoplastic diseases, like cancer.

There have been many FDA-approved kinase inhibitors that have made it past clinical trials and into general use for cancer patients, one of which includes Crizotinib. This drug, manufactured by Xalkori, is a small molecule inhibitor drug used to treat NSCLC (non-small cell lung cancer) and ALCL (anaplastic large cell lymphoma). It can be administered orally through a capsule and works by blocking the action of a natural substance, Tyrosine, which is needed to help cancer cells multiply and grow.

Small Molecule MMPs, HSPs inhibitors

MMPs, Matrix metalloproteinases, are a group of endopeptidases like the protein kinase. However, the difference between them is their functions- MMPs are involved in the degradation of extracellular matrices (See Figure 2), which is known for promoting cell invasion and migration. There are over 20 MMPs that are naturally in humans, and they are generally regulated by the TIMPs (tissue inducers of metalloproteinases). When a patient has cancer, certain gelatinases like MMP-2 and MMP-9 turn to target signaling pathways and aggravate cancer cell migration and invasion. This causes the promotion of cancer-related tumor growth and metastasis spreading. However, these MMPs did not find great success at clinical trials and came with certain side effects making it less desirable than Kinase inhibitors, for example. The main reason why they were not able to pass the clinical trials was because of the fact that the MMP inhibitors would non-specifically bind to a variety of different MMPs in the body- including a few that were not identified as having cancer-promotion functions. This means that certain normal, healthy MMPs are harmed which can lead to various adverse side effects in the body.
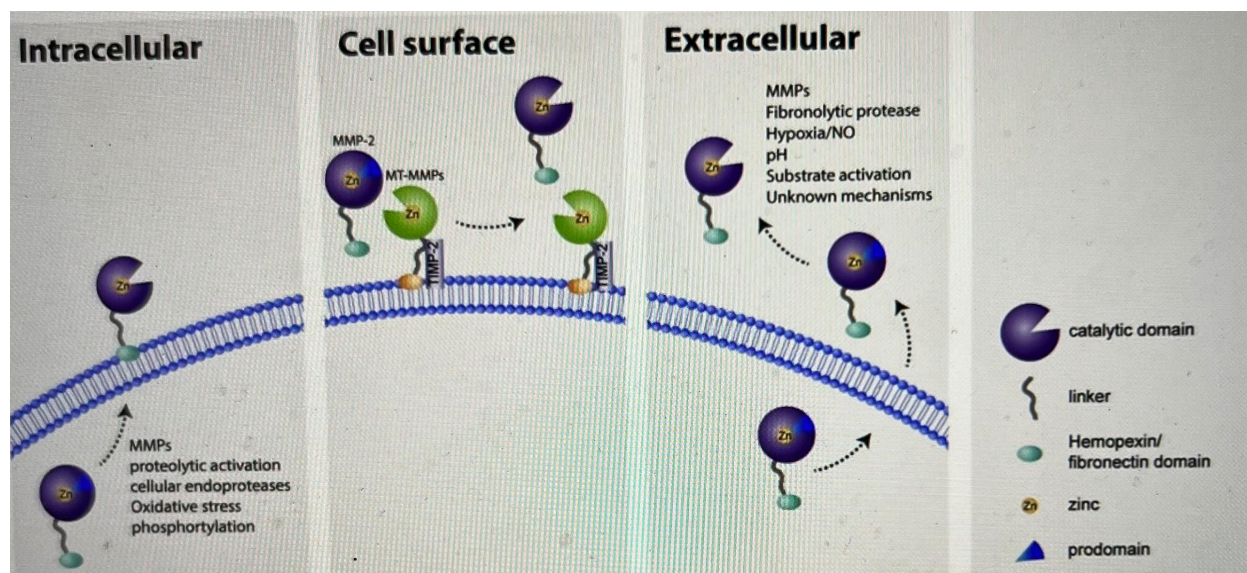
Figure 2. Schematic representing different types of MMP activation. These different types of activation of MMPs are what case the degradation of extracellular matrices, resulting in promotion of cancer cell invasion and migration. From Gaffney, J., Solomonov, I., Zehorai, E., & Sagi, I. (2015, May 1). Multilevel regulation of matrix metalloproteinases in tissue homeostasis indicates their molecular specificity in vivo. ScienceDirect.

HSPs, Heat shock proteins, are chaperons that are responsible for folding and transporting proteins across the cellular membrane. This is related to cancer progression and aggression because it is also responsible for the folding and transport of oncoproteins. These oncoproteins play an important role in many signaling pathways and are found to support and promote cancer. Through extended and deep research, scientists have observed that the expression levels of HSPs are particularly high when a patient has cancer, when compared to a normal person. These high expression levels of HSPs have been linked to resistance to chemotherapy and inhibition of apoptosis (C. Soti, P. Csermely). So, through the use of HSP inhibitors, scientists were able to regulate the expression levels of HSPs, which in turn resulted in a patient being less resistant to chemotherapy and more open to cancer-cell apoptosis inside their body. This allowed a slower progress in cancer cell growth and allowed room for cancer-management- hence why it is used as a target for targeted cancer inhibitors.

Small Molecule Proteasome inhibitors

Proteosomes are large enzymes in the body that are expressed in the nucleus and cytoplasm of all eukaryotic cells. They are mainly responsible for protein degradation and play roles in maintaining cellular protein homeostasis. They are responsible for various tasks regarding cell survival, proliferation of malignant cells, and DNA repair (A. Nunes, C. Annunziata, 2019). The small molecule proteosome inhibitors work on a specific pathway known as the UPP, ubiquitin proteasome pathway. This pathway is known to help maintain homeostasis at a cellular level, and also favors cancer cell survival by promoting cell

144

proliferation and inhibiting apoptosis of tumors. The UPP is involved in degradation of cell cycle regulators and proteolysis of various cyclin kinases, both of which contribute to transition (from one phase to another) of the cell cycle. The UPP plays a major role in tumor cell survival and progression due to the resistance to cancer cell aptosis. Through the use of proteosome inhibitors, scientists were able to prevent the degradation of the cell cycle and aptotic regulators. This lowered the efficacy and survival rate of cancer cells, allowing for ease of cancer management and therapy.

One example of a small molecule proteasome inhibitor is bortezomib, manufactured by Velcade. It is mainly used to treat various special cancers, including renal carcinoma, mantle cell lymphoma, and multiple myeloma. Bortezomib was shown to promote apoptosis, or cell death, of cancer cells and had tumor suppressing abilities. It was able to successfully suppress the p53 gene, which led to promotion in cancer cell aptosis. The main disadvantage of Bortezomib comparing to other competing drugs (like oprozomib, ixazomib, and marizomib) is that Bortezomib has to be administered through injection, whereas these other inhibitors are able to be orally administered. However, the use of UPP-targeting drugs during clinical trials were linked with some adverse effects like thrombocytopenia and peripheral neuropathy. Additionally, when the patients were taking bortezomib- the researchers noticed that the cancer in their bodies eventually started developing resistance to the drug.

Concluding Statements - Future Outlooks and Limitations

Currently, there are exactly 89 small-molecule drugs designed to treat cancers which have been approved by the FDA and/or NMPA. Although molecular biology and use of targeted drugs have been a relatively long researched area, it has only gained attention of the general public over the last decade. Consequently, the development and application of small molecule drugs – which are able to use the knowledge of molecular structure in order to effectively target intracellular and extracellular cell – have entered at a rapid development stage. As a result, over the last decade or so, the success of small molecule targeted cancer drugs has been of higher success than conventional chemotherapy, and other types of traditional cancer therapy. However, the rate at which new drugs are researched and developed are very slow- with many of them failing at clinical phases (See Figure 3). This is mainly due to the various limitations that small molecule drugs bring, as well as the limited experience we have in the field. One of these limitations include the body developing drug resistance- after a period of time of clinical use. The drug-resistance that is developed by the body after period of use of anti-cancer drugs have been mainly been caused by gene mutations, amplifications, apoptosis

Brigatinib: ALK/EGFR/IGF1R/FLT3/ROS inhibitor
Tivozanib: PDGFR/VEGFR/FGFR/KIT/RET inhibitor
Acalabrutinib: BTK inhibitor
Ribociclib: CDK4/6 inhibitor
Abemaciclib: CDK4/6 inhibitor
Neratinib: EGFR/HER2 inhibitor
Midostaurin: FLT3/KIT inhibitor
Enasidenib: IDH2 inhibitor
Niraparib: PARP inhibitor
Copanlisib: PI3K inhibitor

Pemigatinib: FGFR inhibitor
Avapritinib: KIT/PDGFR inhibitor
Ripretinib: KIT/PDGFR inhibitor
Selumetinib: MEK1/2 inhibitor
Capmatinib: c-Met inhibitor
Tepotinib: c-Met inhibitor
Tucatinib: HER2 inhibitor
Almonertinib: EGFR inhibitor
Tazemetostat: EZH2 inhibitor
Selpercatinib: RET inhibitor
Pralsetinib: RET inhibitor

Cabozantinib: VEGFR/ROS/TIE2/c-Met//KIT/TRK2/RET inhibitor
Ponatinib: Bcr-Abl/PDGFR/FGFR/Src/FLT3/KIT inhibitor
Afatinib: EGFR/HER2/4 inhibitor
Ibrutinib: BTK inhibitor
Trametinib: MEK1/2 inhibitor
Dabrafenib: BRAF/CRAF inhibitor

Imatinib: Bcr-Abl/PDGFR/KIT inhibitor

Pazopanib: PDGFR/VEGFR/KIT/FGFR/ITK inhibitor
Everolimus: mTOR inhibitor

Erlotinib: EGFR inhibitor

Axitinib: VEGFR inhibitor
Radotinib: Bcr-Abl inhibitor
Bosutinib: Abl1/Src inhibitor
Vismodegib: SMO inhibitor
Carfilzomib: Proteasome inhibitor
Regorafenib: VEGFR/PDGFR/FGFR/RAF/RET/KIT inhibitor

Pexidartinib: CSF1R/KIT/FLT3 inhibitor
Zanubrutinib: BTK inhibitor
Entrectinib: TRK inhibitor
Erdafitinib: FGFR inhibitor
Quizartinib: FLT3 inhibitor
Fedratinib: JAK2 inhibitor
Alpelisib: PI3Kα inhibitor

Sunitinib: PDGFR/VEGFR/FLT3/KIT/RET inhibitor
Dasatinib: Bcr-Abl/Src/KIT/LCK/PDGFR inhibitor
Vorinostat: HDAC inhibitor

2001 2003 2004 2005 2006 2007 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Gefitinib: EGFR inhibitor
Bortezomib: Proteasome inhibitor

Nilotinib: Bcr-Abl inhibitor
Lapatinib: HER2/EGFR inhibitor
Temsirolimus: mTOR inhibitor

Ceritinib: ALK/ROS inhibitor
Apatinib: VEGFR2 inhibitor
Belinostat: HDAC inhibitor
Olaparib: PARP inhibitor
Idelalisib: PI3Kδ inhibitor

Venetoclax: BCL-2 inhibitor
Rucaparib: PARP inhibitor

Romidepsin: HDAC inhibitor

Sorafenib: VEGFR/KIT/FLT3/PDGFR inhibitor

Icotinib: EGFR inhibitor
Crizotinib: ALK/ROS/c-Met inhibitor
Vandetanib: EGFR/VEGFR/RET inhibitor
Ruxolitinib: JAK1/2 inhibitor
Vemurafenib: BRAF inhibitor

Alectinib: ALK inhibitor
Cobimetinib: MEK1/2 inhibitor
Palbociclib: CDK4/6 inhibitor
Osimertinib: EGFR inhibitor
Sonidegib: SMO inhibitor
Sirolimus: mTOR inhibitor
Panobinostat: HDAC inhibitor
Tucidinostat: HDAC inhibitor
Ixazomib: Proteasome inhibitor
Lenvatinib: PDGFR/VEGFR/FGFR/KIT/RET inhibitor
Nintedanib: VEGFR/PDGFR/FGFR/MDR1/BCRP inhibitor

Anlotinib: VEGFR/PDGFR/FGFR inhibitor
Lorlatinib: ALK inhibitor
Fruquintinib: VEGFR inhibitor
Binimetinib: MEK1/2 inhibitor
Encorafenib: BRAF inhibitor
Dacomitinib: EGFR inhibitor
Gilteritinib: FLT3 inhibitor
Glasdegib: SMO inhibitor
Ivosidenib: IDH1 inhibitor
Larotrectinib: TRK inhibitor
Talazoparib: PARP inhibitor
Duvelisib: PI3Kδ/γ inhibitor

Timeline for the approval of small-molecule targeted anti-cancer drugs

Figure 3. A timeline showing the approval, targets, and name of small-molecule inhibitors for cancer treatment. From Zhong, L., Li, Y., Xiong, L., Wang, W., Wu, M., Yuan, T., Yang, W., Tian, C., Miao, Z., Wang, T., & Yang, S. (2021, May 31). Small molecules in targeted cancer therapy. Signal Transduction and Targeted Therapy. https://www.nature.com/articles/s41392-021-00572-w?error=cookies_not_supported&code=79503ca7-6a44-488f-9834-8fe078a1b219#Fig1

The leading reason that contributes to cancer drug resistance is gene mutations. There are two main types of gene mutations: gene mutations induced by the drugs, and drug-resistant mutations that have already existed by chance. When the treatment has just started, the cancer cell with no mutations dominates and decrease the number

However, when a period of time has passed and the drug is fully introduced to the cells, the cancer cells with no mutations will be killed allowing the cells with resistant mutations to become mainstream and split across the population.

Another common reason contributing to cancer drug resistance is amplification. When certain genes, like MET, CSC, and efflux transporters, are amplified, they tend to resist the inhibitor by hindering it from doing its job. For instance, the CSC theory says that different cells

withing a tumor, all originate from the same single subpopulation of cells with self-renewable and differentiation capabilities. Due to this theory connecting the methodologies of tumor cells and stem cells, we can conclude that amplifying CSC gene, which causes drug resistance and recurrency to increase, at the original subpopulation level can cause the rest of the tumor cell population to change- allowing for resistance to drugs across all tumor cells.

Aside from gene mutations and amplifications, another major challenge for anti-cancer drugs at a clinical trial phase is the low efficacy. The lower efficacy of targeted anti-cancer drugs, when compared to the traditional means of cancer treatment, is why it has not been adopted as the main form of cancer treatment yet. Currently, the reason why many patients go through chemotherapy, radiation, and surgery for cancer treatment is that anti-cancer drugs are not very versatile, as of now, and have only worked in limited number of patients. Due to the pre-existing mutations explained earlier, less than 20% of patients with NSCLC are sensitive to EGFR inhibitors (type of small molecule inhibitor). This means that these EGFR inhibitors have less than 20% chance of efficacy in treating a patient with NSCLC.

In conclusion, the current state of small molecule drugs, although seemingly promising, is not very ready for providing efficient and effective treatment for cancer at a public level. Due to the various benefits that small molecule drugs bring (like low cost), it can be used in the near future to treat cancer in patients around the world (no matter where they life, whether it be a low- or middle-income country). Along with continuing to explore current cancer targets and increasing the efficiency of current drugs on the market, researchers should also explore new types of cancer treatments and other pathways that play a significant role in cancer and tumor cells. Additionally, it is important to note that the power of small molecule drugs have been researched to work well when combined with other means of cancer treatment like tumor immunotherapy. So, although scientists have implemented this and gotten it over clinical trials yet, it is hopeful to believe that in the next decade, small molecule drugs like ADC and PROTAC will gain significant development and improvement. Soon, there definitely be new small molecule drugs on the public market with increased efficacy- and further & continued research in this field may result in a revolutionary medicine being discovered. There is no doubt that small-molecule targeted drugs will continue to be in the mainstream research area for cancer treatment, given their unique advantages over macromolecule drugs.

Works Cited

Burger, A., & Seth, A. (2004, October 1). The ubiquitin-mediated protein degradation pathway in
cancer: therapeutic implications. ScienceDirect.
https://www.sciencedirect.com/science/article/abs/pii/S0959804904005660

Cancer. (2021, March 3). World Health Organization.
https://www.who.int/en/news-room/fact-sheets/detail/cancer

Coussens, N., Braisted, J., Peryea, T., Sittampalam, G., Simeonov, A., & Hall, M. (2017, October
1). Small-Molecule Screens: A Gateway to Cancer Therapeutic Agents with Case Studies
of Food and Drug Administration–Approved Drugs. Pharmacological Reviews.
https://pharmrev.aspetjournals.org/content/69/4/479

Differences between Biologics and Small Molecules. (2020, August 14). UCL Therapeutic
Innovation Networks.
https://www.ucl.ac.uk/therapeutic-innovation-networks/differences-between-biologics-an
d-small-molecules

Han-Chung, W., Chang, D., & Chia-Ting, H. (2006, January). Targeted Therapy for Cancer.
Research Gate.
https://www.researchgate.net/publication/26576352_Targeted_Therapy_for_Cancer

Khera, N., & Rajput, S. (2017, May). Therapeutic Potential of Small Molecule Inhibitors.
PubMed. https://pubmed.ncbi.nlm.nih.gov/27813176/

Lavanya, V., Adil, M., Ahmed, N., Rishi, A., & Jamal, S. (2014, November 9). Small molecule
inhibitors as emerging cancer therapeutics. OAT Open Access Text.
https://www.oatext.com/small-molecule-inhibitors-as-emerging-cancer-therapeutics.php#
ICST_jumpmenu7

Nunes, A., & Annunziata, C. (2017, December 1). Proteasome Inhibitors: Structure and
Function. PubMed Central (PMC).
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6020165/

Patel, T., Adhikari, N., Amin, A., Biswas, S., Jha, T., & Ghosh, B. (2021, March 29). Small
molecule drug conjugates (SMDCs): an emerging strategy for anticancer drug design and
discovery. New Journal of Chemistry (RSC Publishing).
https://pubs.rsc.org/en/content/articlelanding/2021/nj/d0nj04134c#!divAbstract

Pharmaceutical Drug Development (Small Molecules / Large Molecules). (2021, June 21).
Contract Laboratory.
http://blog.contractlaboratory.com/pharmaceutical-drug-development-small-molecules-lar
ge-molecules/#:%7E:text=Large%20molecules%2C%20or%20biologics%2C%20are,ide
ntical%20versions%20of%20human%20proteins.

Soti, C., & Csermely, P. (n.d.). Molecular chaperones in the etiology and therapy of cancer. NIH
National Library of Medicine. Retrieved August 2, 2021, from
https://pubmed.ncbi.nlm.nih.gov/9887365/

Wilkes, G. (2017, September 29). Targeted Therapy: Attacking Cancer with Molecular and Immunological Targeted Agents. PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5863423/

Wu, P., Nielsen, T., & Clausen, M. (2015, July 1). FDA-approved small-molecule kinase inhibitors. ScienceDirect. https://www.sciencedirect.com/science/article/abs/pii/S0165614715000772#:%7E:text=Seven%20approved%20small%2Dmolecule%20inhibitors,%C2%AE%2C%20Eisai%20Inc.)

.Zhong, L., Li, Y., Xiong, L., Wang, W., Wu, M., Yuan, T., Yang, W., Tian, C., Miao, Z., Wang, T., & Yang, S. (2021, May 31). Small molecules in targeted cancer therapy:. . . Signal Transduction and Targeted Therapy. https://www.nature.com/articles/s41392-021-00572-w?error=cookies_not_supported&code=e7d68080-dc92-42dd-b0e4-e143375d4c44#Sec26

Exploring the Pathophysiology of Migraine with Aura By June Choi

Abstract

A migraine is a common neurological disease that causes a headache with the symptoms of severe throbbing or pulsing pain, typically on one side of the head. Up to 30% of people with migraine experience auras or visual disturbances as a symptom that occurs before or during the headache. Through experiments using animal models, researchers have found many possible reasons for the cause of migraine. While the underlying mechanisms of this disease are not yet fully understood, current research theorizes that migraine with aura is likely due to Cortical Spreading Depression (CSD). CSD is a temporary wave of electrical activity that spreads in the outer layer of the brain, the cortex. CSD can also directly affect the visual cortex, which contributes to the development of auras associated with migraine. This wave is thought to be caused by the excessive buildup of glutamate, an excitatory neurotransmitter. CSD is also thought to trigger the release of Calcitonin Gene-Related Peptide (CGRP), a neuropeptide that causes blood vessels to dilate and widen. This leads to the inflammation and pain that occurs during a migraine attack. People with this disease usually take prescription drugs such as sumatriptan and rizatriptan to help reduce the pain. Another common method is using antibodies that target the CGRP receptors and CGRP itself. Further research is necessary to improve our understanding of aural migraines and develop more effective treatments.

1 Introduction

Migraines are essentially a type of headache, but there are some key differences between standard headaches and migraines. While headaches cause pain in the head and face, migraines produce more intense and debilitating symptoms in comparison to headaches (1). Also, headaches start in the nerves of muscles and blood vessels that surround one's facial areas, while migraines are thought to begin near the cortex. Migraines affect around 14% of the world's population (2). The frequency and duration of these migraines will vary, but they can be as frequent as 15 times a month, and last from 4 hours to 3 days. The disease is more common in women than men and is more frequent after puberty or when adults hit age 30 (3). This disease is divided into two main groups: migraine with aura (MwA) and migraine without aura. The common symptoms of MwA include visual disturbances, like flashing lights and hallucinations, pulsing head pain, nausea leading to vomiting, and sensitivity of the senses, especially sound and light (3). Based on observations, the visual aura can best be described as something that precedes migraine headache attacks. Migraines can also increase the chances of ischemic strokes and cardiovascular diseases such as heart attacks (4, 5).

There are many theories regarding the etiology of MwA that scientists have put forth based on their experiments in rodents and in patients experiencing migraine. The most common theory is that MwA is the result of Cortical Spreading Depression (CSD), a slowly propagating wave of neuronal and glial depolarization that moves across the cerebral cortex (6). Scientists have utilized Magnetic Resonance Imaging (MRI), Single-Photon Computed Tomography

(SPECT), and Positron Emission Tomography (PET) to visualize this (7). Some possible causes of CSD include an excess of glutamate build-up in the body and changes in the blood flow in the brain. Changes in blood perfusion- the rate at which blood is flowing to an area, can also be a consequence of CSD, along with the failure of brain homeostasis (8). The Trigeminovascular System, (TGVS) located in the Trigeminal Ganglion, also plays an important role in MwA. Activation of the TGVS can lead to the release of several neuropeptides, like substance P and CGRP.

Various medications and treatments, like CGRP inhibitors, nerve decompression surgery, and blood vessel relaxants, all aim to reduce migraine symptoms. However, these options often only offer short-term relief and do not fully address all the migrainous disturbances (9, 10). Those with chronic migraines must get some form of long-lasting treatment so that they can have a better quality of life.

2. The Trigeminovascular System (TGVS)

The trigeminovascular system (TGVS) is essentially a network of neurons that connects the blood vessels in the head to the brainstem and spinal cord. The TGVS is very crucial in regulating blood flow in the head and detecting and responding to pain and other sensations (11). Hence, the TGVS is involved in several neurological disorders, including migraines, cluster headaches, and trigeminal neuralgia.

In 1979, Moskowitz proposed the trigeminovascular hypothesis of the migraine which suggested that the trigeminal nerve, which supplies sensation to the face and head, plays a key role in migraine headaches (12). The trigeminal nerve has branches that innervate the blood vessels in the meninges, the thin membranes that surround the brain. When this nerve is activated, it often releases neuropeptides, such as substance P and CGRP. These neuropeptides can cause the dilation of blood vessels, which leads to increased inflammation and pain, which are prominent symptoms of migraine (13).

2.1. Neuropeptides
2.1.1. CGRP

CGRP is a type of protein that is widely distributed throughout the nervous system (14). Research has found that people with chronic migraines, especially women, tend to have much more CGRP in their blood. It is a key player in both physiological and pathological conditions. Around 50% of trigeminal neurons express CGRP. There are two major forms of CGRP- αCGRP and βCGRP. The CALCA gene encodes αCGRP, and the CALCB gene encodes βCGRP. These two peptides are very similar in their activities, but most of the CGRP expressed by the trigeminal neurons mentioned above are αCGRP (15).

CGRP injections or infusions can create migraine-like attacks in patients (16). During migraine attacks, salivary CGRP levels were found to be significantly increased. This supports the theory that an increase in CGRP leads to migraines (17). CGRP receptor antagonists have proven to be an effective way in reducing migrainous pain. Tests have also revealed that an

increase in CGRP leads to vasodilation, the dilation of blood cells, neurogenic inflammation, and nociception, a type of pain caused by damage to tissues (18).

2.1.1.2 Substance P

Substance P is another neuropeptide that is thought to play a role in initiating migraines by inducing significant inflammation in the dura mater, the protective membrane surrounding the brain (19). The dura mater is a critical component of the meninges, the three-layered protective covering of the brain and spinal cord. When Substance P is activated, the dura mater amplifies pain signals and contributes to the perception of headaches and other migraine-related symptoms (20).

In a study published by Ramachandran et al., 2018, researchers induced inflammation in the dura mater of rats by injecting Complete Freund's Adjuvant (CFA). The study found that the CFA-induced inflammation led to the release of Substance P, which resulted in vasodilation and mast cell degranulation. Ultimately, this resulted in the release of inflammatory mediators such as histamine and leukotrienes (21). These mediators then have many effects on patients, like causing blood vessels to widen and increasing the permeability of blood vessels (22).

2.3 Cortical Spreading Depression (CSD)

Cortical Spreading Depression (CSD) is theorized to be the underlying cause of MwA. CSD is known to be a short disturbance of the cerebral cortex caused by a depolarization wave (6). This theory was created by Leao in 1944, who observed changes in blood vessel size as electrical brain activity decreased, with increased blood flow accompanying these electrical changes. In his paper from 1945, Leao along with Morrison showed a possible link between these events and MwA, especially given that the development of visual effects was slow (23).

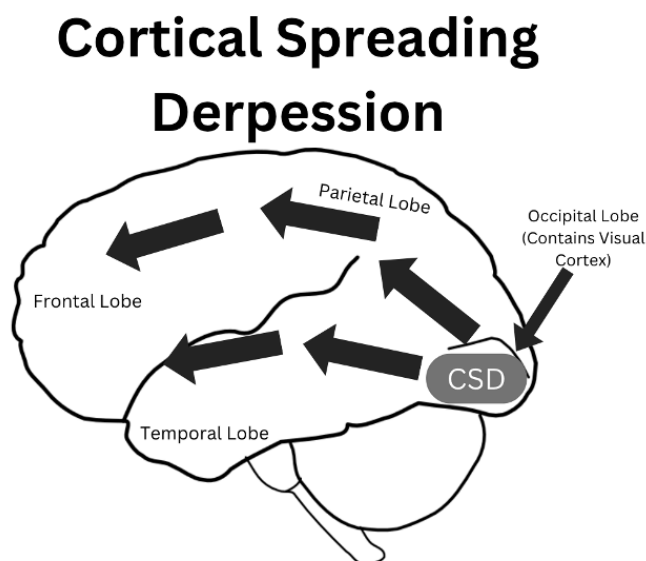*2.3.1 Mechanisms of Cortical Spreading Depression*

Figure 1: Schematic diagram of cortical spreading depression. Cortical spreading depression starts near the occipital lobe, where the visual cortex is, causing the development of auras. As the wave of depression spreads, there is a prolonged decrease in cerebral blood flow.

Currently, scientists believe that aural migraines are the result of the build-up of CSD. CSD is a slowly spreading wave of depolarization that represses parts of brain activity, which results in many changes between the vascular and neural systems. This activity lasts up to several minutes and spreads in all directions of the cortex at a rate of around 3-5 mm/min (6). Once this depression affects the primary sensory cortex, the common somatosensory symptoms such as numbness, prickling or tingling sensations, and burning will start to occur, along with neurovascular dysfunction (24). CSD can be measured through the use of an electroencephalogram (EEG), which measures the electrical activity of the brain. During the 30-60 seconds when the neurons of affected areas are silenced, the electrical activity is significantly reduced. This wave is also thought to directly affect the visual cortex, which is why the aural symptoms occur. After several minutes, this brain tissue will recover, with neuronal activities returning to normal. This is typically when aural symptoms are also thought to return back to normal with glial cells and neurons regaining homeostasis. Pi et al. induced CSD in the visual cortex of mice using light inflammation and found that the somatosensory, primary sensory, olfactory, basal ganglia, and default-mode networks had been activated (25).

In addition to EEG, scientists have also used functional Magnetic Resonance Imaging (fMRI) in order to gain further insights into the effects of CSD during aural migraines. fMRI studies revealed blood oxygenation level-dependent (BOLD) signal changes during the visual aura, which demonstrated consistency with eight characteristics that are found in CSD: the initial cortical gray hyperemia, the characteristic duration, the characteristic velocity, hypoperfusion, the attenuated response to visual activation, the recovery to baseline mean level, the recovery of stimulus-driven activation, and the non-crossing of prominent sulci. (26)

2.3.3 Triggers and Effects of Cortical Spreading Depression

While the causes of CSD remain uncertain, there are some factors that scientists think might influence the likelihood of its occurrence and severity. For instance, one study conducted on rats has shown that high-fat diets could increase the susceptibility to CSD (8, 27).

Additionally, there is evidence suggesting a role for glutamate in CSD. Through studies conducted on human subjects, levels of glutamate have been confirmed to be much higher in the peripheral circulation, especially during migraine attacks. During CSD, glutamate transporters can operate in reverse, leading to the release of large amounts of glutamate in the occipital cortex. This prolonged release contributes to the extended duration of CSD and may result in longer-lasting effects of aural migraines. Alongside glutamate dysregulation, CSD also involves changes in cerebral blood flow, potassium levels, and cortical oxidation (28). Changes in the blood flow are a prominent feature of migraines. When CSD and migraines occur, the brain continues to regulate blood flow, but its responsiveness to changes in carbon dioxide becomes

impaired, which leads to the changes in cerebral blood flow (CBF). CBF can also be decreased through vascular unresponsiveness or vasoconstriction (narrowing of blood vessels) after the initial depolarization-induced hyperemia (excess blood going to a part of the body) (29).

3. Treatment for Migraines

There are mainly two broad categories of medications designed to treat migraines: acute and preventive medications. The goal of acute medications is to stop a migraine as soon as it starts (30). When some warning signs of migraine occur, such as an aura, neck stiffness, mood changes, or food cravings, this type of medication is taken to relieve the pain, nausea, and other migrainous symptoms (3). On the other hand, preventive medications are types of drugs that are taken regularly to reduce the severity and frequency of migraines (31). This type of treatment is mainly used on chronic migraineurs since these migraineurs get migraines very frequently (32).

Some of the most common types of acute medications include ibuprofen, isometheptene-dichloralphenazone-acetaminophen, and CGRP antagonists like rimegepant and zavegepant (30). CGRP inhibitors have also been proven successful. When 2.5 mg of BIBN4096, a CGRP inhibitor, was given to patients intravenously, 66% of migraineurs were pain-free for around two hours. There was also a decrease in nausea and photophobia, along with an improvement in functional capacity among migraineurs (9). Frequently used preventive medications include beta-blockers such as propranolol and metoprolol, calcium channel blockers like verapamil, and antidepressants such as amitriptyline. Beta-blockers work by blocking the effects of adrenaline, lowering the blood pressure. Calcium channel blockers, on the other hand, work by relaxing the blood vessels and reducing the amount of calcium that enters the heart and blood vessels, which can help constrict migraines (32, 33).

Aside from prescriptions and medication, there is also the option for migraine surgery, also known as nerve decompression surgery. This is a type of migraine surgery that involves removing tissues or blood vessels that are constricting nerves, thereby reducing the chances of migraines. Patients who have undergone this surgery have been shown to have a significant overall reduction in migraine intensity, frequency, and duration. Some have even been shown to have migraine elimination, showing the surgery's relative success in improving migraines (10). However, many people, afraid of side effects such as nerve injury, hair loss, and incomplete relief, don't take up this surgery (34). Moreover, many insurance companies are not willing to pay for this procedure, citing that there is too little evidence of its effectiveness. The American Headache Society has also urged patients not to pursue this surgery, since there isn't enough reliable research that shows its potential harms and long-term effects (35).

4 Conclusion

In conclusion, this review has provided an overview of the underlying mechanisms of migraines with aura. Looking forward, researchers should aim to prioritize the limitations and gaps in our understanding of migraines and their treatments especially due to the high incidence of migraine across the world. The low rates of success in many of the treatments underscore the

need for a more consistent and universal cure for those who suffer migraines. Researchers should aim to develop therapies that target the fundamental causes of migraines to offer better relief to migraineurs.

Works Cited

Robbins, M. S. (2021). Diagnosis and Management of Headache. *JAMA*, *325*(18), 1874.
https://doi.org/10.1001/jama.2021.1640

Stovner, L. J., Hagen, K., Linde, M., & Steiner, T. J. (2022). The global prevalence of headache:
an update, with analysis of the influences of methodological factors on prevalence
estimates. *The Journal of Headache and Pain*, *23*(1).
https://doi.org/10.1186/s10194-022-01402-2

Mayo Clinic . (2023, July 7). *Migraine - Symptoms and causes*. Mayo Clinic.
https://www.mayoclinic.org/diseases-conditions/migraine-headache/symptoms-causes/syc-20360201

Migraine and Cardiovascular Disease: Key Points. (n.d.). American College of Cardiology.
Retrieved February 19, 2024, from
https://www.acc.org/latest-in-cardiology/ten-points-to-remember/2023/08/15/14/43/migraine-and-cardiovascular-disease

Migraine a "risk factor" for cardiovascular disease. (2018, February 1).
www.medicalnewstoday.com.
https://www.medicalnewstoday.com/articles/320783#Cardiovascular-risk-heightened-by-migraine

Lauritzen, M. (1994). Pathophysiology of the migraine aura. *Brain*, *117*(1), 199–210.
https://doi.org/10.1093/brain/117.1.199

Charles, A., & Brennan, K. (2009). Cortical Spreading Depression—New Insights and Persistent
Questions. *Cephalalgia*, *29*(10), 1115–1124.
https://doi.org/10.1111/j.1468-2982.2009.01983.x

Mathew, A. A., & Panonnummal, R. (2022). Cortical spreading depression: culprits and
mechanisms. *Experimental Brain Research*. https://doi.org/10.1007/s00221-022-06307-9

Russo, A. F. (2015). Calcitonin Gene-Related Peptide (CGRP): A New Target for Migraine.
Annual Review of Pharmacology and Toxicology, *55*(1), 533–552.
https://doi.org/10.1146/annurev-pharmtox-010814-124701

ElHawary, H., Barone, N., Baradaran, A., & Janis, J. E. (2021). Efficacy and Safety of Migraine
Surgery. *Annals of Surgery*, *Publish Ahead of Print*.
https://doi.org/10.1097/sla.0000000000005057

May, A., & Goadsby, P. J. (1999). The trigeminovascular system in humans: pathophysiologic
implications for primary headache syndromes of the neural influences on the cerebral
circulation. *Journal of Cerebral Blood Flow and Metabolism: Official Journal of the
International Society of Cerebral Blood Flow and Metabolism*, *19*(2), 115–127.
https://doi.org/10.1097/00004647-199902000-00001

Ashina, M., Hansen, J. M., Do, T. P., Melo-Carrillo, A., Burstein, R., & Moskowitz, M. A.
(2019). Migraine and the trigeminovascular system—40 years and counting. *The Lancet
Neurology*, *18*(8), 795–804. https://doi.org/10.1016/s1474-4422(19)30185-1

Salahi, M., Parsa, S., Delaram Nourmohammadi, Zahra Razmkhah, Salimi, O., Rahmani, M., Saeid Zivary, Monireh Askarzadeh, Mohammad Amin Tapak, Vaezi, A., Hamidreza Sadeghsalehi, Shirin Yaghoobpoor, Mehran Mottahedi, Setareh Garousi, & Niloofar Deravi. (2022). Immunologic aspects of migraine: A review of literature. *Frontiers in Neurology*, *13*. https://doi.org/10.3389/fneur.2022.944791

Russell, F. A., King, R., Smillie, S.-J. ., Kodji, X., & Brain, S. D. (2014). Calcitonin Gene-Related Peptide: Physiology and Pathophysiology. *Physiological Reviews*, *94*(4), 1099–1142. https://doi.org/10.1152/physrev.00034.2013

Labastida-Ramírez, A., Caronna, E., Cédric Gollion, Stanyer, E. C., Austėja Dapkutė, Braniste, D., Hoda Naghshineh, L. Meksa, Nino Chkhitunidze, Tamari Gudadze, Pozo‑Rosich, P., Burstein, R., & Hoffmann, J. (2023). Mode and site of action of therapies targeting CGRP signaling. *Journal of Headache and Pain*, *24*(1). https://doi.org/10.1186/s10194-023-01644-8

Håkan Ashina, Henrik Winther Schytz, & Messoud Ashina. (2018). CGRP in Human Models of Migraine. *Handbook of Experimental Pharmacology*, 109–120. https://doi.org/10.1007/164_2018_128

Alpuente A, Gallardo Vj, Asskour L, Caronna E, Torres-Ferrus M, & Pozo-Rosich P. (2020). Salivary CGRP as diagnostic and migraine attack phase monitor biomarker: CGRP (in)dependent attacks. *MedRxiv (Cold Spring Harbor Laboratory)*. https://doi.org/10.1101/2020.11.18.20233841

Kuburas, A., & Russo, A. F. (2023). Shared and independent roles of CGRP and PACAP in migraine pathophysiology. *The Journal of Headache and Pain*, *24*(1). https://doi.org/10.1186/s10194-023-01569-2

May, A., & Goadsby, P. J. (2001). Substance P receptor antagonists in the therapy of migraine. *Expert Opinion on Investigational Drugs*, *10*(4), 673–678. https://doi.org/10.1517/13543784.10.4.673

Kursun, O., Yemisci, M., van den Maagdenberg, A. M. J. M., & Karatas, H. (2021). Migraine and neuroinflammation: the inflammasome perspective. *The Journal of Headache and Pain*, *22*(1). https://doi.org/10.1186/s10194-021-01271-1

Ramachandran, R. (2018). Neurogenic inflammation and its role in migraine. *Seminars in Immunopathology*, *40*(3), 301–314. https://doi.org/10.1007/s00281-018-0676-y

Branco, A. C. C. C., Yoshikawa, F. S. Y., Pietrobon, A. J., & Sato, M. N. (2018). Role of Histamine in Modulating the Immune Response and Inflammation. *Mediators of Inflammation*, *2018*, 1–10. https://doi.org/10.1155/2018/9524075

Tfelt-Hansen, P. (2009). History of migraine with aura and cortical spreading depression from 1941 and onwards. *Cephalalgia*, *30*(7), 780–792. https://doi.org/10.1111/j.1468-2982.2009.02015.x

Lauritzen, M., Dreier, J. P., Fabricius, M., Hartings, J. A., Graf, R., & Strong, A. J. (2010). Clinical Relevance of Cortical Spreading Depression in Neurological Disorders: Migraine, Malignant Stroke, Subarachnoid and Intracranial Hemorrhage, and Traumatic

Brain Injury. *Journal of Cerebral Blood Flow & Metabolism*, *31*(1), 17–35. https://doi.org/10.1038/jcbfm.2010.191

Pi, C., Tang, W., Li, Z., Liu, Y., Qi, J., Dai, W., Wang, T., Yang, C., & Yu, S. (2022). Cortical pain induced by optogenetic cortical spreading depression: from whole brain activity mapping. *Molecular Brain*, *15*(1). https://doi.org/10.1186/s13041-022-00985-w

Hadjikhani, N., Sanchez del Rio, M., Wu, O., Schwartz, D., Bakker, D., Fischl, B., Kwong, K. K., Cutrer, F. M., Rosen, B. R., Tootell, R. B. H., Sorensen, A. G., & Moskowitz, M. A. (2001). Mechanisms of migraine aura revealed by functional MRI in human visual cortex. *Proceedings of the National Academy of Sciences*, *98*(8), 4687–4692. https://doi.org/10.1073/pnas.071582498

Kentar, M., Mann, M., Sahm, F., Olivares-Rivera, A., Sanchez-Porras, R., Zerelles, R., Sakowitz, O. W., Unterberg, A. W., & Santos, E. (2020). Detection of spreading depolarizations in a middle cerebral artery occlusion model in swine. *Acta Neurochirurgica*, *162*(3), 581–592. https://doi.org/10.1007/s00701-019-04132-8

Borsook, D., Maleki, N., & Burstein, R. (2015, January 1). *Chapter 42 - Migraine* (M. J. Zigmond, L. P. Rowland, & J. T. Coyle, Eds.). ScienceDirect; Academic Press. https://www.sciencedirect.com/science/article/abs/pii/B9780123982704000422?via%3Dihub

Frederiksen, S. D., Haanes, K. A., Warfvinge, K., & Edvinsson, L. (2017). Perivascular neurotransmitters: Regulation of cerebral blood flow and role in primary headaches. *Journal of Cerebral Blood Flow & Metabolism*, *39*(4), 610–632. https://doi.org/10.1177/0271678x17747188

25 Migraine Treatments, Preventative Meds & Abortive Drugs. (n.d.). WebMD. https://www.webmd.com/migraines-headaches/migraine-treatments

Mayo Clinic. (2019). *Migraine - Diagnosis and treatment - Mayo Clinic*. Mayoclinic.org; Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/migraine-headache/diagnosis-treatment/drc-20360207

Agostoni, E. C., Barbanti, P., Calabresi, P., Colombo, B., Cortelli, P., Frediani, F., Geppetti, P., Grazzi, L., Leone, M., Martelletti, P., Pini, L. A., Prudenzano, M. P., Sarchielli, P., Tedeschi, G., & Russo, A. (2019). Current and emerging evidence-based treatment options in chronic migraine: a narrative review. *The Journal of Headache and Pain*, *20*(1). https://doi.org/10.1186/s10194-019-1038-4

Cho, S., & Kim, B.-K. (2023). Update of Gepants in the Treatment of Chronic Migraine. *Current Pain and Headache Reports*. https://doi.org/10.1007/s11916-023-01167-6

Bolt, A. (n.d.). *Nerve Decompression Surgery for Migraine*. WebMD. https://www.webmd.com/migraines-headaches/migraine-nerve-release-surgery

Migraine Surgery: What You Need to Know. (2022, February 28). Healthline. https://www.healthline.com/health/migraine/migraine-surgery/

Batteries Review By Angad Arora

1. Abstract:

Due to the world turning away from fossil fuels and towards renewable energy, electrical energy is becoming increasingly important. Aluminum-ion batteries (AIBs) are promising contenders in the realm of electrochemical energy storage. While lithium-ion batteries (LIBs) have long dominated the market with their high energy density and durability, sustainability concerns stem from the environmental impact of raw material extraction and manufacturing processes, and performance-related drawbacks include limited lifespan, safety hazards like thermal runaway, and challenges in recycling. AIBs stand out for their superior sustainability and theoretical capacity, powered by the usage of trivalent aluminum ions (Al^{3+}), due to a higher abundance in Earth's crust and a well-established recycling infrastructure. Despite the advantages of AIBs in sustainability and theoretical capacity, their widespread commercial use has been hindered by certain electrochemical limitations, such as challenges in achieving competitive energy density and addressing issues related to the efficient cycling of trivalent aluminum ions. This paper delves into the merits of AIBs, exploring their potential to surpass LIBs and serve as the leading battery technology of the future.

2. How Lithium and Aluminum ion Batteries work

Lithium-ion batteries (LIBs) dominate the battery market as they provide high energy density and long cyclability, meaning it can endure numerous charge and discharge cycles while retaining its capacity and performance, to enable an increasingly electrified world. However, they have significant disadvantages compared to other electrochemical systems in terms of overall sustainability and performance. Aluminum-ion batteries (AIBs) show promising characteristics that suggest they could potentially outperform lithium-ion batteries in terms of sustainability and theoretical capacity due to their natural abundance and trivalent nature.

To accurately compare LIBs and AIBs it is necessary to understand how they operate. A typical AIB consists of an aluminum anode, a cathode (often made of materials such as graphite), a separator, an electrolyte, and two current collectors. AIB batteries operate on the principle of the reversible electrochemical reaction of aluminum with oxygen to form aluminum oxide. The aluminum in the anode serves as the charge carrier, a role similar to the lithium ions in lithium-ion batteries. As the aluminum ions are positively charged, they migrate from the anode to the cathode through the electrolyte and separator. This migration process creates free electrons in the anode, culminating in a charge at the positive current collector. When discharging, aluminum at the anode loses electrons (is oxidized) to become aluminum ions. These ions then migrate through an electrolyte towards the cathode where they are received, while the electrons travel through the external circuit to do useful work as shown in Figure 1(b). During charging, the process is reversed: aluminum ions leave the cathode, travel back to the anode, and regain electrons to become metallic aluminum again[1,2].

A lithium-ion (Li-ion) battery functions based on the movement of lithium ions between the anode and the cathode as shown in Figure 1(a). The most common setup involves a graphite

anode and a metal oxide cathode, with a lithium salt electrolyte in between. During discharge, lithium ions move from the graphite anode, through the electrolyte, and intercalate into the metal oxide cathode. At the same time, electrons released from the anode travel through the external circuit, providing power to devices, before rejoining the lithium ions at the cathode. The charging process reverses this movement, with lithium ions deintercalating from the cathode and returning to the anode[3].
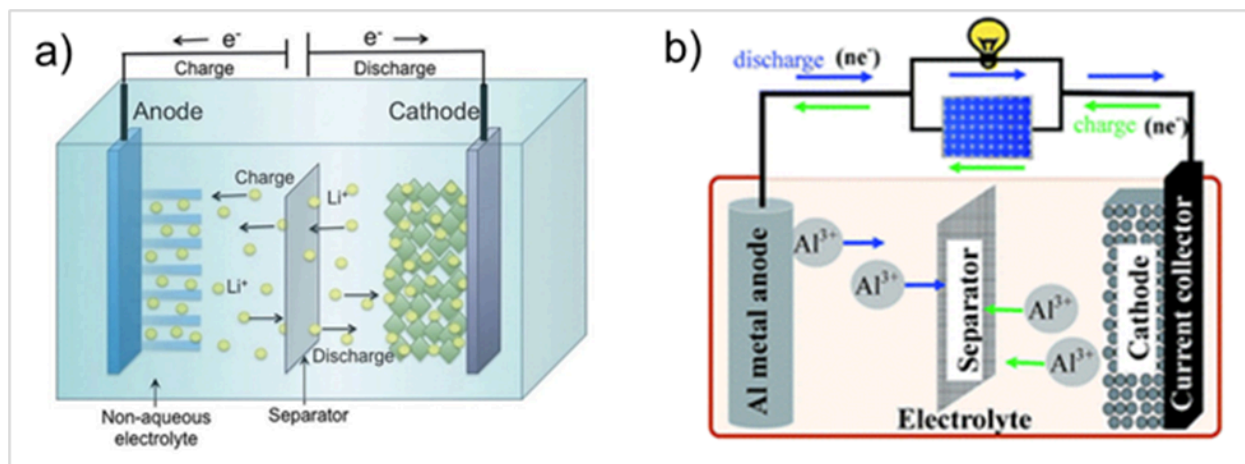

FIGURE 1(A): SCHEMATIC AND OPERATION DIAGRAM OF A LITHIUM-ION BATTERY[3]. FIGURE 1(B): SCHEMATIC AND OPERATION DIAGRAM OF AN ALUMINUM-ION BATTERY [4].

AIBs utilize trivalent aluminum ions, which possess a +3 charge, in contrast to the monovalent lithium ions in LIBs with a +1 charge. This disparity in charge magnitude greatly influences energy storage, conductivity, and ion mobility in the respective electrolytes. Trivalent ions, due to their capacity to convey more charge per ion than monovalent ions, may exhibit elevated charge/discharge potentials[4]. Structurally, LIBs intercalate (insert between crystal layers) between anode and cathode materials without significant structural alterations, AIBs predominantly witness the plating of aluminum ions onto, or their stripping from, the metal anode, bypassing the typical intercalation[5]. Furthermore, on average aluminum costs $2.55 per kilogram while lithium costs $18.75 per kilogram[6]. The cost of Li is >7x higher than aluminum, making this cost difference compelling at large scale and because of this, news articles praise aluminum batteries as "dirt cheap" compared to li-ion batteries[7]. Lastly, while LIBs incorporate various metal oxide cathodes, AIBs frequently adopt carbon-based materials like graphite, underscoring the distinct material requirements and possibilities each battery system presents[4,5]. While electrochemical operation, involving the efficiency of the conversion of chemical energy to electrical energy through redox reactions, is a large part of choosing the right battery for a particular application, factors such as sustainability, safety, and cost should also play a role in battery selection. Even though both the aluminum and the lithium that are used in the batteries are naturally occurring metals in Earth's crust, many components make one metal far more consumer-friendly and environmentally favorable than the other such as the vast difference in abundance. Additionally, a large amount of research is being done currently to match the

electrochemical performance of aluminum ion batteries to that of the current industry standard. Simply put, the emergence of aluminum-ion batteries could redefine the economic landscape of energy storage. Delivering comparable performance to lithium-ion batteries but at a significantly reduced cost, this innovation has the potential to broaden access to advanced energy solutions, impacting not just consumers but entire industries. Exploring the process of how resources are extracted and the life cycles of both these metals can help with fairly comparing them.

3. Comparison of Resource Extraction

One of the main reasons for the high price of lithium and low price of aluminum is their abundance in Earth's crust. Aluminum is the third most abundant element after oxygen and silicon. Lithium metal only makes up about 0.002% of Earth's crust by mass while aluminum makes up nearly 8% of Earth's crust[8]. This massive difference shows how rare lithium reserves are on Earth and further demonstrates that it is not a sustainable solution. Using a more abundant material could lead to a more stable and potentially lower-cost supply chain from miner to manufacturer to consumer. Furthermore, the well-established extraction processes could make aluminum-ion batteries more cost-effective than lithium-ion batteries as these systems have been refined over the centuries to make aluminum mining exceptionally efficient.

Other than abundance, mining metals takes a toll on our planet. The extraction of lithium requires significant water usage, which could lead to environmental concerns in water-scarce regions. According to Wenjuan Liu et. al., brine extraction in areas like the Lithium Triangle and hard rock mining in regions like Australia contribute to water stress, impacting local ecosystems[9]. Brine extraction may use anywhere from around 500 to 5,000 cubic meters of water per ton of lithium produced, depending on factors such as brine concentration, extraction efficiency, and local operational practice and estimates suggest that water usage in hard rock mining can range from approximately 1 to 2.5 cubic meters per ton of lithium produced[9].

Moreover, the environmental benefits of aluminum battery adoption do not stop at mining. Aluminum metal can be recycled 50-70 times while lithium can be recycled less than once[10]. The money saved through mining a more abundant metal can be invested into recycling plants to repurpose old aluminum batteries.

According to a paper written by Hubertus Bardt, aluminum is not classified as critical when considering the reserves-to-production ratio, political implications, and supply risks[11]. One reason for this is the various sources of aluminum. Naturally occurring aluminum is not usually found as a pure metal but rather in the form aluminum silicates. To produce the pure form of aluminum suitable for various applications, it must be extracted either from minerals like bauxite or via recycling from scrap. According to a study by Ostojic et al., one kilogram of pure aluminum can be extracted from 4 kg of bauxite[12]. Additionally, the concentrations of aluminum in raw materials are twice that of the concentrations of lithium. Using this approximation, one can deduce that less soil needs to be displaced when mining aluminum than when mining the same mass of lithium. Furthermore, over twice the amount of aluminum atoms can be sourced

from 1 kg of raw material as compared to lithium, underscoring the efficiency of using aluminum in batteries.

Even though aluminum is abundant in the Earth's crust, the recycling process determines the life cycle and overall sustainability of the material. Infrastructure around aluminum has been globally established for some time now, and every continent has its own resources for mining, producing, and recycling of the metal[13,14]. A study conducted by Fathi Habashi in 2003 reported significant advancements in reducing the energy consumption of the aluminum production process by up to 95%. This means that in today's world, 35% of the global aluminum demand is provided by recycled aluminum compared to 5% of lithium batteries[1,10].

Recycling and manufacturing process to produce aluminum does not come without an environmental impact. The aluminum industry accounts for about 1% of greenhouse gas emissions split across two categories. Direct emissions from the aluminum production process account for 40% and the remaining 60% are indirect emissions from electricity generation[15]. The carbon footprint of producing 1 kg of raw aluminum is between 5 to 40 kg of CO_2. Therefore, it is important to consider renewable energy processes as aluminum production grows to counterbalance these carbon emissions. An example of ongoing efforts to counterbalance is that most aluminum production facilities are strategically located next to hydro-electric power stations due to the high energy demand[16].

As per a study into the extractive metallurgy of aluminum, the production of 1 kg of aluminum requires temperatures around 1,000°C and an energy input of between 9 to 12 kWh, with process efficiencies ranging from 85 to 95%. On the other hand, the production of lithium demands even higher temperatures, up to 1,150°C[10]. Both metals are produced by a fused-salt electrolysis method, but aluminum's production consumes significantly less electrical energy than lithium's, especially when weighing the other factors such as the gravimetric or volumetric capacity of each metal. Table 1 summarizes the production requirements and parameters discussed.

TABLE 1: COMPARATIVE ANALYSIS OF ALUMINUM AND LITHIUM PRODUCTION PROCESSES FOR BATTERY MANUFACTURING. HIGHLIGHTING ENERGY SOURCES, PRODUCTION TEMPERATURES, ENERGY INPUT, PROCESS EFFICIENCIES, AND ADDITIONAL CONSIDERATIONS FOR SUSTAINABLE PRODUCTION[10].

Parameter	Aluminum Production	Lithium Production
Energy Source	Primarily hydro-electric power stations	Primarily non-renewable electricity sources
Production Temperature	-1000 °C	Up to 1150 °C
Energy Input per kilogram	9-12 Wh	12+ Wh
Process Efficiency	95%	97%
Production Method	Fused-salt electrolysis	Fused-salt electrolysis
Energy Consumption Comparison	Aluminum strategically located near hydro-electric sources and consumes	While specific figures vary, lithium extraction generally consumes more electrical energy than aluminum due to

	significantly less electrical energy than lithium.	its higher production temperature and geographic location.
Additional Considerations	Efforts to counterbalance energy demands, considering gravimetric or volumetric capacity of each metal.	Sustainable lithium production efforts focus on improving energy efficiency in high-temperature processes through advanced electrolysis methods, optimized reaction conditions, and innovative materials.

4. Electrochemical disadvantages of Aluminum

Although aluminum is a far more sustainable metal than lithium, the main factor preventing the widespread adoption of aluminum-ion batteries and replacement of lithium-ion batteries is the superiority in electrochemical performance. There are a few challenges that AIBs face before they can replace LIBs on a larger scale and be adopted in the long term. One crucial consideration is energy density and voltage: the potential difference in a battery originates from the differential electrochemical potential between its anode and cathode. Notably, the standard AIB design currently exhibits a lower voltage than its LIB counterpart, leading to a diminished energy density, a vital metric for applications like electric vehicles where the balance of range and weight is paramount. Another challenge stems from aluminum's trivalent nature, which emits three electrons upon ionization which complicates the ion's intercalation into cathode materials[1]. On the contrary, LIBs use a monovalent lithium ion and its well-researched and optimized cathode materials like lithium cobalt oxide or lithium iron phosphate. The search for a suitable electrolyte that efficiently handles Al^{3+} ions and remains stable across the battery's operational voltage poses a significant challenge. A further limitation resides in the discharge rate of AIBs. Due to the inherent complexities associated with the movement of trivalent Al^{3+} ions compared to monovalent Li^+ ions, AIBs currently struggle to achieve the rapid energy release rates seen in LIBs, making them less suitable for high-demand applications. Moreover, AIBs do not match LIBs performance for cycle life and long-term stability, especially under fluctuating temperature and usage conditions[17].

However, the push for Al-ion innovation is not without its reasons such as its sustainability and safety benefits along with certain electrochemical performance metrics. Furthermore, the Al-ion's resilience against damage and reduced risk of hazards like thermal runaway paves the way for safer energy storage solutions. Al-ion batteries are less prone to the formation of dendrites, unwanted growths that can cause short circuits in a battery. Additionally, aluminum's superior thermal conductivity facilitates more efficient heat dissipation, reducing the risk of overheating and thermal runaway, a critical safety concern in battery technology. The robust compatibility of Al-ion batteries with stable electrolytes further enhances their safety by mitigating the potential for chemical reactions that could compromise the battery's integrity.

Moreover, the inherent stability of aluminum as a material contributes to the overall durability and resilience of these batteries. All in all, although Al-ion batteries currently trail behind Li-ion in certain performance aspects, their innate benefits, and the possibility of overcoming present challenges make them a real candidate to replace Li-ion batteries.

5. Improvements to Electrochemical Performance

Scientists have understood the areas that need to be improved upon in AIBs. Specifically, scientists have developed the "Molten $AlCl_3$/urea electrolyte" AIB[18], the "Super long-life CMK-3" AIB[19], the "High Coulombic Efficiency Aluminum-Graphite" AIB[20], and the "Graphene film 3H3C Ultrafast Quarter-Million Life cycle" AIB[21]. The following four battery technologies are proprietary AIB systems that each have a unique characteristic that improves performance of general AIBs to match or even outperform current state-of-the-art LIBs as seen in Figure 2.

Two main aspects of electrochemical performance that must be improved in Al-ion batteries are cycle life and discharge rate. One recently proposed advancement to improve cyclability is a molten aluminum chloride-urea graphite battery. This battery improves the mechanism of aluminum ions migrating between their anode and cathode during the charging and discharging phases, using a unique electrolyte made of molten $AlCl_3$/urea. When charging, the anode, made of aluminum, undergoes oxidation to release trivalent aluminum ions (Al^{3+}). As these ions traverse the electrolyte to the graphite cathode, they combine with chloride ions to form $AlCl_4^-$ ions. These ions then insert themselves between the graphite layers of the cathode. During discharge, the $AlCl_4^-$ ions exit the graphite layers and as they approach the aluminum anode, release an aluminum ion. This ion then assimilates three electrons, reverting to its original metallic form. The performance improvement is achieved with a specific $AlCl_3$ to urea ratio of 1.5 in the electrolyte and at an operational temperature of approximately 120°C, allowing the cationic species $[AlCl_2(urea)]^+$ to move with fewer losses. However, high temperature batteries pose management challenges as they may require an external power supply, which could be a potential drawback of this advancement. These conditions not only ensure efficient ionic movement but also stave off undesired side reactions. While this elevated temperature might raise concerns about the safety of battery operation, it is essential to note that the effectiveness of the battery system relies on these conditions, and it is crucial to implement appropriate safety measures and thermal management strategies. The battery touts a high specific capacity, demonstrating that it can store substantial energy relative to its weight. This, combined with its exceptional rate capability and longevity (with notable capacity retention even after 500 cycles), renders it a promising candidate for large-scale energy storage, especially when juxtaposed against traditional Al-ion batteries with pricier electrolytes[18].

To further improve the cyclability of aluminum-ion batteries, the "Super long life aluminum battery" has been proposed as a potential successor to traditional lithium-ion batteries. This battery features a volumetric capacity reaching up to 8046 mAh cm^−3. This metric signifies the immense energy these batteries can store within a confined space, making them

ideal for compact electronic devices. Also, by introducing CMK-3 (mesoporous carbon), an ordered mesoporous carbon, as an efficient and commercially available cathode, this chemistry can reach high levels of cyclability, exhibiting over 36,000 charge/discharge cycles with negligible degradation. A significant highlight of CMK-3 lies in its architecture; the high surface area and structured pores provide rapid pathways for ion movement, thereby enhancing the battery's rate capabilities. Similar to the molten aluminum chloride chemistry, CMK-3 allows for intercalation of Al-ions on the anode side. have verified this mechanism, revealing how these anions interact with CMK-3's structure to ensure consistent and robust battery performance. Packing an energy punch, the Al/CMK-3 battery showcases an energy density nearing 45 Wh kg^{-1}, competitive with several mainstream battery technologies. Even better, unlike their lithium-ion counterparts, which are notorious for safety issues, including fire hazards, this Al-ion battery boasts a high safety profile[19].

 Discharge rate and Coulombic efficiency go hand in hand. This is why the innovation of the high CE aluminum-ion battery is a promising improvement for the discharge rate problem of Al-ion batteries. This battery technology works by utilizing a novel electrolyte made from a blend of $AlCl_3$ and urea, formulated in a 1.3:1 molar ratio. This battery operates using aluminum, as the anode and graphite as the cathode. Electrochemically, the battery exhibits distinct voltage plateaus around 1.9 and 1.5 V, with an average discharge of 1.73 V. These clear voltage plateaus offer consistent and predictable energy delivery stages, simplifying battery management and ensuring more stable performance during operation. What sets this battery apart is its outstanding CE of approximately 99.7% and a commendable cathode capacity of about 73 mAh g^{-1} at a current density of 100 mA g^{-1}. Compared to LIBs, this aluminum-ion prototype presents several advantages. Furthermore, during its operation, in-situ Raman spectroscopy elucidated the chloroaluminate anion's intercalation and deintercalation within the graphite during the battery's charge and discharge cycles[17]. This indicates the formation of a stage 2 graphite intercalation compound when fully charged. Importantly, this battery offers an improved safety profile since its electrolyte is nonflammable, addressing one of the primary concerns with LIBs. Given these attributes, the aluminum-ion battery technology offers a promising solution for future high-performance, cost-effective energy storage needs[20].

 The challenge with aluminum-ion batteries has traditionally been their lower voltage in comparison to lithium-ion batteries. However, by focusing on enhancing the discharge rate, the challenges of reduced voltage can be offset to some extent. The ultrafast all-climate aluminum-graphene battery is a promising solution to this problem. At the heart of the design is the graphene film cathode with a "trihigh tricontinuous (3H3C) design". The electrochemical operation relies on the movement of ions between the anode and the cathode. In this battery, the graphene cathode, orientation, and channeling (3H), facilitates efficient ion movement with its continuous electron-conducting matrix, ion-diffusion highway, and electroactive mass (3C). By capitalizing on this efficient ion transport, the battery can discharge at much higher current rates, thus compensating for its lower voltage by delivering the required power in a shorter time frame. This structure allows the battery to achieve a high specific capacity of around 120 mAh g^{-1} even

at ultrahigh current densities and display exceptional retention after a quarter-million cycles. Compared to lithium-ion batteries, this aluminum-graphene battery boasts several advantages: the aluminum anode's three-electron redox property provides high capacity, the non-flammability of materials enhances safety, and the unique graphene structure supports fast charging and stable cycling. Furthermore, the battery functions efficiently across a wide temperature range, from -40 to 120°C, and displays remarkable flexibility, essential attributes for all-climate wearable devices. The graphene's high crystalline nature and the designed interconnected channels ensure rapid ion diffusion, enabling the battery's impressive rate capability and cycle life. By strategically increasing the discharge rate, the aluminum-graphene battery can effectively address the limitations associated with lower voltage, making it a strong contender for the lithium-ion battery[21].
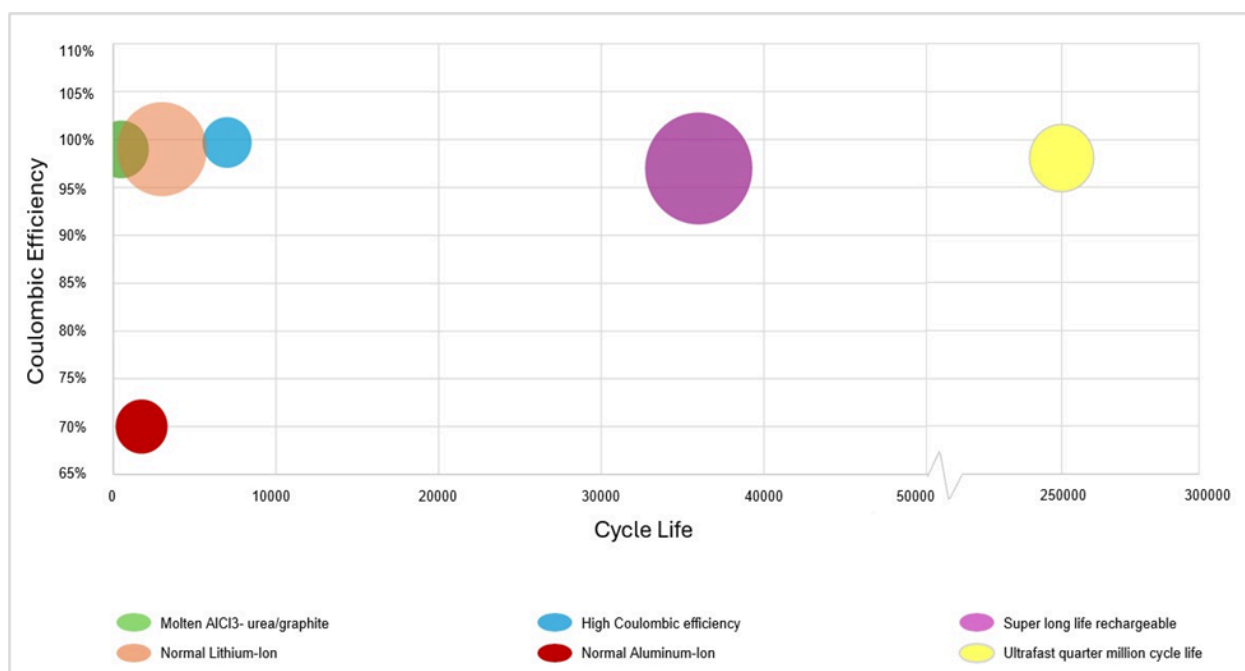

FIGURE 2: COMPARISON OF EACH BATTERY TECHNOLOGY. PLOTTED BY CYCLE LIFE (X AXIS) AND COULOMBIC EFFICIENCY (Y AXIS). SIZE OF CIRCLE IS REPRESENTATIVE OF BATTERY CAPACITY[18–23].

6. Applications

Lithium-ion batteries have been used as a universal solution for electrochemical energy storage. However, specific Al-ion battery chemistries have unique advantages, which may be suitable for individual applications. Notably, Table 2 outlines key metrics for Al-ion batteries in comparison to lithium-ion counterparts, offering insights into their performance across crucial parameters for specific applications. The top three uses for rechargeable batteries—electric vehicles (EVs), portable devices (PDs), and energy storage systems (ESS)—each have distinct requirements, and the ability of Al-ion batteries to tailor their strengths to these needs makes them an intriguing contender in the evolving landscape of electrochemical energy storage

solutions[24]. As technology advances, the diversified landscape of battery options fosters a more nuanced approach to selecting the most suitable power source for specific applications, promoting efficiency, safety, and sustainability.

TABLE 2: CONSISTS OF THE CURRENT ELECTROCHEMICAL PERFORMANCE METRICS REQUIRED BY A BATTERY FOR ELECTRIC VEHICLES, PERSONAL DEVICES, AND ENERGY STORAGE SYSTEMS[25–28]

	EV	PD	ESS
Energy Density?	270 Wh/kg	15 Wh/kg	250 Wh/kg
Life Cycle (times)	>3000 (10 yrs)	>3000 (10 yrs)	>3000 (10 yrs)
Efficiency (%)	>95%	>95%	>95%
Discharging C-rate	9 hours (C/9)	Portable Devices: 18 hours (C/18)	ESSs: 12 hours (C/12)
Charging C-rate	10min - 8 hours	<1 hour	12 hours
Operating temperature ©	-20 C - 50 C	0 C - 35 C	20 C - 30 C
Battery Cost	$137 per kWh	$50-$200	$10,000

The Rechargeable Aluminum Batteries with CMK-3 Cathode stand out as the premier consideration for Energy Storage Systems (ESS) due to a combination of performance and safety metrics. Their remarkable cycle life, reaching over 36,000 charge/discharge cycles, ensures that these batteries can deliver sustained performance for years, making them ideal for large-scale storage systems that experience frequent charge and discharge cycles. This longevity is coupled with an intrinsic high safety profile, reducing the inherent risks like fire hazards associated with many traditional battery systems, especially vital for installations near populated areas. Furthermore, the battery's volumetric capacity, marked at an impressive 8046 mAh cm^−3, highlights its ability to store vast amounts of energy in a limited space, optimizing real estate for large installations. Despite their notable advantages, these batteries are not currently widely used for large-scale storage, mainly because they are still in the early stages of development and commercialization. Established technologies like lithium-ion batteries, with their proven reliability, mature supply chains, and extensive integration into grid-scale applications, currently dominate the market for large-scale energy storage solutions. As the CMK-3 Cathode Rechargeable Aluminum Batteries undergo further testing, standardization, and increased commercial viability, their adoption in the energy storage sector may see growth in the future[19]. When it comes to Electric Vehicles (EVs), the demands for a reliable and high-performing battery are paramount. The ideal choice for EVs would be the advanced Aluminum-Graphene

Battery, known for its exceptional rate capabilities and safety profile. With a high specific capacity of around 120 mAh g^{-1}, it ensures that EVs can cover substantial distances on a single charge. Additionally, its robust cycle life, showing negligible degradation even after a quarter-million cycles, makes it well-suited for the rigorous use expected in EVs, ensuring longevity. The non-flammable materials in its construction enhance safety, addressing concerns related to fire hazards, which is of utmost importance in high-capacity batteries. Furthermore, its ability to operate efficiently across a wide temperature range from -40°C to 120°C ensures that it can cater to the diverse environments that EVs may encounter. Considering the need for rapid charging and the unique requirements of EVs, the Aluminum-Graphene Battery emerges as a promising solution for the future of electric transportation[21].

In the realm of Portable Devices (PDs), lightweight, long-lasting, and safe battery technology is key. The Aluminum-Ion Battery with High CE stands out as an excellent candidate for these applications. While portable devices may not require the same energy density as EVs, they do need to be efficient and offer extended use on a single charge. This battery's high CE of approximately 99.7% ensures that a significant portion of the stored energy is effectively utilized, resulting in prolonged device operation. Moreover, its impressive cathode capacity of about 73 mAh g^{-1} at a current density of 100 mA g^{-1} allows PDs to run for extended periods without frequent recharging. The non-flammable electrolyte addresses safety concerns, which are particularly crucial for devices that people carry with them daily. Overall, the Aluminum-Ion Battery with High CE is a well-rounded choice for powering the next generation of portable devices[20].

7. Conclusion and Outlook:

In conclusion, the comparison between Aluminum-Ion Batteries and Lithium-Ion Batteries highlights an interesting relationship of advantages and challenges. AIBs, powered by trivalent aluminum ions and sustainable sourcing, hold immense promise for transforming the landscape of electrochemical energy storage. These batteries address critical environmental concerns and resource limitations associated with LIBs. The diverse array of AIB chemistries—from molten aluminum chloride-urea graphite batteries to aluminum-graphene variants—demonstrates ongoing innovation to overcome electrochemical limitations.
While LIBs have long reigned supreme due to their high energy density and proven reliability, the scarcity of lithium and its environmentally impactful extraction processes necessitate alternative solutions.

AIBs, abundant in the Earth's crust and reinforced by robust recycling infrastructure, present a compelling case for sustainability. Their safety advantages, including resilience against damage and reduced risk of hazards like thermal runaway, further enhance their appeal as safer energy storage options.
Looking ahead, the future of battery technology lies in the hands of AIBs. As research continues, we anticipate breakthroughs in cycle life, discharge rates, and overall performance. Innovations in materials, manufacturing, and design will shape the next generation of energy storage devices.

Perhaps we'll witness AIB-powered electric vehicles dominating the roads, grid-scale AIB installations revolutionizing energy distribution, and portable AIB-based gadgets seamlessly integrating into our lives. Imagine a world where aluminum-ion batteries power our devices, homes, and cities. The journey has just begun, and the outlook is electrifying.

Works Cited

(1) Leisegang, T.; Meutzner, F.; Zschornak, M.; Münchgesang, W.; Schmid, R.; Nestler, T.; Eremin, R. A.; Kabanov, A. A.; Blatov, V. A.; Meyer, D. C. The Aluminum-Ion Battery: A Sustainable and Seminal Concept? *Front. Chem.* **2019**, *7*. https://doi.org/10.3389/fchem.2019.00268.

(2) tycorun666. *Exclusive study on aluminum ion battery*. The Best lithium ion battery suppliers | lithium ion battery Manufacturers - TYCORUN ENERGY. https://www.takomabattery.com/exclusive-study-on-aluminum-ion-battery/ (accessed 2024-04-14).

(3) Ghiji, M.; Novozhilov, V.; Moinuddin, K.; Joseph, P.; Burch, I.; Suendermann, B.; Gamble, G. A Review of Lithium-Ion Battery Fire Suppression. *Energies* **2020**, *13* (19), 5117. https://doi.org/10.3390/en13195117.

(4) Das, S. K.; Mahapatra, S.; Lahan, H. Aluminium-Ion Batteries: Developments and Challenges. *J. Mater. Chem. A* **2017**, *5* (14), 6347–6367. https://doi.org/10.1039/C7TA00228A.

(5) *The Development and Future of Lithium Ion Batteries - IOPscience*. https://iopscience.iop.org/article/10.1149/2.0251701jes (accessed 2024-04-14).

(6) *Aluminum-air batteries - game changer or hype?* https://web.archive.org/web/20211213164503/https://www.sparkanalytics.co/post/aluminum-air-batteries-game-changer-or-hype (accessed 2024-04-14).

(7) Brahambhatt, R. *New aluminum batteries could be the dirt cheap alternative to lithium-ion that we've all been waiting for*. ZME Science. https://www.zmescience.com/science/news-science/new-aluminum-batteries-could-be-the-dirt-cheap-alternative-to-lithium-ion-that-weve-all-been-waiting-for/ (accessed 2024-04-14).

(8) *Element Abundance in Earth's Crust*. http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/elabund.html (accessed 2024-04-14).

(9) Liu, W.; Agusdinata, D. B. Interdependencies of Lithium Mining and Communities Sustainability in Salar de Atacama, Chile. *J. Clean. Prod.* **2020**, *260*, 120838. https://doi.org/10.1016/j.jclepro.2020.120838.

(10) *Lithium ion battery recycling | CAS*. https://www.cas.org/resources/cas-insights/sustainability/lithium-ion-battery-recycling (accessed 2024-04-14).

(11) Bardt, H. Raw Materials in the Field of Electrochemical Energy Storage – A Risk Analysis. *AIP Conf. Proc.* **2016**, *1765* (1), 020002. https://doi.org/10.1063/1.4961894.

(12) Meyer, D. C.; Leisegang, T.; Zschornak, M.; Stöcker, H. *Electrochemical Storage Materials: From Crystallography to Manufacturing Technology*; Walter de Gruyter GmbH & Co KG, 2018.

(13)   *Are Lithium Ion Batteries Compatible With a Sustainable Future?*. Earth.Org. https://earth.org/data_visualization/are-lithium-ion-batteries-compatible-with-a-sustainable-future/ (accessed 2024-04-14).

(14)   *Map of Aluminum Deposits Worldwide*. https://databayou.com/aluminum/world.html (accessed 2024-04-14).

(15)   *Global Aluminium Recycling: A Cornerstone of Sustainable Development - International Aluminium Institute*. https://international-aluminium.org/resource/global-aluminium-recycling-a-cornerstone-of-sustainable-development/ (accessed 2024-04-14).

(16)   lbowen. *Decarbonizing the aluminum market: Challenges and opportunities*. Atlantic Council. https://www.atlanticcouncil.org/in-depth-research-reports/report/decarbonizing-the-aluminum-market-challenges-and-opportunities/ (accessed 2024-04-20).

(17)   Jiang, F.; Peng, P. Elucidating the Performance Limitations of Lithium-Ion Batteries Due to Species and Charge Transport through Five Characteristic Parameters. *Sci. Rep.* **2016**, *6* (1), 32639. https://doi.org/10.1038/srep32639.

(18)   Jiao, H.; Wang, C.; Tu, J.; Tian, D.; Jiao, S. A Rechargeable Al-Ion Battery: Al/Molten AlCl3–Urea/Graphite. *Chem. Commun.* **2017**, *53* (15), 2331–2334. https://doi.org/10.1039/C6CC09825H.

(19)   Zafar, Z. A.; Imtiaz, S.; Li, R.; Zhang, J.; Razaq, R.; Xin, Y.; Li, Q.; Zhang, Z.; Huang, Y. A Super-Long Life Rechargeable Aluminum Battery. *Solid State Ion.* **2018**, *320*. https://doi.org/10.1016/j.ssi.2018.02.037.

(20)   Angell, M.; Pan, C.-J.; Rong, Y.; Yuan, C.; Lin, M.-C.; Hwang, B.-J.; Dai, H. High Coulombic Efficiency Aluminum-Ion Battery Using an AlCl3-Urea Ionic Liquid Analog Electrolyte. *Proc. Natl. Acad. Sci. U. S. A.* **2017**, *114* (5), 834–839. https://doi.org/10.1073/pnas.1619795114.

(21)   Chen, H.; Xu, H.; Wang, S.; Huang, T.; Xi, J.; Cai, S.; Guo, F.; Xu, Z.; Gao, W.; Gao, C. Ultrafast All-Climate Aluminum-Graphene Battery with Quarter-Million Cycle Life. *Sci. Adv.* **2017**, *3* (12), eaao7233. https://doi.org/10.1126/sciadv.aao7233.

(22)   *Aqueous Rechargeable Zinc/Aluminum Ion Battery with Good Cycling Performance | ACS Applied Materials & Interfaces*. https://pubs.acs.org/doi/abs/10.1021/acsami.5b06142 (accessed 2024-04-14).

(23)   *An Outlook on Lithium Ion Battery Technology | ACS Central Science*. https://pubs.acs.org/doi/10.1021/acscentsci.7b00288 (accessed 2024-04-14).

(24)   *Used Lithium-Ion Batteries | US EPA*. https://www.epa.gov/recycle/used-lithium-ion-batteries (accessed 2024-04-14).

(25)   *Performance Metrics Required of Next-Generation Batteries to Make a Practical Electric Semi Truck | ACS Energy Letters*. https://pubs.acs.org/doi/10.1021/acsenergylett.7b00432 (accessed 2024-04-14).

(26)   Sakti, A.; Azevedo, I. M. L.; Fuchs, E. R. H.; Michalek, J. J.; Gallagher, K. G.; Whitacre, J. F. Consistency and Robustness of Forecasting for Emerging Technologies: The Case of Li-Ion Batteries for Electric Vehicles. *Energy Policy* **2017**, *106*, 415–426. https://doi.org/10.1016/j.enpol.2017.03.063.

(27)   Sapunkov, O.; Pande, V.; Khetan, A.; Choomwattana, C.; Viswanathan, V. Quantifying the Promise of 'beyond' Li–Ion Batteries. *Transl. Mater. Res.* **2015**, *2* (4), 045002. https://doi.org/10.1088/2053-1613/2/4/045002.

(28)   Eroglu, D.; Ha, S.; Gallagher, K. G. Fraction of the Theoretical Specific Energy Achieved on Pack Level for Hypothetical Battery Chemistries. *J. Power Sources* **2014**, *267*, 14–19. https://doi.org/10.1016/j.jpowsour.2014.05.071.

Lifestyle and How It Affects Cellular Aging By Ana Yang

Introduction

On Menlo Grandfriends Day, my grandma was noticeably absent. She was diagnosed with dementia and Alzheimer's last year and could not attend. It all started six years ago when my grandma hit a mailbox while driving. Once she returned home, my parents got a call that she hit someone's mailbox, but she had no recollection of the incident. After the incident, my dad sent her to the doctor to see what was wrong. My parents didn't know for sure what it was but knew something about her was off. Alzheimer's is a degenerative disease that worsens progressively, and there is no medication to treat it. Now that she has reached stage 5, she has been having outbursts of frustration and has the mentality of a five-year-old. In the beginning of her Alzheimer's condition, she would forget to do basic things such as washing dishes and daily chores. Then, she would start to refuse to wash her own hair but only if she went to the salon. My mom would take her to the salon every week for 6-7 months. Later on, she would forget she got her hair down and have mental breakdowns as if she were a 5-year-old. Now, we cannot take her out because she has lots of episodes and forgets family members. My experience with my grandma sparked my interest in biology and how cells are affected by aging. I am mostly interested in aging because I want to see how Alzheimer's is caused, how people are affected by aging, and why. In this essay, I will ask three main questions. The first question is, what happens in the changes of an aging cell? Secondly, what is epigenetics, and how does your body recognize problems? Finally, how do diet and exercise help your cells?

Cellular Aging

Over time as people age, cells also age and become senescent. At this stage, they are affected by telomere degradation as well as genomic instability. Telomeres are little caps of DNA that protect the ends of chromosomes. The more we age, the more cells divide and the shorter the telomeres become (Max Planck Institute for Biology of Ageing, 2022). Cells stop dividing once the end of the chromosome becomes short up to a certain point. This can cause inflammation of many cells and result in early aging. Luckily, a rare enzyme called telomerase can prevent the telomeres from becoming shorter by re-attaching more DNA to the telomere. However, most cells in the human body do not contain the enzyme. Although telomerase can prevent accelerated aging by lengthening telomeres, if the human body generates too much telomerase, it can also make humans more susceptible to accelerated aging and diseases such as cancer (Aunan et al., 2016).

The next part of how cells become affected during aging is genomic instability, or when DNA becomes extremely damaged, which is also a mark of cellular senescence. Our DNA is frequently being damaged externally and internally. Some factors that damage the human body are UV radiation from the sun or reactive chemical species and enzymes in the mitochondria. The DNA in our body is estimated to be damaged about one million times daily from these factors. Luckily, most of the damage is fixed immediately because the cells have excellent

reaction and repair mechanisms (Max Planck Institute for Biology of Ageing, 2022). However, sometimes repairing the human body could be better than we think. Sometimes, a small amount of the damaged DNA is unrepaired. As we age, this DNA damage accumulates and continues to develop, which can cause several negative effects. The mutations in our DNA can cause an increased susceptibility to tumor growth and cancer risks (Aunan et al., 2016). Finally, the damage to our DNA can cause the cells to function less and cause cells to become senescent, also causing a loss of organ function.
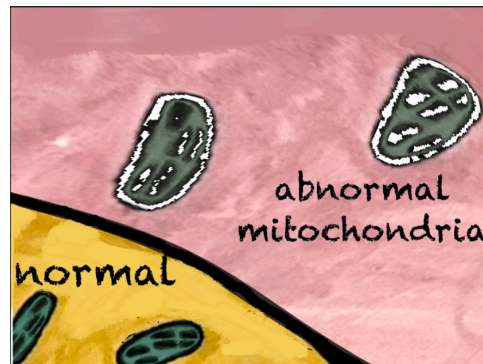
Figure 1. Normal and Abnormal Mitochondria (own photo).

As we age, the epigenetics in our body change. But what is epigenetics, and how does it change? Epigenetics is a part of the body's blueprint stored in your DNA. Sometimes our DNA is bookmarked by specific chemical changes, and this results in various proteins wrapping around the DNA and recognizing it for specific functions, which altogether is called the epigenome. Epigenetics is very important because it helps the human body adapt to what we eat, what drugs we use or consume, and changing levels of stress as we age. One of the most important changes is called DNA methylation, which adds a small chemical group onto a portion of DNA. Some people call it an "epigenetic clock" as a metaphor because DNA methylation may measure how well someone is aging (Max Planck Institute for Biology of Ageing, 2022). This so-called "clock" can be used as a marker to see how to treat certain conditions and to help patients build a new lifestyle. For example, if someone is sick, the clock can be a perfect tool to identify what treatment doctors need to offer and what type of lifestyle the patient will need after being diagnosed with a particular sickness. Although the epigenome may be a perfect marker for new treatments, it can also play a role in aging. Although this is possible, it has not yet been proven in the clinic.

Another reason why our body recognizes problems is mitochondrial dysfunction and how the proteins in the mitochondria develop problems. The mitochondria are tiny little compartments, or organelles, inside of all cells and particles that work as a powerhouse to generate energy for your cells. They use oxygen to create energy with a process called mitochondrial respiration. The mitochondria have their own special genome called mtDNA (Max Planck Institute for Biology of Ageing, 2022). With mice, scientists discovered that having damaged mtDNA can cause accelerated aging. This is why mitochondria are a very important

component of our bodies: they can let us have healthy and well-aged lives. The mitochondria can also make reactive oxygen species, also known as ROS, while producing energy. ROS can be a negative effect sometimes because excessive levels might hurt important cells in the human body. Many scientists thought that ROS could cause people to age faster, but recently, scientists have been finding different results. They found that ROS can also be a positive factor by letting cells communicate and fix things. The mitochondria in younger people have the perfect balance between protein damage and stress response pathways, meaning that the stress response pathways have enough time to fix most of the protein damage that is caused (Moehle et al., 2019). But as we age, the protein damage that builds up over time as we age ends up exceeding how much our stress response pathways can handle.
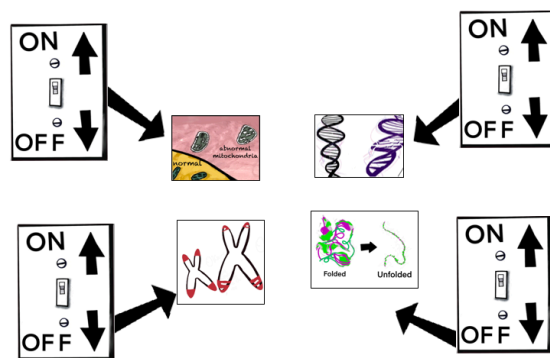

Figure 2. On and Off Switch for Cellular Aging (own photo).

Diet and Exercise

Diet and exercise can also be crucial factors in health and aging. For example, impaired perception of nutrients, exercising, fasting, and sugar all dramatically affect how we age. How much animals eat has also been shown to affect healthy aging. Reduced food intake, or dietary restriction (DR), extends life and can improve health, affecting not only animals but also a wide variety of organisms. Originally, scientists and people thought that the cause of extended living and health was high caloric intake, but now recent studies have shown a reduction in dietary systems. They realized protein is an extremely important part of the dietary system, which includes lots of nutrients. The cells in our body sense nutrients so that we can grow and sustain metabolism. The cells have pathways to extend life, which represents a type of "network" that responds to certain foods. This can also help doctors and scientists to find and develop new medications. Another factor in healthy aging is fasting. Eating less and having restrictions can help your health by reducing inflammation and having a diminished chance of accelerated aging. It activates a "cleaning" process called autophagy which helps your brain and muscles. It also can raise NAD+, a certain chemical, and strengthen people's DNA (Moehle et al., 2019). This can put people's bodies in "survival mode," meaning that if they are in very rough situations with getting food, they won't have too much trouble and will still be strong and have energy.
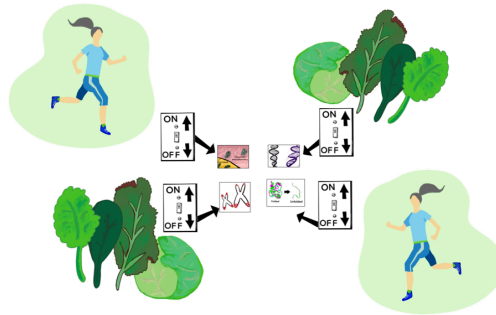
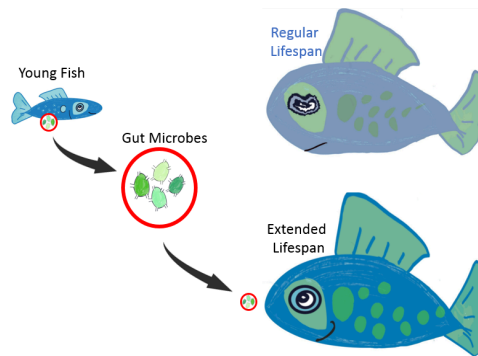*Figure 3*. Healthy Diet and Exercising (own photo).

Figure 4. Regular Lifespan and Extended Lifespan (own photo).

Another factor in healthy aging is sugar intake. People's dietary styles are not meant to involve so much sugar. Extreme amounts of sugar intake can lead to type 2 diabetes and even cause heart disease. Sugar can also shut down pathways that involve AMPK and sirtuin molecules, which are known as two connected mechanisms of increasing lifespan. Consuming too much sugar can lower your defenses against disease and aging. This means that when people consume sugar, their bodies will slowly lose the power of protection from diseases and accelerated aging (Moehle et al., 2019).

Finally, exercising is the last factor in healthy aging. Many studies show that acute exercising relates to the process of aging so much that their effects on the body are almost identical. This is true in multiple organ systems, including the brain, cardiovascular system, neuroendocrine system, metabolic systems, and musculoskeletal system. Rates of chronic disease are lower, and rates of normal aging increase when we exercise frequently. When we work out, our body experiences a "go" or stressful process, which is similar to the process of aging; however, working out also includes a "rest" process. When people's bodies go through the resting process, they are able to cool down the stress that they are dealing with. If we stop exercising, it gives us time to recover, which helps our body get stronger and more used to dealing with challenges. Because acute exercise and aging are similar, repetitive exercise can help the human body become more prepared as we age. This can help decrease our susceptibility to diseases and accelerated aging in general (Moehle et al., 2019)

Conclusion

        Based on my research I have learned that reduced sugar intake and exercising can help prevent cellular aging. Some factors of cellular aging are cellular senescence, genomic instability, and telomere shortening. Some future questions are whether scientists and researchers will find a way to reduce accelerated aging. Based on my research, I really want to find out how people in the blue zone areas work and how their population lives the longest. For example, how does a balanced diet help with aging and how can having a plant-based diet and less processed foods help aging? Another reason is exercising and based on my research, exercising naturally– such as by taking your dog out for walks, standing more, and spending more time outside– can be more effective than going to the gym. Something I found extremely interesting is how drinking wine, belonging, and hanging out with your loved ones make an impact on aging on a cellular level (Buettner et al., 2016). In the future. I want to see how doctors can prove that this can reduce accelerated aging.

Works Cited

Aunan, J. R., Watson, M. M., Hagland, H. R., & Søreide, K. (2016). Molecular and
        biological hallmarks of ageing. *British Journal of Surgery*, *103*(2), e29-e46.
        https://doi.org/10.1002/bjs.10053.

Buettner, D., & Skemp, S. (2016). Blue Zones: Lessons From the World's Longest
        Lived. *American Journal of Lifestyle Medicine*, *10*(5), 318-321.
        https://doi.org/10.1177/1559827616637066.

How do we age? The Hallmarks of Aging. How do we age? | Max Planck Institute for Biology of
        Ageing. (2022, November 29). https://www.age.mpg.de/how-do-we-age.

Moehle, E. A., Shen, K., & Dillin, A. (2019). Mitochondrial proteostasis in the context of
        cellular and organismal health and aging. *Journal of Biological Chemistry*, *294*(14),
        5396-5407. https://doi.org/10.1074/jbc.TM117.0008 93

Vanishing Children: Understanding Russian Child Kidnappings in Ukraine By Arseny Biryukov

Abstract: This essay discusses in detail the war crimes committed by the Russian Federation in the ongoing Russia-Ukraine Conflict. Discussing international organizations like the UN and non-government organizations like HRW, this essay analyzes how these violations occur and what has been done to help those who are suffering. Analyzing the situation through theoretical foundations like liberalism and realism, this essay highlights key concepts of human rights, justice, and liberty.

Twenty-four years into the 21st century, we have climbed further than ever before. After a century of pain, suffering, the misery of two world wars, and the narrow escape from a third, humanity has emerged into the modern era with the profound hope that we may learn from our grievous errors and safeguard human rights. Since 1948, an elaborate international system has developed to promote and protect human rights globally. At the center of this system stands the UN Universal Declaration of Human Rights, which built upon the premise urged in the 1945 UN charter of the promotion of "universal respect for, and observation of, human rights and fundamental freedoms for all" (UN 1945) by specifying and defining the human rights that states had to guarantee and respect. Human rights, by definition, are inalienable and universal and thus must be a consideration for policymakers worldwide. Yet, tragically, modern states are the most frequent violators of human rights, which creates a necessity to identify violations and hold those responsible accountable. One such violation, which has destroyed lives and communities, is the effort by the Russian Federation to forcibly transfer Ukrainian children and civilians, including those fleeing hostilities, to Russia or Russian-occupied areas of Ukraine.

The Russian Federation, as a member of the United Nations and a signatory to the UN Universal Declaration of Human Rights and other critical documents on human rights, is, by law, bound by an obligation to respect human rights. However, as the situation in Ukraine demonstrates, Russia is unwilling to respect these laws of war. Many non-governmental organizations, such as Human Rights Watch (HRW), as well as international organizations like the Organization for Security and Co-operation in Europe, have investigated and reported on these crimes in extensive detail. As Elly Bleier of HRW writes, "Ukrainian children were forcibly deported to Russia or transferred within Russian-controlled territory. This constitutes a war crime. It also concluded that forcibly deported Ukrainian children had been subjected to "numerous and overlapping violations" of their rights […] forcibly deported children were placed in an unfamiliar environment far removed from Ukrainian language, culture, customs, and religion." (HRW 2023). Russia's ongoing effort to forcibly transfer Ukrainian children and civilians to Russia is an abhorrent mockery of human rights, justice, and liberty, perpetuating an erasure of Ukrainian identity and culture.

Ukraine's prosecutor general, Andriy Kostin, whose office is investigating some 90,000 cases of alleged war crimes, said the deportation of children is a special case. The Russians are intentionally keeping Ukrainian children as "hostages," refusing to return them and stripping

them of their identities, Kostin communicated to NBC News in an interview. "This is the type of crime which is so far from the war," he said. "It's not about the war itself. It's about the intention to steal children from the Ukrainian nation." These war crimes are clear violations of international laws and diminish the strength of human rights proponents worldwide. When Russia exhibits flagrant disregard for human rights, the global system of institutions and organizations meant to hold violators accountable suffers. This is especially true given that these violations take place in Europe, the birthplace of the UDHR and many other critical components and instruments of human rights in the modern day. Indeed, Russia's invasion violates Article 3 (by kidnapping children, Russia violates the right to liberty), Article 5 (there are several documented instances of Ukrainian children being tortured by Russian soldiers) Article 13 (By forcefully moving children, their negative right to choice of movement and residence is denied), Article 15 (Russia explicitly erases Ukrainian national identity through brainwashing and propaganda directed at Ukrainian youth), and Articles 18 and 19 (Ukrainians must renege their Ukrainian identity and opinions in Russia or be denied other critical rights such as lifesaving treatment). By violating human rights, Russia simultaneously violates the principles of justice and liberty. Justice, or the idea of fairness and rights, is closely intertwined with liberty, or freedom and autonomy, and in this scenario, the maintenance of both depends heavily on international organizations.

Russia, from its perspective, has tried to justify its actions as humanitarian. Maria Lvova-Belova, the head of what Russia terms its "children's rights program", claims 700,000 kids have been taken in on a humanitarian basis (This number includes all children in Russia-occupied territories, while the 20,000 refers to the children specifically kidnapped into Russia proper). The Russian Perspective and subsequent claims regarding the situation in Ukraine are based on a certain conceptualization of reality promoted by Putin and the broader Russian propaganda network, which maintains that Ukraine is not a state and that the Ukrainian government routinely violates the human rights of its citizens. Justifications of this nature are not rooted in evidence and have fallen on unsympathetic soil, as the International Criminal Court has both condemned the invasion and issued arrest warrants for President Vladimir Putin and Maria Lvova-Belova. Of course, these measures have encountered the insurmountable issue of unenforceability. Nonetheless, the Russian perspective on the issue can be described as deeply realist, disregarding what they view as vague and inapplicable notions in favor of more concrete factors such as power dynamics, which dictate that it is advantageous for the Russian state statistically speaking to grow its population.

Figure 1: Russian President Vladimir Putin meets with Maria Lvova-Belova, Russian children's rights commissioner, at the Novo-Ogaryovo state residence, outside Moscow, on February 16, 2023

In international relations, there is a term called the "Responsibility to Protect" (R2P). Produced by the International Commission on Intervention and State Sovereignty, R2P states two criteria for justifiable military action: large-scale loss of life, and large-scale ethnic cleansing. When these criteria are met, the ICISS asserts that not only does the international community

have a right to intervene, but a more direct responsibility to protect the victims of these acts. For example, the establishment of a "no-fly zone" in northern Iraq in 1991 not only prevented possible reprisal attacks and even massacres after the Kurdish uprising but also allowed Kurdish areas to develop a significant degree of autonomy and relative quietude. And it is clear that in these circumstances both criteria have been met. As stated by Lauren Wolfe writing for the Atlantic, "Forcibly removed from Ukraine, used as leverage, "reeducated," and "Russified," the children at the center of Russia's agitprop are the potential victims of war crimes and crimes against humanity." (Wolfe 2023). If a no-fly zone was established in Ukraine, it would not only aid Ukrainian efforts to win the war greatly, but it would also save thousands of civilians who are otherwise vulnerable to airstrikes from Russia's deadly SU-35 multirole fighters. From the perspective of universalism and the safeguarding of human rights, there are no drawbacks to such an initiative. Yet, no actor within the system is brave enough to invoke the responsibility to protect, not against a great power, showcasing that European powers ultimately operate from a perspective of realism, albeit with a humanitarian agenda in mind. Thus, Ukraine must rely only on itself and whatever pittance it receives from European powers to address this issue.

       Working with Ukraine are several charities and NGOs to retrieve the kidnapped Ukrainian Children. One such NGO is the charity Save Ukraine, the only NGO that regularly organizes rescue missions to return deported children from Russia. Mykola Kubela, the CEO who founded the charity, stated in a conversation with NPR, "We need everything. We need to rescue more children. We need to provide recovery for these kids - housing, food, health. These kids received traumas, and we have to help." (NPR 2024). On January 31st, 2024, three young Ukrainians – still minors by American standards – testified before the U.S. Congress about the torture they endured when they were abducted by Russia and about their way home with the help of the Save Ukraine Foundation. 20-year-old Oleksandr Korzun told the participants of the hearings about the abuse he suffered from the Russian occupiers, who set up a torture chamber in a looted grocery store with broken windows in the Kyiv region: "They put us on our knees and pointed our guns at us. We thought our lives had come to an end, and I said goodbye to my friends. One of the soldiers dragged me and shouted that we were Nazis, that we had a Nazi mentality, and that we "must be destroyed." There are hundreds of other stories like this, real-world examples of people who have suffered that cannot be ignored.

       In conclusion, through an agenda of erasure, fear, and destruction, Russian forces invading Ukraine have wreaked havoc on the lives of people and the wellbeing of communities, not only through the tragedies of war but through a targeted campaign of child kidnappings and broader ethnic cleansing. Through their egregious conduct, Russia disregards the fundamental importance of human rights, justice, and liberty.

Works Cited

Wolfe, Lauren. "The Children Russia Kidnapped." *The Atlantic*, 1 July 2023,
www.theatlantic.com/international/archive/2023/07/russia-kidnapping-abducting-ukrainian-children/674535/.

Brennan, Margaret, and Richard Escobedo. "Ukrainian Children Recount Horrors of Being
Kidnapped by Russian Soldiers - CBS News." *Www.cbsnews.com*, 27 Feb. 2024,
www.cbsnews.com/news/ukrainian-children-kidnapped-russian-soldiers-united-nations/.

NPR. "Ukrainian Children, Abducted by Russia and Then Returned, Are Speaking Out." *NPR*,
NPR, 5 Feb. 2024,
www.npr.org/2024/02/05/1229117422/ukrainian-children-abducted-by-russia-and-then-returned-are-speaking-out.

"Fresh Details on Russia's Forcible Transfer of Ukrainian Children." *Human Rights Watch*, 25
May 2023,
www.hrw.org/news/2023/05/25/fresh-details-russias-forcible-transfer-ukrainian-children.

*Organization for Security and Co-Operation in Europe Office for Democratic Institutions and
Human Rights*.

Britton, Yuliya Talmazan, Daryna Mayer and Bianca. "Ukraine's Missing Children: The Search
for Babies Taken by Russia." *Www.nbcnews.com*,
www.nbcnews.com/specials/ukraine-missing-children-taken-by-Russia-kherson/

"Children of War." *Childrenofwar.gov.ua*, childrenofwar.gov.ua/en/.

"Ukrainians Accuse Russia of Kidnapping, Indoctrinating Ukrainian Children - CBS News."
Www.cbsnews.com, 19 Nov. 2023,
www.cbsnews.com/news/ukrainians-accuse-russia-of-abducting-indoctrinating-children-60-minutes-transcript/.

Petrova, Sasha. "He's a Hostage": Ukrainian Children Reported Seized, Missing." *Al Jazeera*,
www.aljazeera.com/news/2022/7/1/ukraines-missing-children-2. Accessed 24 Mar. 2024.

Time, Current. "More than 700,000 Ukrainian Children Taken to Russia since Full-Scale War
Started, Official Says." *RadioFreeEurope/RadioLiberty*,
www.rferl.org/a/russia-children-taken-ukraine/32527298.html.

"The Sad Legacy of Russian Orphans Lies behind Putin's Troops Kidnapping Tens of
Thousands of Ukrainian Children." *Fortune Europe*,
fortune.com/europe/2023/07/07/why-is-russia-kidnapping-ukrainian-children-vladimir-putin-soviet-book-author/.

"Another Genocide: Russia Kidnaps Ukraine's Children - the Institute of World Politics."
Www.iwp.edu, 4 Nov. 2022,
www.iwp.edu/articles/2022/11/04/another-genocide-russia-kidnaps-ukraines-children/.
Accessed 24 Mar. 2024.

"Deportation, Treatment of Ukraine's Children by Russian Federations Takes Centre Stage by
Many Delegates at Security Council Briefing | UN Press." *Press.un.org*, 24 Aug. 2023,
press.un.org/en/2023/sc15395.doc.htm.

"Ukraine: Russia's Unlawful Transfer of Civilians a War Crime and Likely a Crime against
Humanity – New Report." *Amnesty International*, 10 Nov. 2022,
www.amnesty.org/en/latest/news/2022/11/ukraine-russias-unlawful-transfer-of-civilians-a
-war-crime-and-likely-a-crime-against-humanity-new-report/.

"How One Group Rescues Ukraine's Children from Russia." *TIME*, 7 Apr. 2023,
time.com/6268214/russia-save-ukraine-children-interview/. Accessed 24 Mar. 2024.

Council on Foreign Relations. "The Rise and Fall of the Responsibility to Protect." *World101
from the Council on Foreign Relations*, 20 Apr. 2023,
world101.cfr.org/understanding-international-system/building-blocks/rise-and-fall-respon
sibility-protect.

Exploring Behavioral Biases: A Comparative Study of Investors from X-Class and Y-Class Cities in India by Agastya Bassi

Abstract

Behavioral biases significantly influence investment decisions, often deviating from rational choices and impacting investment outcomes. These biases are particularly relevant in the context of the Indian market, where investors from different socio-economic backgrounds may exhibit varying degrees of bias. The present study is aimed at comparing the level of bias between investors from X and Y class cities in India, with a specific focus on four common biases: herding, overconfidence, confirmation, and recency. It addresses a critical gap in the field by providing insights into how different socio-economic contexts can impact an investor's mindset. The sample comprises 127 active stock market investors from X and Y class cities in India, with data collected through a self-administered quantitative survey. This survey was based on standardized scales developed by Ngoc (2014), Khan et al. (2017), Özen and Ersoy (2019), and Pinsker (2011) to measure the four behavioral biases. Amongst others, a major finding is that investors from X class cities exhibit a significantly higher degree of herding bias compared to those from Y class cities. This research contributes to the understanding of how different socio-economic contexts can shape investor behavior and decision-making processes. It has implications for investors, financial institutions, regulators, policymakers, and market analysts, as it provides insights that can help tailor strategies to mitigate risks and enhance decision-making in the financial ecosystem.

Introduction

Behavioral economics, a branch that encompasses behavioral finance, emerged from the groundbreaking work of Kahneman & Tversky (1979) and their influential prospect theory. What is intriguing is that these pioneers, both psychologists, approached finance without traditional financial training. This field of behavioral finance investigates the impact of psychological factors on market behaviors, delving into the intricacies of human decision-making in financial contexts. It offers a lens through which one can interpret a wide spectrum of market phenomena and outcomes, ranging from individual investment patterns to broader market trends. By exploring the intricate interplay between human psychology and financial decisions, behavioral finance provides a nuanced understanding of market dynamics, fostering the development of more nuanced and adaptive financial models and strategies.

From this arises the question, why are investors prone to biases in their decision making? Cultural nuances, societal expectations, and historical perspectives on finance can all contribute to distinct cognitive biases. (Williamson et. al, 2019). Considering the role of experience in the formation of behavioral biases from a developmental, cross-cultural, and evolutionary perspective may impact decision-making in financial matters. The reason is multifold but stems from overconfidence, tendency to avoid regret (regret aversion bias), wanting to follow other investors (herding bias) and many more. It is believed that the investors are subjected to various

cognitive biases, in spite of making an attempt to behave rationally. This is consistent with the findings of various recent studies conducted in the Indian context (Mishra & Metilda, 2015; Mushinada & Veluri, 2018).

The field of behavioral finance has a wide range of captivating research themes. Scrutinizing biases in investment decisions unveils the psychological factors steering individual choices. Market anomalies, such as the January effect and momentum, challenge conventional financial theories, providing insights into irregular patterns (Thaler, 1987). Emotional influences on trading, notably fear and greed, wield a substantial impact on shaping market volatility. Cultural variances affect financial decision-making, molding risk tolerance, time preferences, and perceptions of fairness, according to Halpern & Hess (2014) and Yates & De Oliveira (2016). A study comparing how investors perceive different information sources found that more than half of all respondents in a Mumbai based survey consider information obtained via the internet to be an important source in making investment decisions, while 45 percent consider TV channels to be an important source in making investment decisions, and nearly half of all respondents consider newspapers to be an important source in making investment decisions. However, in a Delhi based survey, 45 percent of the respondents say they make decisions based on company's financial data (Saxena & Chawla, 2022). Comparing the biases in different Indian cities and exploring if there is a difference due to these geographical factors is a new perspective and one of the gaps this paper aims to fulfill.

While prior research has extensively examined behavioral biases in investment decision-making, there is a paucity of studies that specifically compare these biases across investors from diverse urban settings within India. Existing studies primarily focus on understanding the general nature of biases such as overconfidence, loss aversion, and herding behavior among investors in various global contexts. However, there is a lack of research that delves into how these biases may vary among investors residing in cities of differing socio-economic strata and developmental stages, as delineated by the Indian government's tier classification system. Moreover, the few studies that do touch upon the behavioral differences among investors in different cities often generalize findings from metropolitan cities to represent urban investors at large, overlooking the nuanced behavioral distinctions that may exist between investors from X-class (metropolitan and large cities) and Y-class (smaller cities and towns) cities in India. This study intends to fill this gap by providing a more granular analysis of investor biases, thereby contributing to a deeper understanding of behavioral finance in the Indian context.

This study aims to explore the difference in biases of Indian investors from different tier cities (X-class and Y-class). This is beneficial in several ways: economic conditions vary across different classes of cities, affecting risk perceptions, investment choices, and financial goals. Analyzing these variations provides insights into how economic factors interact with behavioral biases. Different class cities often have distinct socioeconomic and sociocultural dynamics. Studying biases in these contexts can reveal how societal structures, income levels, and education impact financial decision-making at various levels. The study makes use of a

quantitative survey that was rolled out to investors belonging to different city classes. It uses standardized scales for measuring four commonly seen biases in the Indian financial markets. This paper explores the most common biases found in the Indian subcontinent in investors. These are herding bias, recency bias, overconfidence bias and confirmation bias (Prosad et. al, 2015). The survey also collected information on a variety of demographics like income, age, education, employment status and the nature of work. Using these results, statistical analysis was done to determine the degree of bias in different tier cities along with the coinciding demographics.

Methodology

This section will delve into the study's objectives and hypotheses, elucidate the chosen sampling technique and delineate the characteristics of the selected sample. Additionally, it will expound upon the data collection procedure employed and provide insights into the scales and tools utilized in the study.

Research Aim

The aim of the research paper is to gauge whether investors from different tier cities have different levels of cognitive biases in the Indian financial markets. The primary objective of this quantitative research endeavor is to conduct an exhaustive study into the behavioral biases inherent among Indian investors, with a keen focus on understanding the nuanced influence of geographical factors across different classes of cities. For this purpose the study compares X-Class city investors and Y-Class city investors with respect to the most common biases found in the Indian subcontinent. The four behavioural biases considered in this paper are herding bias, recency bias, overconfidence bias and confirmation bias.

Essentially, the aim of this paper is to gauge whether investors from Y-Class cities have higher levels of cognitive biases as compared to investors from X-Class cities. The formulated hypothesis postulated that investors originating from X-Class cities would demonstrate a lower degree of biases compared to their counterparts in Y-Class cities. This supposition was because of the expectation that individuals in X-Class cities would possess higher levels of education and training, contributing to more informed investment decision-making. The secondary aim of the study is to delve into the underlying factors influencing cognitive biases among investors from X-Class and Y-Class cities. This includes investigating socioeconomic disparities, access to financial education, and cultural influences that may contribute to varying levels of behavioral biases. By identifying these factors, the study aims to provide a comprehensive understanding of how geographical and contextual differences shape investor behavior in Indian financial markets.

Following are the hypotheses of the study:

1. H_{01}: *There is no significant difference in the herding bias of investors based on their city class.*
   H_{a1}: *There is a significant difference in the herding bias of investors based on their city class.*

2. H_{02}: *There is no significant difference in the overconfidence bias of investors based on their city class.*
   H_{a2}: *There is a significant difference in the overconfidence bias of investors based on their city class.*

3. H_{03}: *There is no significant difference in the confirmation bias of investors based on their city class.*
   H_{a3}: *There is a significant difference in the confirmation bias of investors based on their city class.*

4. H_{04}: *There is no significant difference in the recency bias of investors based on their city class.*
   H_{a4}: *There is a significant difference in the recency bias of investors based on their city class.*

5. H_{05}: *There is no significant difference in the herding bias of investors based on their household income.*
   H_{a5}: *There is a significant difference in the herding bias of investors based on their household income.*

6. H_{06}: *There is no significant difference in the overconfidence bias of investors based on their household income.*
   H_{a6}: *There is a significant difference in the overconfidence bias of investors based on their household income.*

7. H_{07}: *There is no significant difference in the confirmation bias of investors based on their household income.*
   H_{a7}: *There is a significant difference in the confirmation bias of investors based on their household income.*

8. H_{08}: *There is no significant difference in the recency bias of investors based on their household income.*
   H_{a8}: *There is a significant difference in the recency bias of investors based on their household income.*

9. H_{09}: *There is no significant difference in the herding bias of investors based on their age.*
   H_{a9}: *There is a significant difference in the herding bias of investors based on their age.*

10. H_{010}: *There is no significant difference in the overconfidence bias of investors based on their age.*
    H_{a10}: *There is a significant difference in the overconfidence bias of investors based on their age.*

11. H_{011}: *There is no significant difference in the confirmation bias of investors based on their age.*
    H_{a11}: *There is a significant difference in the confirmation bias of investors based on their age.*
12. H_{012}: *There is no significant difference in the recency bias of investors based on their age.*
    H_{a12}: *There is a significant difference in the herding bias of investors based on their age.*
13. H_{013}: *There is no significant difference in the herding bias of investors based on their profession.*
    H_{a13}: *There is a significant difference in the herding bias of investors based on their profession.*
14. H_{014}: *There is no significant difference in the overconfidence bias of investors based on their profession.*
    H_{a14}: *There is a significant difference in the overconfidence bias of investors based on their profession.*
15. H_{015}: *There is no significant difference in the confirmation bias of investors based on their profession.*
    H_{a15}: *There is a significant difference in the confirmation bias of investors based on their profession.*
16. H_{016}: *There is no significant difference in the recency bias of investors based on their profession.*
    H_{a16}: *There is a significant difference in the recency bias of investors based on their profession.*

Research Design

The paper uses a quantitative research methodology, employing statistical analysis to systematically collect and analyze numerical data through employing a survey. To analyze the differences between investors from different cities, the study uses the X Y Z classification system, which categorizes cities based on their level of development (Ministry of Heavy Industries and Public Enterprises, 2015). This classification system considers factors such as population size, infrastructure, and economic indicators. The same system is employed in this study to categorize cities and analyze investor behavior.

Sampling and Sample Characteristics

The study utilizes both convenience sampling and snowball sampling methodologies to select investors from X-Class and Y-Class cities who were not only readily accessible but also within the defined criteria of these cities. The sample included participants from X-Class cities like Mumbai, Kolkata, Hyderabad, New Delhi, and so on. Additionally, some of the Y-Class cities included in the sample were Gurugram, Noida, Amritsar, Ranchi, and so on. The sample initially had a total of 165 sample units. In order to ensure a focused and pertinent sample, individuals who did not invest were intentionally excluded from the study based on

predetermined exclusion criteria-those who do not invest in the stock market. Following the application of these exclusion criteria, a total of 38 respondents were excluded, resulting in a revised sample size of 127.

The sample predominantly comprised males, constituting 83 percent of the group, while females constituted a 17 percent minority. There were 49% responses from X-class residents and 51% from Y-class. Among the participants, 72 percent held financial roles in their professional capacity, whereas 22 percent were not engaged in financial roles, and an additional 6 percent were not currently employed. There was a variety of household income among respondents. The major part, 59.4 percent of respondents, reported an annual income surpassing the 20 Lakhs level.

Scales and Techniques Used

The present work is based on data collection through a quantitative survey instrument. Four standardized scales have been used to measure the four biases included in this study.

In order to measure *herding bias,* the 3-item scale developed by Ngoc (2014) was adopted to fit the Indian market. This scale measures the tendency of an investor to follow the decisions of other investors in making investments. It consists of three statements like, 'I follow the action of selling/buying other investors' shares', 'I react quickly to follow the market reaction', and so on. *Overconfidence bias* was measured by a scale developed by Khan et al. (2017). It measures the degree of individuals' tendency to overestimate their knowledge, ability, and information accuracy, or to be overly optimistic about the future and their ability to control it. It includes seven statements, some of which were 'When I make a plan, I'm sure it will work.', 'My predictions on stocks are always right.', 'I can identify stocks that will perform well in the future.', and so on.

In order to measure *confirmation bias,* the scale developed by Özen and Ersoy (2019) has been used. It measures the attitude of someone who tends to pay more attention to information or views that are in line with his views than those that are contrary. It consists of the following three statements, statements, 'I ignore information related to stock selection that is contrary to belief.', 'I don't change my mind even if I start to lose investments that I believe will be profitable.', and 'When I lose an investment, I don't change my belief in my investment.' *Recency Bias* is the final bias considered in the study. The scale used was developed originally by Pinsker (2011). It measures behavior carried out by individuals who only remember or are based on the latest sources of information that have just been obtained. This is a 4-item scale , including statements like, 'I'm basing my decision on the most recent information I've gathered.', 'I will look at the investment record of one to three years to see how the investment has performed recently.', among others. The scoring methodology involved participants rating their agreement on the Likert scale, 1 representing Strongly Disagree and 5 representing Strongly Agree, where a higher score signified a more pronounced agreement of their tendency to display the specific investment bias.

Data Collection Procedure and Statistical Analysis

The data collection process involved the administration of a survey instrument through Google Forms, systematically rolled out to a diverse group of investors for voluntary participation. The survey was conducted in the English language. Ethical considerations were paramount throughout the research journey, and informed consent was meticulously obtained from each participant. The consent process outlined the study's purpose, ensured the privacy protection of participants, and emphasized their voluntary participation. This study exclusively utilized the statistical technique of t-tests to analyze the data collected using DataTab tool. T-tests were employed to assess statistical differences and relationships between variables of interest, providing valuable insights into the research hypotheses.

Results

The following section presents the results of the study, providing a comprehensive analysis of the collected data. Through meticulous examination and interpretation, valuable insights are offered into the research questions posed in this investigation.

Table 1: Independent T-Test Analysis of Cognitive Biases on the Basis of City Type (N=96)

	Class	n	Mean	Standard Deviation	t	p
Herding	X-Class	47	8.47	2.64	2.15	0.034**
	Y-Class	49	7.33	2.55		
Overconfidence	X-Class	47	20.49	5.07	1.33	0.188
	Y-Class	49	18.94	6.3		
Confirmation	X-Class	47	9.04	2.56	1.02	0.312
	Y-Class	49	8.47	2.96		
Recency	X-Class	47	14.3	3.32	1	0.322
	Y-Class	49	13.49	4.56		

Note: *p<0.10, **p<0.05, ***p <0.01

Conducting an independent sample t-test to assess herding, overconfidence, confirmation, and recency bias among residents of X-Class and Y-Class cities revealed noteworthy distinctions, as seen in Table 1. The analysis indicated a significant difference in herding bias (t(95)=2.15, p<0.05), with residents of X-Class cities exhibiting a higher degree of this bias compared to their counterparts in Y-Class cities. However, when examining overconfidence (t(95)=1.02, p>0.05),

confirmation (t(95)=1.33, p>0.05), and recency bias (t(95)=1, p>0.05), no statistically significant differences were observed between the two groups. Thus, through this test, H_{01} has been rejected, whereas H_{02}, H_{03} and H_{04} have been accepted.

Table 2: Independent T-Test Analysis of Cognitive Biases on the Basis of Household Income (N=99)

	Class	n	Mean	Standard Deviation	t	p
Herding	Above 20	50	7.8	2.6	-0.15	0.882
	Below 20	49	7.88	2.58		
Overconfidence	Above 20	50	20.98	5.95	2.09	0.039**
	Below 20	49	18.63	5.18		
Confirmation	Above 20	50	9.04	2.51	0.98	0.331
	Below 20	49	8.49	3.06		
Recency	Above 20	50	14.7	3.55	1.93	0.057*
	Below 20	49	13.14	4.43		

Note: *p<0.10, **p<0.05, ***p <0.01

According to the t-test conducted in Table 2, there was a significant difference observed in overconfidence bias among individuals earning Above 20 Lakhs (t=2.09, p<0.05). This suggests a heightened level of overconfidence in the higher income bracket. Recency Bias was also statistically significant at the 10% level (t=1.93, p<0.10) Nevertheless, the differences in Herding (t=1.04, p>0.05) and Confirmation (t=0.8, p>0.05) across income groups were not deemed statistically significant. Thus H_5 and H_8 are accepted and H_6 and H_7 are rejected.

Utilizing an independent sample t-test to scrutinize Herding, Overconfidence, Confirmation, and Recency Bias between individuals who work in Finance and those who do not work in Finance, an intriguing distinction came to light. A significant variation surfaced in overconfidence bias (t=-1.75, p<0.10) at the 10% significance level, emphasizing a greater prevalence of this bias among those employed in the financial sector at their place of work (see Table 3). However, the examination of Herding(t=1.04, p>0.05) , Confirmation (t=0.8, p>0.05), and Recency Bias (t=-0.86, p>0.05) did not reveal statistically significant differences between the groups. Thus null hypothesis H10 was rejected, whereas H9, H11 and H12 were accepted.

Table 3: Independent T-Test Analysis of Cognitive Biases on the Basis of Having a Job in Finance (N=89)

	Class	n	Mean	Standard Deviation	t	p
Herding	No	45	8.4	2.43	1.04	0.3
	Yes	44	7.86	2.43		
Overconfidence	No	45	18.91	4.32	-1.75	0.083*
	Yes	44	20.61	4.82		
Confirmation	No	45	8.89	2.63	0.8	0.427
	Yes	44	8.43	2.77		
Recency	No	45	13.6	3.99	-0.86	0.395
	Yes	44	14.27	3.41		

Note: *p<0.10, **p<0.05, ***p <0.01

Table 4: Independent T-Test Analysis of Cognitive Biases on the Basis of Age (N=85)

	Class	n	Mean	Standard Deviation	t	p
Herding	Above 45	42	8.02	2.3	-0.38	0.703
	Below 45	43	8.23	2.72		
Overconfidence	Above 45	42	20.81	4.8	1.75	0.084*
	Below 45	43	19.07	4.35		
Confirmation	Above 45	42	8.38	2.65	-0.38	0.707
	Below 45	43	8.6	2.82		
Recency	Above 45	42	14.93	2.74	1.92	0.058*
	Below 45	43	13.44	4.24		

Note: *p<0.10, **p<0.05, ***p <0.01

Finally, to dissect the difference in Herding, Overconfidence, Confirmation, and Recency Bias, the study looked at age: those above 45 years and those below 45 years. A significant difference was seen in the two groups with regard to overconfidence bias (t=1.75, p<0.10) (see Table 4), the 10% level, indicating a proclivity for this bias among the older age group. There was also a significant difference in the recency bias (t=1.92, p<0.10). However, the tones of Herding (t=-0.38, p>0.05) and Confirmation (t=-0.38, p>0.05) were lacking statistically significant distinctions between the two categories. Therefore, through this H_{13} and H_{15} were accepted and H_{14} and H_{16} were rejected.

Discussion

From this study's results, it has been discovered that individuals from X-Class cities tend to display a higher degree of herding bias as compared to investors from Y-Class cities. Studies have usually found that herding behavior is most noticeable in emerging markets, followed by frontier markets and then developed markets. This trend can be attributed to factors such as lower liquidity, stability, and transparency. In less developed markets with shorter trading histories, irrational herd behavior tends to prevail. This behavior isn't driven by market fundamentals, but rather by external influences or intentional actions by economic players. Emerging and frontier markets typically show moderate and intentional herding behavior due to their less developed financial infrastructure. However, contrary to conventional belief, this paper has found a significantly higher tendency of herding bias in investors of more developed X-Class cities. This could be due to the presence of self-attribution, illusion of control, and information availability in investors from more developed regions. These factors exert a positive influence on the tendency to follow the crowd in decision-making processes as backed up by another study (Din et. al, 2021) on the impact of behavioral biases on herding. Furthermore, the prevalence of institutional investors and financial advisors in X class cities may contribute to herd behavior among individual investors. The influence of institutional investors, who often drive market trends and herd behavior, can create a domino effect where individual investors feel compelled to follow suit to align with perceived market consensus. On the other hand, investors from Y class cities may have less exposure to financial institutions and investment firms, resulting in reduced influence from institutional investors and financial advisors who often drive herd behavior (Kim et. al., 2019) Secondly, as observed by Din et. al (2021), social networks in Y-class cities may have less influence on investment decisions, as investors may have smaller, less interconnected social circles, reducing the pressure to conform to prevailing market sentiments.

Research consistently shows that investors in X-class cities, such as those in Pakistan, display herding bias in their decision-making (Qasim et al, 2019). Firstly, the interconnectedness of social circles within these cities can lead to a heightened awareness of investment trends and a tendency to conform to prevailing market sentiment. Secondly, the availability of sophisticated investment tools and financial literacy may paradoxically contribute to herding behavior, as individuals may rely too heavily on data and overlook contrarian viewpoints. Moreover, the fear

of losing substantial wealth or missing out on potential gains may intensify the desire to follow the crowd and avoid deviating from consensus behavior. (Lynott, 2020)

With regards to those who work in the financial sector, it was discovered that they are statistically more prone to overconfidence bias. Another study by Broihanne et. al (2014) also found upon interviewing 64 finance professionals that they are overconfident in both the general and the financial domains. Finance professionals may exhibit higher levels of overconfidence while investing due to their extensive knowledge and experience in financial markets, which can lead to overestimation of their abilities to predict market movements accurately. Access to vast amounts of financial data and analytical tools may increase their confidence in investment decisions. Additionally, the finance industry's culture often rewards and celebrates risk-taking and bold investment strategies, further reinforcing overconfidence. This culture, combined with pressure to outperform peers and benchmarks, may drive finance professionals to make overly aggressive investment decisions without fully considering associated risks.

Furthermore, this study found the same result for high income individuals as well. This means that high income individuals tend to showcase excessive confidence in making investment decisions as compared to low income individuals. This is supported by Tekçe (2015), who found that male investors, who are more likely to have higher incomes, are more overconfident. Perhaps the reason is that their higher income gives them a sense of security which allows them to invest more and thus reap higher returns. All this can contribute to increasing one's confidence levels.

Recency bias in the above 20 lakh income bracket could arise due to several reasons. Firstly, individuals with higher incomes may have busier schedules and less time to thoroughly research investment options, leading them to rely more heavily on recent market trends or news when making decisions (Habib & Hui, 2017). Additionally, their access to real-time financial information and sophisticated investment tools may make them more susceptible to placing undue emphasis on recent events, even if those events are not necessarily indicative of long-term market trends (Mattan & Cloutier, 2020).

Finally, the paper also found that adults above the age of 45 tend to display a higher degree of the overconfidence bias as compared to younger investors. As individuals age, they may become more confident in their investment decisions due to their wealth of experience, longer-term perspectives, and the sense of financial security they've accumulated over the years. A study by Prims & Moore (2017) found that confidence that one knows the truth increases with age. The results imply that older people may, at least under some circumstances, be more susceptible to overestimating their knowledge and making overly confident judgments. This confidence can stem from their years of experience in predicting market trends and their perceived stability in financial matters, such as having retirement funds. Additionally, older individuals often have stable sources of income, which can further bolster their confidence in their financial decisions. Therefore, it's in line that this research observed a higher level of overconfidence among older investors.

Conclusion

      This paper delved into the behavioral biases of investors across various demographic categorizations, particularly focusing on city class, age, income, and profession. The findings revealed distinct tendencies: investors from X-class cities exhibited a marked herding bias, while older individuals, finance professionals, and high-income earners displayed notable levels of overconfidence. It also found recency bias in higher income individuals being more prevalent than those with an under 20 lakh income level. These insights underscore how socio-economic contexts influence investor behavior, offering practical implications for various stakeholders.

      For investors, this study provides valuable insights to make informed decisions, steering clear of herd mentality prevalent in certain urban classes. Financial institutions can tailor services to cater to diverse client needs and manage risks associated with overconfidence in specific demographics. Regulators and policymakers can use these findings to devise targeted interventions for fair and transparent markets, mitigating systemic risks. Furthermore, market analysts can benefit from incorporating socio-economic factors into risk assessments, thereby enhancing market efficiency.

      However, the study had limitations that warrant consideration. The need for social desirability might have led respondents to alter their answers, potentially masking their true biases. Additionally, self-reporting could be limited by biases, inaccuracies, and difficulties in measuring internal states. The relatively small sample size of 127 units, concentrated primarily in areas like Gurugram and New Delhi, could limit the generalizability of the findings. Moreover, the study focused on only four biases out of many, suggesting the need for future research to explore a broader array of biases across different geographic areas for more comprehensive insights.

Works Cited

Armansyah, R. F. (2022). Herd instinct bias, emotional biases, and information processing biases in investment decisions. Jurnal Manajemen dan Kewirausahaan, 24(2), 105-117.

Bogdan, S., Suštar, N., & Draženović, B. O. (2022). Herding Behavior in Developed, Emerging, and Frontier European Stock Markets during COVID-19 Pandemic. *Journal of Risk and Financial Management*, 15(9), 400. https://doi.org/10.3390/jrfm15090400

Broihanne, M., Merli, M., & Roger, P. (2014). Overconfidence, risk perception and the risk-taking behavior of finance professionals. *Finance Research Letters*, 11, 64-73.

Din, S. M. U., Mehmood, S. K., Shahzad, A., Ahmad, I., Davidyants, A., & Abu-Rumman, A. (2021). The impact of behavioral biases on herding behavior of investors in Islamic financial products. *Frontiers in Psychology*, 11, 600570.

Habib, K. N., & Hui, V. (2015). An activity-based approach of investigating travel behaviour of older people. *Transportation*, 44(3), 555–573. https://doi.org/10.1007/s11116-015-9667-1

Halpern, D., & Hess, D. (2014). Cross-Cultural Risk Behavior in Financial Decisions and the Cushion Hypothesis. *Claremont McKenna College.*

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. Econometrica, 47(2), 263. https://doi.org/10.2307/1914185

Khan, A. R., Azeem, M., & Sarwar, S. (2017). Impact of overconfidence and loss aversion biases on investment decision: Moderating role of risk perception. International Journal of Transformation in Accounting, Auditing & Taxation, 1(1), 23–35.

Kim, J.Y., Kim, Y., & Shim, M. (2019). Do Financial Analysts Herd? *Global Economic Review,* 52, 202 - 219.

Lynott, W. J. (2020, November 13). Avoid the "herd" mentality: Stay focused on long-term investment goals. Dermatology Times. https://www.dermatologytimes.com/view/avoid-herd-mentality-stay-focused-long-term-investment-goals

Mattan, B. D., & Cloutier, J. (2020). A registered report on how implicit pro-rich bias is shaped by the perceiver's gender and socioeconomic status. *Royal Society Open Science*, 7(8), 191232. https://doi.org/10.1098/rsos.191232

Ministry of Heavy Industries and Public Enterprises. (2015). Office Memorandum-Reclassification/Upgradation of Cities/Towns on the basis of Census 2011 for the purpose of grant of House Rent Allowance for CPSE employees. *Department of Public Enterprises.* https://dpe.gov.in/sites/default/files/re_calassification_upgradation.pdf

Mishra, K., & Metilda, M. J. (2015). A study on the impact of investment experience, gender, and level of education on overconfidence and self-attribution bias. IIMB Management Review/IIMB Management Review, 27(4), 228–239. https://doi.org/10.1016/j.iimb.2015.09.001

Mushinada, V. N. C., & Veluri, V. S. S. (2019). Elucidating investors rationality and behavioural biases in Indian stock market. *Review of Behavioral Finance*, 11(2), 201-219.

Ngoc, L. T. B. (2014). Behavior pattern of individual investors in stock market. International Journal of Business and Management, 9(1), 1–16. https://doi.org/10.5539/ijbm.v9n1p1

Özen, E., & Ersoy, G. (2019). The impact of financial literacy on cognitive biases of individual investors. In S. Grima, E. Özen, H. Boz, J. Spiteri, & E. Thalassinos (Eds.), Contemporary issues in behavioral finance (Contemporary Studies in Economic and Financial Analysis, Volume 101) (pp. 77–95). Emerald Publishing Limited. https://doi.org/10.1108/S1569-375920190000101007

Pinsker, R. (2011). Primacy or recency? A study of order effects when nonprofessional investors are provided a long series of disclosures. Behavioral Research in Accounting, 23(1), 161–183. https://doi.org/10.2308/bria.2011.23.1.161

Prims, J. P., & Moore, D. A. (2017). Overconfidence over the lifespan. *Judgment and Decision Making*, 12(1), 29–41. https://doi.org/10.1017/s1930297500005222

Prosad, J.M., Kapoor, S., & Sengupta, J. (2015). Behavioral biases of Indian investors: a survey of Delhi-NCR region. Qualitative Research in Financial Markets, 7, 230-263.

Qasim, M., Hussain, R. Y., Mehboob, I., & Arshad, M. U. (2019). Impact of herding behavior and overconfidence bias on investors' decision-making in Pakistan. Accounting, 81–90. https://doi.org/10.5267/j.ac.2018.7.001

Saxena, A., & Chawla, P. (2022). An Empirical Study on the Influence of Behavioral Biases on Investment Decisions in Delhi NCR. *Global Journal of Enterprise Information System*, 14(3), 9-19.

Tekçe, B., & Yılmaz, N. (2015). Are individual stock investors overconfident? Evidence from an emerging market. *Journal of Behavioural and Experimental Finance*, 5, 35–45. https://doi.org/10.1016/j.jbef.2015.02.003

Thaler, R. H. (1987). Anomalies: the January effect. Journal of economic perspectives, 1(1), 197-201.

Williamson, R. A., MacDonald, B., & Brosnan, S. F. (2019). Considering the Role of Experience in the Formation of Behavioral Biases from a Developmental, Cross-Cultural, and Evolutionary Perspective. Animal Behavior and Cognition, 6(3), 179–193. https://doi.org/10.26451/abc.06.03.03.2019

Yates, J., & De Oliveira, S. (2016). Culture and decision making. Organizational Behavior and Human Decision Processes, 136, 106–118. https://doi.org/10.1016/j.obhdp.2016.05.003

Bridging the Gap: Understanding Higher Knee Injury Rates in Female Collegiate Rowers
By Shloka Nath

Research Question

Why do female collegiate-level rowers tend to sustain knee injuries at a higher rate than their male counterparts?

Abstract

Rowing is a team-oriented water sport in which athletes use oars to propel forward a boat. Sweeping and sculling (two types of rowing) are physically demanding—requiring upper body, core, and leg muscles. The sport involves repetitive motion, which leads to rowers often developing overuse injuries due to the continuous strain on the same muscles and joints. While general and overuse injuries are common amongst rowers, female athletes are disproportionately negatively impacted. This review aims to investigate the physiological factors contributing to the higher rate of knee injuries among female collegiate-level rowers compared to their male counterparts. Potential factors contributing to increased injury risk in female rowers include anatomical differences, strength imbalances, and biomechanics. As a result of such constituents, females are at greater risk for conditions such as patellofemoral pain syndrome or patellar tendinopathy. Understanding these factors is crucial for injury prevention and progressions in training strategies for collegiate athletes to maintain their peak performance.

Introduction

Rowers primarily engage their quadriceps, latissimus dorsi, and gluteal muscles, indicating that the sport is physically demanding in strength and endurance. As of the 2018-2019 rowing season, 7294 females and 2340 males across all divisions were recorded as student-athletes competing in the NCAA[2]. While the number of athletes may fluctuate yearly, approximately 76% of collegiate rowers are female. Collegiate-level rowers train approximately twenty hours per week, averaging 1-2 practices per day. Workouts include strength training, erging, and rowing. The intensity and frequency of collegiate training takes a toll on many athletes, with overuse injuries amongst the most common for athletes. Most rowing injuries impact the wrist, ribcage, knee, and lumbar spine[3]. While injuries occur amongst all collegiate rowers, female athletes are more likely to sustain overuse and rowing-related knee injuries compared to male counterparts. This review paper will discuss how frequently reported rowing-related knee injuries are correlated to anatomical differences, strength imbalances, and biomechanics.

Anatomical Differences

One of the most commonly reported injuries amongst rowers, regardless of gender, includes patellofemoral pain syndrome; however, the incidence rate amongst females is 20%

compared to 7.4% in males[4]. Joint malalignment and quadricep strength imbalances contribute to the development of knee-related conditions, both of which are predisposed in female athletes.

Females, on average, tend to have wider hips and pelvises compared to their male counterparts. This leaves female athletes more predisposed to a greater Q-angle, which is the angle between the quadriceps muscles and the patellar tendon.[4] A wider pelvis makes athletes more prone to malalignments such as increased femoral anteversion, also known as "pigeon toes," and genu valgum, both of which result in an increased Q angle, a known factor for inducing patellofemoral pain syndrome and other problems[4]. Because a wider pelvis results in an increased angle between the bones in the knee joint, additional stress is placed on the knee while rowing—increasing the risk of patellofemoral pain syndrome or patellar tendinopathy. Consequently, females are twice as likely as males to develop patellofemoral pain[5].

Along with being predisposed to malalignments, having a wider pelvis makes it more likely for females' knees to slope inwards while their ankles are normally spaced apart[6],[7]. This places additional stress on the anterior cruciate ligament (ACL) and possibly contributes to females being six times more likely to injure their ACL. [8]

Another possible explanation for this phenomenon is the role estrogen plays in the stability of ligaments[9]. While both males and females circulate estrogen, females exhibit significantly higher levels. Estrogen decreases the stiffness of ligaments and tendons, compromising the strength and stability of one's knees—a result of estrogen's effect on ligamentous metabolism[10],[11]. During the menstrual cycle, estrogen levels are elevated, which is potentially correlated to increased anterior cruciate ligament injuries.

Strength Imbalances

A strength imbalance refers to an uneven distribution of muscular strength, leaving the weaker group of muscles more prone to injury. Muscle imbalances occur due to stronger quads and glutes in the context of rowing, whereas the hip flexors and hamstrings remain underdeveloped.[12]

The H:Q torque ratio (H-hamstring, Q-quadriceps) is an important index when evaluating muscle strength imbalances surrounding the knee joint[13]. The H:Q torque ratio represents the muscle strength ratio between the hamstrings and quadriceps and is used to observe muscle imbalances and knee joint stability[14]. A low H:Q ratio is indicative of potential injury to the ACL, for it represents a weaker hamstring compared to the quadriceps, reducing the muscles' capacity to stabilize the knee joint throughout its full range of motion[15]. Female athletes are more likely than male athletes to exhibit a lower H:Q ratio. This is because a male's hamstring peak torque has been shown to develop considerably past puberty, whereas females' torque plateaus at puberty.[16] At low velocities, these differences are not significant; however, during higher knee flexion velocities, such as during competitive rowing, the increased stress leaves the ACL vulnerable.[16]

Anatomical Differences

Most females exhibit a broader pelvis and rounder pelvic inlet than males. In females, the angle between the inferior pubic rami measures 90°-100°[1], whereas in males, it is 70°[1].

The Q-angle represents the angle formed between the intersection of the line connecting the anterior superior iliac spine to the middle of the patella and the line from the center of the patella to the tibial tubercle[18]. It is a standard measurement used to evaluate patellar alignment. A Q-angle within the range of 13°to 18°[19] is considered normal, and a value greater than 14°[19] is considered excessive. Females are more likely to have abnormal Q-angles, demonstrating up to a 3.25° difference compared to males[20]. The Q-angle ranges from 11° to 20° in females and 8° to 14° in males[19]. Typically, a value greater than 14°[19] can constitute improper tracking of the patella and patellar instability. A smaller Q-angle is also associated with a taller height[22]. Female collegiate rowers are typically 5 '8 and above, taller than an average height of 5' 4.

As stated, a larger Q-angle is observed more frequently in females and exacerbated by a wider pelvis. As an individual grows, their pelvis widens. This causes the anterior superior and anterior inferior iliac spines to be moved to the side, resulting in lateral forces on the patellar tendon. Factors that increase the Q angle simultaneously increase the lateral force on the patella, essentially pulling it sideways[20]. When the lateral force is strong enough, the patella can shift or dislocate when the quadricep is activated with an extended knee[20]. Knee extension corresponds to the drive phase of the stroke, where rowers produce much of their power. The abnormal Q angle makes female athletes subject to malalignments and injuries such as patellofemoral pain syndrome, femoral anteversion, genu varum, genu recurvatum, etc. To illustrate, patellofemoral pain syndrome (PFPS) affects a much more significant proportion of females than males; the rate of occurrence amongst female athletes is 12.7% compared to 1.1% observed in male athletes[23].

Further, females are more than two times more likely to develop patellofemoral pain syndrome than males[23]. Consistent physical activity exacerbates the incident rate of PFPS, making this occurrence more harmful in female rowers. The Q-angle plays a key role in this disparity. As the angle increases, the load on the patella and femoral condyle increases, and a 10% increase in the Q-angle can account for a 45% increase in the stress placed on the patellofemoral joint[23]. Moreover, a Q-angle greater than 20° causes the patella to track laterally, explaining the development of PFPS amongst females exhibiting an abnormal Q-angle[24]. Rowing with compromised joint alignment impacts the catch and drive phases by altering the angles at which the rower extends their knee. Consistently rowing without addressing malalignments places significant and repetitive stress on the lower extremities. This strain on the knee perpetuates biomechanical stress, which can cause or exacerbate an already abnormal Q-angle.

Hormonal differences play a vital role in the stability and laxity of female ligaments. Estrogen is the dominant female hormone and is known to instigate laxity. Ligaments prevent excessive motion in the knee; estrogen relaxes ligaments and tendons, which compromises their ability to support the knee during swift movements, increasing the likelihood of anterior cruciate ligament tears and other knee injuries. The rowing stroke involves rapid movements and changes of direction; therefore, lax ligaments in the knee may be more prone to tears and further injury.

The prevalence of ACL injuries during the menstrual cycle may result from estrogen's effect on ligament stability[11][26]. A female's estrogen levels peak preceding ovulation; this spike relaxes the ligaments and tendons, putting the athlete at a higher risk for injury. Additionally, female athletes taking oral contraceptives containing high levels of and progesterone exhibited increased ACL laxity when compared to athletes not taking the contraceptive[6]. Therefore, spikes in estrogen subject female rowers to increased ligament and tendon laxity, increasing the risk of injury.
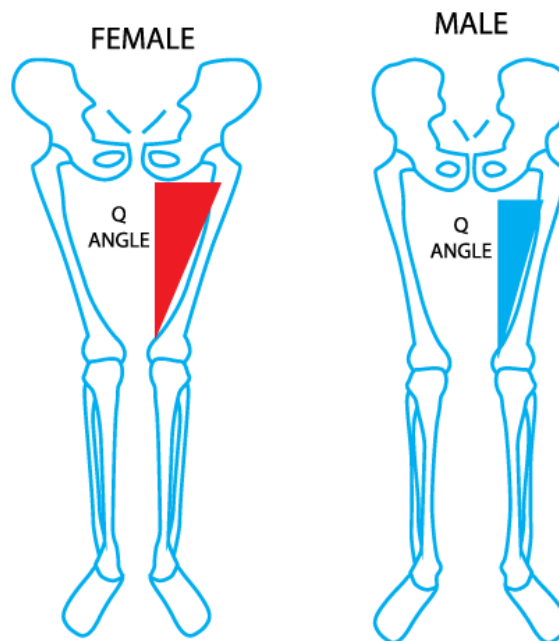
Fig 1: Visual Comparison of the Q-Angle in Females versus Males[30]

Strength Imbalance

Strength imbalances occur when muscular strength is not evenly distributed across the body, making certain muscle groups more susceptible to injury. The quadriceps, gluteal muscles, hamstrings, latissimus dorsi, trapezius muscle, etc., are primarily used during the rowing stroke. Regarding the knee joint, the H:Q torque ratio assesses muscle strength and strength imbalances. The ratio considers the hamstrings and quadriceps to evaluate muscle imbalances and knee joint stability; it is an important measurement when examining injuries in athletes.

Reduced hamstring strength compared to the quadriceps, or vice versa, indicates a potential injury—a lack of strength signifies the muscles' inability to support the knee joint throughout its range of motion[15]. Females increase their H: Q torque ratio at high knee flexion velocities at a slower rate than males[16]. During high-velocity activities, males exhibit a considerably greater H:Q ratio, meaning their hamstrings are effectively stabilizing the knee[16]. When the knee is extending at high speeds, the hamstring and the anterior cruciate ligament work coactively to counteract the force generated by the quadriceps. Females exhibit a lower H:Q ratio, meaning their hamstrings may not be able to provide the necessary resistance in response to the quadriceps. This diminishes athletes' ability to control coronal and sagittal movement of

the knee joint, putting them at an increased risk for knee injuries, such as anterior cruciate ligament tears[16]. This disparity becomes apparent during the rowing stroke. Rowers' quadriceps must extend the knees at a high rate of speed, which is not sustainable compared to the rate at which the hamstrings simultaneously extend the hip. Comparatively, males have a higher H:Q ratio during angular velocities, so the hamstrings are able to counter the force of the quadriceps, which stabilizes the knee and protects the anterior cruciate ligament[16]. This may explain the fact that female athletes are eight times more likely to injure their anterior cruciate ligament than their male counterparts[28].

Further, female athletes display lower H:Q ratios compared to male athletes before and after puberty. In children aged between 7 and 12 years old, boys exhibited considerably higher H:Q ratios than girls from every age group. On average, the boys' H:Q ratios were 10% higher than the girls. This demonstrates that even from a young age, strength imbalances in the hamstrings and quadriceps are present in prepubescent girls, suggesting that preventative strength training should be considered[29]. However, females do not make up for this difference following puberty. Males' hamstring peak torque continues to progress significantly following puberty, whereas females reach a plateau in their development. Following puberty, males experience a significant spike in muscle mass and strength, which corresponds to their increased ability to support the knee joint during high-velocity movements.[21] Females lack this development and as a result, mature female athletes display a lower H:Q ratio, contributing to the prevalence of strength imbalance-related injuries.

Alternate Perspectives

The Q-angle is undoubtedly an important factor when considering patellar stability; however, the extent to which Q-angles differ in females and males is a current topic of debate. The generally accepted reasoning behind females' greater Q-angles is their wider pelvises. *The Journal of Bone and Joint Surgery* disputes this by stating that the large changes in the position of the anterior superior iliac spine necessary to affect the Q-angle were not present in their study[32]. However, the prevalence of a greater Q angle in females is greatly exacerbated by a wider pelvis. The pelvis broadens as an individual matures. This causes the anterior superior and anterior inferior iliac spines to be moved to the side, resulting in lateral forces on the patellar tendon. The increased lateral force essentially pulls the patella sideways[19]. This phenomenon is exacerbated in females, as hormonal influences contribute to a wider pelvis. This fundamental difference causes the lateral force exhibited on the patellar tendons to be greater, seeing as the anterior superior iliac spine and the anterior inferior iliac spines are pushed to the side more in females due to their wider pelvises.

Additionally, the study finds that the average Q-angle in males is 13.3° and 15.7° in females. They state that the Q angles differed by an average of only 2.3° degrees, equating this result to females and males having "similar" Q-angles[32]. However, this difference is significant enough to impact female athletes negatively. Athletes with a Q-angle higher than 14° are at greater risk for patellar conditions. Because of factors like genu recurvatum, genu varum, wider

pelvis, and excessive pronation of the subtalar joint (conditions more frequently observed in females), females' Q-angles are consistently recorded as higher than 14°, contributing to the overall prevalence of knee injury[19].

Conclusion

In the sport of rowing, female athletes sustain knee injuries at a rate disproportionate to their male counterparts. Patellofemoral pain syndrome, patellar tendinopathy, and ACL injuries are amongst the many knee-related injuries sustained by female collegiate rowers. Explanations for this disparity are often attributed to anatomical differences and strength imbalances, with female athles demonstrated a wider pelvis, greater Q-angle, and decreased H:Q ratio. These factors contribute to joint malalignment and imbalance, leaving core structures within the knee prone to injury.

The most concerning anatomical variation related to rowing injuries between males and females is the difference in pelvic width and the Q-angle. Females exhibit broader pelvises than males, increasing the angle between their bones in the knee joint. This places additional stress on the knee joint, especially during the rowing stroke. Further, a wider pelvis exacerbates the Q-angle, contributing to female rowers' higher incidence of joint malalignment. Females consistently exhibit Q-angles above normal values, which greatly increases their risk of knee-related injury.

Strength imbalances in athletes can make certain muscle groups more prone to injury. The hamstring-to-quadricep ratio is used to assess muscle imbalance and strength in regard to knee joint stability. During the rowing stroke, female athletes have been observed to increase the H:Q ratio more slowly than male athletes. This indicates that females' hamstrings do not adequately stabilize the knee during rapid motions, leading to a prevalence of anterior cruciate ligament tears among female athletes. The muscle strength imbalance in the hamstring and quadricep is a critical factor in female rowers' tendency to injure the anterior cruciate ligament.

While anatomical differences such as pelvic width are largely inalterable, muscle strength imbalances and resulting injuries can be prevented through targeted strength training. Females sustain anterior cruciate ligament injuries because their hamstrings are unable to combat the force of the quadriceps during high-speed motions. Plyometric training has increased female athletes' H:Q ratio during peak torque. Adopting more preventative training measures for strength imbalances specific to female athletes would be beneficial to reducing the overall number of injuries.

Work Cited

Libre Texts. "7.7E: Comparison of Female and Male Pelves." *Medicine LibreTexts*, Libretexts,
17 Jan. 2023,
med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Anatomy_and_Physiology_(
Boundless)/7%3A_Skeletal_System_-_Parts_of_the_Skeleton/7.7%3A_The_Hip/7.7E%3
A_Comparison_of_Female_and_Male_Pelves. Accessed 16 Nov. 2023.

Irick, Erin. "Student-Athlete 1981-82-2018-19." *Student-Athlete Participation
1981-82-2018-19*, NCAA Sports, Nov. 2019,
ncaaorg.s3.amazonaws.com/research/sportpart/2018-19RES_SportsSponsorshipParticipat
ionRatesReport.pdf. Accessed 24 Jan. 2024.

Hosea, Timothy, and Jo Hannafin. "Orthopaedics & Physical Performance." *Rowing Injuries -
Sports Medicine Program - UR Medicine, University of Rochester Medical Center -
Rochester, NY,*
www.urmc.rochester.edu/orthopaedics/sports-medicine/rowing-injuries.shtml. Accessed
24 Jan. 2024.

Ivković, Alan, et al. "Overuse Injuries in Female Athletes." *Croatian Medical Journal*, U.S.
National Library of Medicine, Dec. 2007,
www.ncbi.nlm.nih.gov/pmc/articles/PMC2213798/#R29. Accessed 24 Jan. 2024.

Mayo Clinic. "Patellofemoral Pain Syndrome - Symptoms and Causes." *Mayo Clinic*, 2018,
www.mayoclinic.org/diseases-conditions/patellofemoral-pain-syndrome/symptoms-cause
s/syc-20350792. Accessed 24 Jan. 2024.

Does Estrogen Cause or Prevent ACL Injuries in Women? – Caring Medical Florida.
www.caringmedical.com/prolotherapy-news/estrogen-ligament-laxity/. Accessed 24 Jan.
2024.

Levine, Nicole. "Gender Differences Mean More Knee Injuries for Women." *Cedars-Sinai*, 23
July 2021, www.cedars-sinai.org/blog/gender-differences-knee-injuries.html. Accessed
24 Jan. 2024.

Shmerling, Robert. "The Gender Gap in Sports Injuries." *Harvard Health Blog*, Harvard Health
Publishing, 22 June 2020,
www.health.harvard.edu/blog/the-gender-gap-in-sports-injuries-201512038708#:~:text=C
onsider%20the%20anterior%20cruciate%20ligament%20%28ACL%29.%20It%27s%20a
,sports-related%20injuries%20are%20also%20more%20common%20among%20women.
Accessed 24 Jan. 2024.

"Why Are Women More Susceptible to Knee Injuries than Men?" *Www.virtua.org*,
www.virtua.org/articles/why-are-women-more-susceptible-to-knee-injuries-than-men#:~:
text=Estrogen%2C%20the%20primary%20female%20hormone%2C%20can%20make%
20a. Accessed 25 Jan. 2024.

Chidi-Ogbolu, Nkechinyere . "Effect of Estrogen on Musculoskeletal Performance and Injury
Risk." *National Library of Medicine*, 15 Jan. 2019,
www.ncbi.nlm.nih.gov/pmc/articles/PMC6341375/#:~:text=However%2C%20unlike%20

bone%20and%20muscle%20where%20estrogen%20improves,make%20women%20mor
e%20prone%20for%20catastrophic%20ligament%20injury. Accessed 24 Jan. 2024.

Legerlotz, Kirsten, and Tina Nobis. "Insights in the Effect of Fluctuating Female Hormones on Injury Risk—Challenge and Chance." *Frontiers in Physiology*, Feb. 2022, www.frontiersin.org/articles/10.3389/fphys.2022.827726/full#ref42. Accessed 24 Jan. 2024.

"What Are the Most Common Rowing Injuries | OrthoIndy Blog." *Blog.orthoindy.com*, 3 Aug. 2020, blog.orthoindy.com/2020/08/03/what-are-the-most-common-rowing-injuries-and-how-are -they-prevented/#:~:text=. Accessed 25 Jan. 2024.

Kellis, Eleftherios, et al. "Is Hamstrings-To-Quadriceps Torque Ratio Useful for Predicting Anterior Cruciate Ligament and Hamstring Injuries? A Systematic and Critical Review." *Journal of Sport and Health Science*, vol. 12, no. 3, Jan. 2022, https://doi.org/10.1016/j.jshs.2022.01.002. Accessed 02 Feb. 2024.

Ruas, Cassio V., et al. "Alternative Methods of Determining Hamstrings-To-Quadriceps Ratios: A Comprehensive Review." *Sports Medicine - Open*, vol. 5, no. 1, 25 Mar. 2019, https://doi.org/10.1186/s40798-019-0185-0. Accessed 02 Feb. 2024.

Hiemstra, Laurie A., et al. "Hamstring and Quadriceps Strength Balance in Normal and Hamstring Anterior Cruciate Ligament-Reconstructed Subjects." *Clinical Journal of Sport Medicine*, vol. 14, no. 5, Sept. 2004, pp. 274–280, https://doi.org/10.1097/00042752-200409000-00005.Accessed 02 Feb. 2024.

Hewett, Timothy E., et al. "Hamstrings to Quadriceps Peak Torque Ratios Diverge between Sexes with Increasing Isokinetic Angular Velocity." *Journal of Science and Medicine in Sport*, vol. 11, no. 5, Sept. 2008, pp. 452–459, https://doi.org/10.1016/j.jsams.2007.04.009.Accessed 02 Feb. 2024.

Loudon, Janice K. "BIOMECHANICS and PATHOMECHANICS of the PATELLOFEMORAL JOINT." *International Journal of Sports Physical Therapy*, vol. 11, no. 6, 1 Dec. 2016, pp. 820–830, www.ncbi.nlm.nih.gov/pmc/articles/PMC5095937/#:~:text=The%20Q%2Dangle%20is% 20the. Accessed 3 Feb. 2024.

"Q Angle - an Overview | ScienceDirect Topics." *Sciencedirect.com*, 2009, www.sciencedirect.com/topics/nursing-and-health-professions/q-angle.Accessed 02 Feb. 2024.

Khasawneh, Ramada R., et al. "Measurement of the Quadriceps (Q) Angle with Respect to Various Body Parameters in Young Arab Population." *PLOS ONE*, vol. 14, no. 6, 13 June 2019, p. e0218387, https://doi.org/10.1371/journal.pone.0218387.Accessed 02 Feb. 2024.

Sharma, Rahul, et al. "A Systematic Review on Quadriceps Angle in Relation to Knee Abnormalities." *Cureus*, vol. 15, no. 1, 29 Jan. 2023, www.cureus.com/articles/128069-a-systematic-review-on-quadriceps-angle-in-relation-to -knee-abnormalities#, https://doi.org/10.7759/cureus.34355.Accessed 02 Feb. 2024.

Grelsamer, R. P., et al. "Men and Women Have Similar Q Angles." *The Journal of Bone and Joint Surgery. British Volume*, vol. 87-B, no. 11, Nov. 2005, pp. 1498–1501, https://doi.org/10.1302/0301-620x.87b11.16485. Accessed 02 Feb. 2024.

Vora, Molly, et al. "Patellofemoral Pain Syndrome in Female Athletes: A Review of Diagnoses, Etiology and Treatment Options." *Orthopedic Reviews*, vol. 9, no. 4, 20 Feb. 2018, https://doi.org/10.4081/or.2017.7281.Accessed 02 Feb. 2024.

"Patellofemoral Pain Syndrome." *Www.thesteadmanclinic.com*, www.thesteadmanclinic.com/patient-education/knee/patellofemoral-pain-syndrome#:~:text=Patients%20with%20a%20larger%20than. Accessed 3 Feb. 2024.

Martin D, Timmins K, Cowie C, Alty J, Mehta R, Tang A and Varley I (2021) Injury Incidence Across the Menstrual Cycle in International Footballers. *Front. Sports Act. Living* 3:616999. doi: 10.3389/fspor.2021.616999Accessed 02 Feb. 2024.

Cullen, Mark. "Why Female Soccer Players Are at Higher Risk of ACL Injuries | Wentworth-Douglass Hospital." *Www.wdhospital.org*, www.wdhospital.org/wdh/services-and-specialties/orthopedic-care/blog/why-female-soccer-players-are-at-risk-of-acl-injuries.Accessed 02 Feb. 2024.

Holm, Inger, and Nina Vøllestad. "Significant Effect of Gender on Hamstring-To-Quadriceps Strength Ratio and Static Balance in Prepubescent Children from 7 to 12 Years of Age." *The American Journal of Sports Medicine*, vol. 36, no. 10, 21 May 2008, pp. 2007–2013, https://doi.org/10.1177/0363546508317963. Accessed 08 Feb. 2024.

Lyons, Meghan, and Eileen. *Isokinetic Hamstring: Quadriceps Strength Ratio in Males and Females: Implications for ACL Injury Suggested Citation Isokinetic Hamstring: Quadriceps Strength Ratio in Males and Females: Implications for ACL Injury*. 2001.Accessed 08 Feb. 2024.

Perera, Dilani, and Anoja Ariyasinghe. "Volume 5 Issue 4, April 2016 Www.ijsr.net Licensed under Creative Commons Attribution CC by Rowing Injuries and Related Factors in Competitive Rowing." Index Copernicus Value, 2013.Accessed 08 Feb. 2024.

NCAA ® Sports Sponsorship and Participation Rates Report STUDENT-ATHLETE.Accessed 08 Feb. 2024.

Hillyard, Hope. "What Is a Q Angle?" *Champion Performance & Physical Therapy*, Champion Performance & Physical Therapy, 9 Mar. 2016, www.kcchampionperformance.com/news/2016/3/9/kx8hq9n3wmbt2pbqy683hisu4y1xm4.Accessed 20 Feb. 2024..

Qu Yuan and the Spiritual Sustenance of Han Literati By Sally Wang

Abstract

      This research paper applies the theory of Cultural Memory to the figure of Qu Yuan屈原 formulated in the Han dynasty. Through the comparative analysis of the representation of Qu Yuan, Wu Zixu伍子胥, and Wei Wuji魏无忌 in Sima Qian's *Shiji*史記, this essay explains the spiritual sustenance of the Han Dynasty literati projected in the Qu Yuan character: the suspending judgment between assuming social responsibility and guarding spiritual freedom. This projection includes two parts. Firstly, the Han continuance and development of the spirit of nobility in the Spring and Autumn and the Warring States periods: the transformation of mandatory social responsibility into an individual's spontaneous awareness of societal issues, which subsequently led to open-ended discussions on the morality of each choice. Secondly, the reflection of Han literati's new ideals: the fundamental struggle with the King, the search for the correct position as a minister, and the growing emphasis on the desire for self-establishment.

Introduction

      Cultural Memory is a well-studied theory of the humanities first introduced by the German Egyptologist Jan Assman in his 1988 essay "Kollektives Gedächtnis und kulturelle Identität" (Collective Memory and Cultural Identity).[1] There, Assman offered a new perspective on how we should interpret history, not as an accurate record of the time it is about, but as a reflection of the time it was made.

      Throughout the years, the theory of cultural memory has been applied to many areas within the humanities and especially to multiple sections of history. From Aleida Assman's exploration on the "permanent nature" of functionalized media which transport cultural knowledge within societies"[2] to Pierre Nora's definition of "lieux de mémoire "('sites of memory'),[3] cultural memory has been developed as a broad combination of history and memory studies. In recent years, cultural memory is no longer contained with studies of Egypt, Israel, and Greece, but is further adopted to interpret the classics of cultures around the world, including that of ancient Chinese literature.

      In this research paper, we would first explain the basic concept of cultural memory, and then apply it to the figure Qu Yuan. Specifically, we will compare the images of Qu Yuan, Wei Wuji, and Wu Zixu depicted by Sima Qian司马迁 in *Shi Ji*. Here, Qu Yuan is not just a historical figure, but a narrative character composed of the Spring and Autumn and the Warring States periods ideals as well as the new pursuits in the Han dynasty; his depicted traits are not exact recordings of the past, but a representation of the changing needs of the Han literati. Through the process, we can see how Qu Yuan represents the transformation of an individual taking on mandatory social responsibility into them developing spontaneous awareness of societal issues. We can also see the nuanced choices of ministers when their value is at odds with societal

---

[1] Kern, *Cultural Memory and the Epic in Early Chinese Literature: The Case of Qu Yuan* 屈原 *and the Lisao* 離騷,131-132.

[2] Dinter, *Cultural Memory in Republican and Augustan Rome, 4.*

[3] Dinter, *Cultural Memory in Republican and Augustan Rome, 4.*

expectations, their fundamental moral struggle, and their growing emphasis on self-cultivation. As a result, the newly emerging issue of Han dynasty literati is highlighted in the projection of Qu Yuan: the conflict between assuming social responsibility and guarding spiritual freedom.

Cultural Memory and Qu Yuan

Cultural memory is a theory aimed to explain the "textuality of the past".[4] It focuses on the "individual storage of texts, images and rites that are meant for reuse related to various societies and epochs",[5] which are important means for cultures to pass on their collectively shared knowledge. This "knowledge" doesn't always have to be true to what happened, but instead, it is the embodiment of values the culture wants to remember and sustain in the future generations.

Among all its widely adopted applications, cultural memory is especially applicable to interpreting historical texts and the history they construct. This method presents a unique perspective as it elucidates the difference between records and history. The primary concern of history, unlike that of records, is not to document all events with extreme accuracy and credible authorship. Rather, it fulfills and passes the needs, values, and identity of the culture that created this "narrative", or in other words, of those that "make history". The texts are not treated as records, but as a representation of their culture; the question is not about what happened, but about why a certain generation chose to emphasize, reconstruct, edit, or leave out certain sections of what happened.

In this model, every figure appearing in historical texts can be regarded as a projection of the people who crafted their lives, beliefs, and morals. Qu Yuan, the great poet who appear in almost all Chinese textbooks as the model for "patriotism", is not an exception. His life-long devotion to protecting Chu, exemplar actions of moral values, and the grandeur death to commit suicide following the destruction of the state portrayed in the great poem *Chu Ci* and Sima Qian's *Shi Ji* are long remembered by the Chinese as the "truth" and the "historical model", even when modern analysis of the context says otherwise.

We can see that the widely accepted narrative of Qu Yuan is a result of cultural memory. Therefore, it is important for us to understand the need of the people that made this image, namely the Han dynasty literati, with Sima Qian as the example. The composite nature of the figure, the clearly targeted narrative, and the lack of definitive judgement from Sima Qian in *Shi Ji* are vehicles that convey the Han literati's self-awareness and changing ideals.

Whether the specific traits displayed are shared acknowledgment of the literati community may be hard to distinguish if we only consider Qu Yuan's image. The prioritized ideals, prevalent conflicts, and general attitude toward pre-imperial teachings can be determined when they're identified recurring in different narratives. Therefore, we should take other figures into consideration to find the commonality between them. The figures used in this paper is Wei Wuji and Wu Zixu in Shi Ji.

---

[4] Ißler, Cultural Memory. In: Kühnhardt, L., Mayer, T. (eds) The Bonn Handbook of Globality. Springer, Cham.
[5] Ißler, Cultural Memory. In: Kühnhardt, L., Mayer, T. (eds) The Bonn Handbook of Globality. Springer, Cham.

Continuation and development of the spirit of nobility in the Spring and Autumn and the Warring States periods

Qu Yuan is a product of Han literati's pursuits. To understand the formation of the Han ideals, we cannot neglect the influence of the morals, values, and spiritual aims of nobilities in the Spring and Autumn and the Warring States periods. On the other hand, we should identify the differences in the morals of the Han ministers, which is shown by their varied choices in moral dilemmas.

First, it is necessary to introduce the figures of Wu Zixu and Wei Wuji whom I will be comparing. In Sima Qian's *Shi Ji*, it is noted that Wu Zixu was initially a subject of King Ping of Chu楚平王, but he subsequently escaped to King He Lv of Wu吳王闔閭 after King Ping murdered his father. Meanwhile, Wei Wuji is the brother of King An Xi of Wei安釐王. He served Lord Ping Yuan平原君 for some time before returning to Wei魏. Generally, Wu Zixu and Wei Wuji followed similar plotlines and underwent similar political setbacks as Qu Yuan.

On the surface level, their narrative is basically: as a moral and intelligent official, they gave effective advices to the King to protect and develop the state; then, some corrupted officials slander them in front of the King; as a result, they got demoted or banished for their righteousness and brilliance; their beliefs are not changed by any setbacks; at last, they die with their life-long commitment to the state. A commonality here is their responsibility and commitment to their respective state. However, a unique aspect depicted in their commitment is the transformation from mandatory social responsibility to the spontaneous awareness of societal issues of individuals. As a result, numerous figures' choices were mentioned in Shi Ji, which all differ under different premises.

From the very beginning of the *Biography of Qu Yuan and Jia Sheng*屈原賈生列傳, the figure Official Shangguan上官大夫 was introduced, "Official Shangguan was at the same position with Qu Yuan, vying for favor of the King. King Huai appointed Qu Yuan to make the constitutional decree, and the draft of is yet to be determined. Official Shangguan was eager to seize the credit, but Qu Yuan did not agree. As a result, Shangguan slandered Qu Yuan in front of the King." (上官大夫與之同列, 爭寵而心害其能。懷王使屈原造爲憲令, 屈平屬草稿未定。上官大夫見而欲奪之, 屈平不與, 因讒之。) [6]

Similarly, in the *Biography of Wu Zixu* 伍子胥列傳, there's the character of Fei Wuji费无忌, the teacher (Shao fu少傅) of Prince Jian of Chu太子建. As a high-class official, Fei is shown with no moral bounds nor considerations for the state. He was "not loyal to Prince Jian" (不忠於太子建)[7] for his own profit and he further "slandered the Prince in front of the King out for terror for his own life." (日夜言太子短於王)[8] Later, he's also the one who advised the King to kill Wu Zixu's father and brother.

---

[6] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2481.

[7] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2171.

[8] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2171.

As further proven by similar figures of Zi Lan子兰in the Biography of Qu Yuan and Pi嚭 in the Biography of Wu Zixu, Sima Qian depicted many nobles as being envious and self-centered. Clearly, the expectations for nobility as having "De德" (power) and "li礼" (rituals) in the Spring and Autumn and Warring State texts *Shi Jing*诗经[9] is not as effective when playing a role of behavior regulation in the Han dynasty. Taking on the social responsibility to act morally and commit to one's King and state is no longer a requirement. The inclusion of those envious ministers supports an interesting attempt of Sima Qian and many Chinese historians in the use of suspending judgment. In their narratives, not to act responsibly and/or morally is merely a choice of the ministers, just like how other ministers may choose to dedicate all their efforts to the state. No definitive judgements on the morality of the choices are made, as this is not the goal of Sima Qian's narratives. To understand his goal, we must remember that the target readers of the historical texts at that time are meant to be the class of literati (the minister). Therefore, the discussion of the diverse characters with their contrasting reactions are intentionally left open-ended, inspiring the ministers to analyze and interpret the lessons on the decisions they should make if placed in a similar situation. In other words, it is pushing the readers to reflect on how to be a qualified minister in the court.

Under this premise, the persevered commitment of Qu Yuan and Wu Zixu are also shown to be prompted by their spontaneous awareness of societal issues instead of being forced to do so as a noble/official. To obey or disobey the King, to make or not make a certain decision, to feel or not feel a certain emotion…the emphasis is on their nuanced reactions to the turbulent court.

In the *Biography of Qu Yuan*, how Qu Yuan developed his concern of Chu was described extensively: "The King was mad and distanced Qu Yuan. Qu Yuan worried that the King was not wise in listening, that the corrupted officials were slandering and flattering to deceive the King, that the wicked and twisted ones was harming the public, and that they're distorting the morals. This is what caused his depression and contemplation."（王怒而疏屈平。屈平疾王聽之不聰也，讒諂之蔽明也，邪曲之害公也，方正之不容也，故憂愁幽思"）[10]This section unfolds right after the first setback Qu Yuan encountered (in the narrative). He is not shown worrying for the state just because he's supposed to do so as an official. Rather, his "contemplation" of the problems with corrupted officials in the society was invoked by his adversity- a possible and acceptable emotion for ministers whose aspirations were twisted and unfulfilled.

On the other hand, one main difference between the *Biography of Wu Zixu* and that of Qu Yuan is that the former placed great emphasis on revealing the backstory of Wu Zixu prior to describing his character. Actually, the significance of this backstory is also to show the reason of Wu Zixu's decision of becoming an official for the Wu court instead of serving his own state: "The King of Chu killed She and Shang."（楚並殺奢與尚也"）[11] The loyalty of Wu Zixu to Wu instead of Chu is justified as revenge for his father and brother, as stated by Sima Qian, "When Zixu was stranded on the river, begging for food, how could he forget the evil of the Chu King

[9] Owen, Stephen, *An Anthology of Chinese Literature*, 1996.

[10] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2481-2482.

[11] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2172-2173.

for an instant?" (方子胥窘於江上，道乞食，志岂尝须臾忘郢邪？)[12]This decision of Wu Zixu is not bound by responsibility of nobles but driven by the persecution his family faced and his will to revenge- how a specific reason led to a specific decision is again left to the audiences.

Furthermore, the third instance that reflect this transformation is the figure of Wei Wuji. In the *Biography of Wei Gongzi*魏公子列傳, Wei Wuji stayed in Zhao赵 after he disobeyed the King of Wei out of fear that the King is still mad at him. The text wrote, "Qin heard that Wei Wuji was in Zhao, so they continuously sent troops to attack Wei. The King of Wei was worried, and he sent messengers to take Wei Wuji back. Wei Wuji is afraid that the King is still mad at him, so he told his ancillaries, 'anyone who helps the Wei messengers will be killed.'" (秦聞公子在趙，日夜出兵東伐魏。魏王患之，使使往請公子。公子恐其怒之，乃誡門下："有敢爲魏王使通者，死。) [13]

Wei Wuji's decision to stay in Zhao instead of protecting his state is for his personal interests, and this diverges from the social responsibility of nobles to always serve their country. In the preceding story, he did a series of actions that disobeyed the King. At this point of decision-making, he was given every reason to feel "afraid that the King is still mad at him". This led to his initial decision of rejecting to help the state of Wei. Although Wei Wuji eventually goes to save Wei, it was because his advisors reminded him that "You're only important to Zhao and well-known among the feudal lords because of the presence of Wei. Now that Qin is attacking Wei, Wei is in danger yet you're not caring at all. If Qin defeats Wei and destroys your ancestors' temples, how would you establish yourself in the world?" (公子所以重于趙，名聞諸侯者，徒以有魏也。今秦攻魏，魏急而公子不恤，使秦破大梁而夷先王之宗廟，公子當何面目立天下乎？) [14]This dialogue elucidates the hidden premise in the situation: Wei Wuji, the minister, is "only important to Zhao and well-known among the feudal lords because of the presence of Wei." With this change of premise, Wei Wuji changed his decision accordingly due to his awareness of his reputation and morals; this emphasized change is a perfect example of Sima Qian's appreciation of the decision-making process of the ministers. Wei Wuji's efforts to save Wei are not due to a noble's responsibility to serve his state, but a minister's desire for self-establishment.

From this comparison, we can see the emergence of self-awareness and focus on the individuality in the Han literati. They acknowledge how ministers can feel different ways and make different choices under nuanced premises, and appreciate the exploration of those differences. They contrast the figures' commitment and lack of commitment through indirect portrayals and open-ended discussions to encourage thinking among the readers, therefore, justifying their commitment to the court as a personal, dependent, and mutable choice rather than a forced requirement.

However, we cannot neglect the continuation of social responsibility present in their text to a certain extent, most notably in the *Biography of Wu Zixu*. The Biography of Wu Zixu wrote:

---

[12] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2183.

[13] 司马迁Sima Qian, *The Biography of Wei Gongzi*魏公子列傳in *Shi Ji*史記, 1959, 2383.

[14] 司马迁Sima Qian, *The Biography of Wei Gongzi*魏公子列傳in *Shi Ji*史記, 1959, 2383.

"Wu Zixu and Shen Baoxu were friends. Wu Zixu told Baoxu, 'I will overthrow Chu.' Baoxu said, 'I will save Chu.'" (始伍員與申包胥爲交，員之亡也，謂包胥曰："我必覆楚。"包胥曰："我必存之。"）[15]

"So, Shen Baoxu went to Qin to get help. The King of Qin didn't agree. Baoxu stood in the Qin court and cried for seven days and nights." (於是申包胥走秦告急，求救於秦。秦不許。包胥立於秦廷，晝夜哭，七日七夜不絕其聲。）[16]

The figure of Shen Baoxu申包胥 is like an embodiment of social responsibility. He was friend with Wu Zixu, and he witnessed the tyranny of the Chu King. However, without giving any reasons, he is depicted as devoted to save Chu by all means. This figure is a direct contrast to the figures of Fei Wuji and Shangguan, while also differing from Wu Zixu and Qu Yuan. He represents a different category of human behavior. His actions are characterized by a great sense of obligation to serve his state regardless of specific reasons except that he should do so as an official. Again, this distinct characteristic offers another type of choice- this time bound by social obligation. Sima Qian chose to emphasize Shen Baoxu's choices, without much explanation nor background, and without any judgment on whether this obligation is "correct" or whether it is better or worse than Wu Zixu's choice when facing the same King.

This is also true for the character Hou Ying in the *Biography of Wei Gongzi*. As Wei Wuji's advisor, Hou Ying侯英 dedicated his life for Wei Wuji's cause, saying, "I should go with you, but I'm too old to do so. Please allow me to count the days of your travel. On the day you arrive at the Jin Bi army, I will kill myself facing north to express my loyalty to see you off." (臣宜從，老不能。請數公子行日，以至晉鄙軍之日，北鄉自刭，以送公子。）[17] Indeed, Hou Ying chose to follow Wei Wuji after testing that Wei Wuji meets his moral and talent standards. But here, Hou Ying kills himself to fulfill his role as an advisor and an ancillary who should follow and help Wei Wuji with his grand cause to save Zhao. This is a personal choice but is also an act to take on social responsibility. In today's idea, the extremity of Hou Ying's act might be questionable. But in the Han era, it is exactly those exaggerated decisions that represent the different poles of humanity. When all those poles are put into a narrative, appearing together, the readers are prompted to make comparisons, contrasts, judgements, and reflections spontaneously.

The presence of all those figures highlights the intertwining debates of personal awareness and social obligations. The Han dynasty sees the development of emphasis on individuality in regulating the commitments of literati, as shown in the recurring characterization of Qu Yuan, Wu Zixu, and Wei Wuji. At the same time, the continuance of a certain degree of social obligation from the Spring and Autumn and Warring States periods cannot be neglected. Under all those influences and the variety of factors, the numerous decisions that Han ministers face under a complicated political climate are overwhelming, every choice leading to a possible debate on morality. So how will the ministers choose? Should they be bound by social obligations? What is the best option? This moral struggle is underlying the Han context. Sima

[15] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2176.

[16] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2177.

[17] 司马迁Sima Qian, *The Biography of Wei Gongzi*魏公子列傳in *Shi Ji*史記, 1959, 2381.

Qian's narratives offer an example of a guidance, where numerous possible choices under possible dilemmas arose, leading to their respective outcomes. Indeed, Sima Qian didn't give his own judgment since there is no clear, universal answer to all the complex situations. Instead, an important characteristic of the composite narrative figures is to encourage the ministers to determine for themselves what will be the "best" choice in a specific struggle. As we can see from Sima Qian's narratives, this characteristic is the guiding principle of the crafts and edits in Han texts.

The projection of new concerns of literati in the image of Qu Yuan

After extracting the continuation of pre-imperial beliefs, we can now identify the relatively new concerns emerging among the Han literati that they projected on the image of Qu Yuan. Specifically, the suspending judgment is on the attitudes of ministers when conflicts arise between personal values and the King's decision, with an unique characterization of the King as a seemingly lesser figure.

The analysis in the previous section about how social responsibility merges and shifts to personal awareness leads to the first newly emphasized issue- dissonance of ideas between the ruler and the minister. In *Shi Ji,* awareness of this fundamental struggle permeates the narratives through the portrayal of different choices that the ministers make in the face of similar political setbacks- in extreme situations confronted by impossible choices with no clear moral answers.

In The *Biography of Qu Yuan*, Qu Yuan is shown with high morals and abilities, yet his advice was constantly denied by the King, and he was ostracized and exiled. Sima Qian often laments Qu Yuan's frustration and helplessness in not being valued. In the process, he detailed the creation of *Li Sao* as Qu Yuan's response to the adversity, "Qu Yuan worried that the King was not wise in listening, that the corrupted officials was slandering and flattering to deceive the King, that the wicked and twisted ones was harming the public, and that they're distorting the morals. This is what caused his depression and contemplation. 'Li Sao' means suffering from sorrow. Heaven is the beginning of humanity, and parents are the roots of human life. When a person is in a difficult situation, they will reminisce about their roots, so when they are extremely tired and hardworking, there is no one who does not call for heaven's help; When encountering illness or sadness, there is no one who does not call for their parents' help. Qu Yuan was upright in his behavior, using his loyalty and wisdom to assist the King while the corrupted officials slandered him and distanced him. This can be said to be a dilemma. His integrity was doubted, and his loyalty was defamed. Can there be no resentment? The reason why Qu Yuan wrote 'Li Sao' is probably due to resentment." (屈平疾王聽之不聰也，讒諂之蔽明也，曲之害公也，方正之不容也，故憂愁幽思作《離騷》。「離騷」者，猶離憂也。夫天者，人之始也；父母者，人之本也。貧則反本，故勞苦倦極，未嘗不呼天也；疾痛慘怛，未嘗不呼父母也。屈平正道直行，竭忠盡智以事其君，讒人間之，可謂窮矣。信而見疑，忠而被謗，能無怨乎？屈平之作《離騷》，蓋自怨生也。)[18]

---

[18] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2482.

An interesting angle in Sima Qian's description is that he gave a detailed account of the production of *Li Sao*离骚 as Qu Yuan's way to express himself after being slandered. Two aspects of Han literati's self-reflection are shown here. Firstly, we see how Qu Yuan's upright values conflict with that of the King. He was "upright in his behavior, using his loyalty and wisdom to assist the monarch" (屈平正道直行, 竭忠盡智以事其君) yet he was "slandered" (讒) by the corrupted officials and "distanced" (間) by the King. He was morally admirable but doubted, loyal but defamed. In the court dominated by corrupted officials and the society where his voice was drowned, his values and abilities were denied. He was inevitably pushed to an extreme situation. Just like how Sima Qian directly pointed out, Qu Yuan's situation was a "dilemma" (窮). To hang on to the impossible fight in the court or to give up his beliefs? There's no clear, moral solution in this dilemma between Qu Yuan the minister and the King. This corresponds with the Han literati's realization that the morality of individuals is not always appreciated by the environment they're in.

Then, this inspires further exploration of the struggle- what are the things individuals, specifically, ministers, can do? What attitude should they adopt? What choices can they make? Those are the rhetorical questions hinted through Qu Yuan's dilemma, which Sima Qian addressed in his explanation. In Qu Yuan's narrative, he turned to writing poems to express his "depression and contemplation" (憂愁幽思) and "resentment". Under this model, writing is depicted as one way for ministers to fulfill their political aspirations without going against the King nor the societal restraints that they have no power over. It is one of the last meaningful yet non-aggressive things they can do as loyal subjects to the King. As literati develop strong feelings when they encounter political oppressions/ setbacks, they can choose to use other ways of expression instead of clinging to the struggle in the court that they clearly will fail.

This discussion recurs in Sima Qian's proceeding description of the production of *Huai Sha*怀沙, where the essence of the struggle is underscored. Before Qu Yuan jumped in the river Mi Luo汨罗江, he and the fisherman had a brief conversation. From the very beginning, Qu Yuan highlights his moral struggle in the society, "The whole world is murky, only I am pure; Everyone is intoxicated, only I am sober. That's why I was exiled." (舉世混濁而我獨清, 眾人皆醉而我獨醒, 是以見放。) [19]Here, the morality of Qu Yuan is recognized and praised. But at the same time, the phenomena that the beliefs and pursuits of individuals are at conflict with those of the society is elaborated.

The fisherman persona asks Qu Yuan directly, "The whole world is murky, so why not go with the flow? Everyone is intoxicated, why not drink along? Why embrace qualities pure as jade to make oneself exiled?" (舉世混濁, 何不隨其流而揚其波？眾人皆醉, 何不餔其糟而啜其醨？何故懷瑾握瑜, 而自令見放為？) [20]The questions here are like an externalization of the inner moral struggles of the figure Qu Yuan and of the Han literati: why not compromise to the societal views? Why not just blindly follow the King's orders for an easier, more prosperous career? Why persist with your own values?

---

[19] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2486.
[20] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2486.

However, the response of Qu Yuan was firm, "I heard that those who have just washed must bounce off the dust on their hats, and those who have just taken a shower must shake off the dust on their clothes. Who can let their innocent body suffer from external pollution? I would rather throw myself into the long flowing river and bury myself in the belly of the river fish. How can one expose one's noble qualities to the dust of the world?" (吾聞之，新沐者必彈冠，新浴者必振衣。人又誰能以身之察察，受物之汶汶者乎？寧赴常流而葬乎江魚腹中耳。又安能以皓皓之白，而蒙世之溫蠖乎？)[21]

In this dialogue, we can see the argument that Sima Qian is making- retaining one's morality is more important than keeping one's life. No matter what the circumstance is, the ministers cannot compromise their morality to fit in the court. They'll stand firm with their beliefs. The result of this led to the realization of the unresolvable issue and the only choice that a minister can make to ease his moral struggle: "So he wrote the poem 'Huai Sha'… Holding a stone, he threw himself into the Mi Luo River and died." (乃作《懷沙》之賦。……於是懷石，遂自投汨羅以死。) [22]For Qu Yuan, and for the Han literati, the ultimate dilemma led to only one way to retain and express their morals- leave the proof of their morality in poems for the later generations to cherish.

Moreover, with this establishment of Qu Yuan's figure, a juxtaposition is created between Qu Yuan and the King. Qu Yuan was shown as moral, loyal, and firm; the King was misguided, cold-hearted, and even a bit foolish. An important question is brought out: why was the King depicted as creating Qu Yuan's dilemma and as a lesser figure in his talents and morals? The King is the dominant figure of the state who makes the most significant decisions. Yet in the narrative, he was fooled by the corrupted officials, was following advice harmful to the state, and was persecuting the righteous ministers. From a modern reader's perspective, this depiction might be dubious. Yet this depiction was common in the Han narratives. For the Han ministers, this embodies their self-establishment in the court. In Sima Qian's depiction, minister Qu Yuan always remained loyal even if the King doesn't seem talented enough. Qu Yuan hopes to help the King improve through his guidance and yearns to change the situation in the court, no matter what the circumstance is. This mirrors the wish of the Han ministers. They wanted to establish themselves as loyal and talented subjects of the King; they wanted the opportunity to change some part of the society. As reflected in the narratives, even before death, Qu Yuan (the ministers) desire to leave some legacy to the society. This linkage with the figures in literary narratives connects them to the ideal position they should be at, encouraging them to find their correct place in the court as advisors. Just like how Qu Yuan detailed his morality and loyalty in Li Sao and Huai Sha, the Han ministers were using narratives to present their high self-cultivation, waiting for future readers to uncover.

Similarly, in the *Biography of Wu Zixu*, Sima Qian offered an identical attitude. Just like Qu Yuan, Wu Zixu is a character with morals and talents that was dismissed by the King due to slanders from corrupted officials. This conflict is summarized in his dialogue to the King's

---

[21] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2486.
[22] 司马迁Sima Qian, *The Biography of Qu Yuan and Jia Shen*屈原賈生列傳in *Shi Ji*史記, 1959, 2486-2490.

servant, "The treacherous minister Bo Xi is causing trouble, but the King is instead trying to kill me. It was I who once made your father the ruler of the feudal lords; when you were not yet appointed as the crown prince, the young masters were competing to become the crown prince, and I used my life to argue for you in front of the previous King, almost unable to appoint you as the crown prince. After you become the King, you want to give me a portion of the land of Wu, but I don't expect that either. However, today you believed in the malicious words of the treacherous minister and intended to kill your elders." (讒臣嚭為亂矣, 王乃反誅我。我令若父霸。自若未立時, 諸公子爭立, 我以死爭之於先王, 幾不得立。若既得立, 欲分吳國予我, 我顧不敢望也。然今若聽諛臣言以殺長者。)[23]

Wu Zixu was the counselor of the previous King of Wu and had made many contributions to the state. He once helped the King to assume office, and he has the ability to help Wu thrive. However, while he clearly identifies the needs of Wu, the King decides to believe in the ill-willed officials and decides to kill him. Wu Zixu is clearly an upright man in an irreconcilable situation, a situation even worse than that of Qu Yuan- he doesn't have much of a choice at all since the King already ordered his death.

In this seemingly impossible circumstance, Wu Zixu still managed to persist his believes and morals through leaving his last words of warning to the King before he was executed. Here, Sima Qian gives another nuanced choice as the result of the minister's moral struggle- to express the firm objection/criticism of the King's choices before accepting the inescapable death. This reiterates that the King is the person contributing to Wu Zixu's tragedy. To bring this expression to a higher level, Wu Zixu also predicts the future of the Wu state, "After I die, I must plant a catalpa tree on my tomb so that it can be useful when it grows. I will take off my eyes and hang them on the east gate of the capital to witness the invasion of the Yue invaders and the downfall of the Wu state." (必樹吾墓上以梓, 令可以為器;而抉吾眼縣吳東門之上, 以觀越寇之入滅吳也。)[24]

This way, Wu Zixu demonstrated his wisdom through the accurate prediction of Wu's fate (as proved in the next paragraphs in the text). He conveyed his message and expressed his everlasting dissatisfaction toward the corrupted Wu society. This represents a more direct confrontation of the King's ill-fitting orders made by the minister, which implies that the King, with his lack of talent and ability to distinguish constructive and harmful advice, was contributing to the decline of the state. From this perspective, Sima Qian is showcasing the lasting loyalty of Wu Zixu- even before his ordered death, he's using his last effort to warn and help the King. Just like Qu Yuan, Wu Zixu left his teachings to the King and to the future society with his last words, presenting the ideal profile of an established advisor/minister.

In the *Biography of Wei Gongzi*, Sima Qian further discusses the changing interaction between Wei Wuj and the King. At the start, Sima Qian points out that "The King of Wei was afraid of the wise and capable young Wei Wuji and dared not appoint him to handle national

---

[23] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2180.
[24] 司马迁Sima Qian, *The Biography of Wu Zixu*伍子胥列傳in *Shi Ji*史記, 1959, 2180.

affairs." (魏王畏公子之賢能, 不敢任公子以國政。)[25] Wei Wuji was wise and capable of helping the state, which again emphasized the importance of self-cultivation, but his talent frightened the King. Once more, the abilities and morality of the minister is at odds with that of the King. The King is too "afraid" for seizing his power that he ignored how Wei Wuji's talents can help the state to thrive.

When the state of Qin attacked the Zhao, Wei Wuji yearned to help defend the Zhao, yet the King is too afraid to do so. On one side, the responsibility of Wei Wuji as a minister is to follow the King's orders, but by fulfilling that he would have to compromise his morality by neglecting his sister and a state in need. Similar to the previous pattern, Wei Wuji is facing a conflict with the King with no clear answer. Sima Qian is creating this third, nuanced moral dilemma to explore another, even more direct type of reaction- the complete negligence and disobedience of the King's order. "Wei Gongzi estimated that he would not be able to obtain the consent of the King to send troops, so he decided not to live on his own if the state of Zhao perish. Therefore, he invited guests and tied more than a hundred chariots, intending to rush to the battlefield with them to fight to the death with the Qin army and die together with the Zhao people." (公子自度終不能得之於王, 計不獨生而令趙亡, 乃請賓客, 約車騎百餘乘, 欲以客往赴秦軍, 與趙俱死。) [26]Wei Wuji eventually disobeyed the King and faked the military order to help the Zhao, clearly knowing that his act will enrage the King and will cause himself trouble, while also accepting the possibility that he might die to fulfill his moral choice. As a minister, he truly stood by his beliefs and persisted in what will change the states for the better. This point, at least, is the ideal of Han ministers. Whether the extremity of him totally abolishing the expectations of the King is appropriate as a minister is left for the readers (ministers) to judge for themselves.

Contrastingly, the second time that Wei Wuji faced a political setback (a new irreconcilable moral struggle), he adopted a different attitude. After he returned to save Wei from Qin, Wei Wuji was again distrusted by the King due to the plot of the Qin, "The King of Wei heard these slanderous words about Wei Wuji every day and couldn't help but believe them to be true. Later, he indeed sent someone to replace Wei Wuji as the general. Wei Wuji himself knew that he was again deposed for defamation, so he pleaded not to serve in the imperial court any more in the excuse of being ill. He feasted with his guests all night at home, indulging in strong alcohol and often interacting with women. He spent four years seeking pleasure day and night, and finally died of excessive drinking and illness." (魏王日聞其毀, 不能不信, 後果使人代公子將。公子自知再以毀廢, 乃謝病不朝, 與賓客為長夜飲, 飲醇酒, 多近婦女。日夜為樂飲者四歲, 竟病酒而卒。)[27]

This time, when Wei Wuji's actual intention was mistaken by the King, Wei Wuji chose to leave the court. He knows that he had been deposed for "defamation," and that this conflict is quite reconcilable. He didn't fight for his beliefs like he did the last time, but he turned to alcohol

---

[25] 司马迁Sima Qian, *The Biography of Wei Gongzi*魏公子列傳in *Shi Ji*史記, 1959, 2377-2378.

[26] 司马迁Sima Qian, *The Biography of Wei Gongzi*魏公子列傳in *Shi Ji*史記, 1959, 2379.

[27] 司马迁Sima Qian, *The Biography of Wei Gongzi*魏公子列傳in *Shi Ji*史記, 1959, 2384.

and entertainment as a consequence of his depression. This ultimately led to a tragic ending: Wei Wuji died of illness and excessive drinking. Even though this doesn't match with the previous self-cultivation principles that Sima Qian focused on, it is still indeed one of the possible choices for ministers in conflict with the King. As a minister, they may choose to leave the court as the King wishes, but they will nevertheless remain in the position of a loyal subject. The most extravagant action in their position is drinking and playing, but nothing more.

In general, all of those nuanced attitudes depicted for Qu Yuan, Wu Zixu, and Wei Wuji seem similar yet also contrasting. We can read the different portrayals as Sima Qian's discussion of the possible routes that ministers can take when their personal talents, morals, or aspirations are not appreciated by the society and/or the King. From writing poems to make one remembered by later generation to ventilating one's rage in their last words, from persisting one's morals over social expectations to giving up one's fight, Sima Qian is listing many different attitudes that ministers can adopt to express themselves in potentially unsolvable moral dilemmas. No definitive solution nor judgment is given. The suspending judgment is left for the readers, which parallels with the Han literati's concern for individuality versus social/court requirements. While reading, Sima Qian provides information that would prompt them to reflect on the ideal position they should take as ministers, as subjects to the King. Sima Qian's writing can be seen as a response to this growing concern and a result of his appreciation in exploring the moral dilemmas.

Conclusion

The composite nature of the figure Qu Yuan is clear from its comparison with figures Wu Zixu, and Wei Wuji in *Shi Ji*. Generally, their narratives, morals, values, and decisions are not purely historical records nor fictional stories, but a representation of the Sima Qian's ideals, conflicts, and needs. More importantly, they're the areas of thoughts for the Han literati community as a whole. In the early dynasty, we can see a continuation of pre-imperial teachings on social responsibility. At the same time, though, in a period of instability, we can also track the emerging consideration of moral dilemmas that ministers face with the society and the King.

With this conclusion, we can say that the narrative of Qu Yuan fits under the Cultural Memory model. Indeed, what happened to the Qu Yuan figure may not be true, yet it is exactly this edited, crafted, and changed narrative that reflects the needs of the Han dynasty literati and the transforming values of the society at that time.

Works Cited

Dinter, Martin. *Cultural Memory in Republican and Augustan Rome*. Cambridge University
        Press & Assessment. Cambridge. Accessed Feb 22, 2024.

https://assets.cambridge.org/97810093/27756/excerpt/9781009327756_excerpt.pdf

Ißler, R.A. (2019). *Cultural Memory*. In: *Kühnhardt, L., Mayer, T. (eds) The Bonn Handbook of Globality*. Springer, Cham. Accessed Feb 22, 2024.

https://doi.org/10.1007/978-3-319-90382-8_6

Kern, Martin. *Cultural Memory and the Epic in Early Chinese Literature: The Case of Qu Yuan* 屈原 *and the Lisao* 離騷. Duke University Press, 2022. Accessed Feb 22, 2024.

Owen, Stephen, *An Anthology of Chinese Literature*, W. W. Norton & Company, Inc.,1996. Accessed Feb 22, 2024.

Sima, Qian. *The Biography of Qu Yuan*屈原賈生列傳in *Shi Ji*史記*, 1959.* Accessed Feb 23, 2024.

Sima, Qian. *The Biography of Wu Zixu*伍子胥列傳 in *Shi Ji*史記*, 1959.* Accessed Feb 23, 2024.

Sima, Qian. *The Biography of Wei Gongzi*魏公子列傳 in *Shi Ji*史記*, 1959.* Accessed Feb 23, 2024.

Studying Death Rates Caused by Air Pollution By Arnav Gorantla

Introduction

Air pollution represents a pervasive environmental hazard that poses grave risks to human health worldwide. Prolonged exposure to various air pollutants, such as particulate matter (PM), ozone (O3), and other harmful substances, can precipitate the development of respiratory and cardiovascular diseases, ultimately contributing to increased mortality rates across diverse populations. This comprehensive study aims to conduct an in-depth analysis of air pollution-related death rates across different regions, countries, and socioeconomic development levels, by identifying spatial and temporal trends, as well as key contributing factors, the findings of this research endeavor to inform evidence-based policymaking and guide the implementation of effective mitigation strategies to safeguard public health globally.

Literature Review

Numerous studies have highlighted the negative effects of air pollution on human health, particularly in densely populated urban areas and regions characterized by a lot of industrial activity (Landrigan et al., 2018; Schraufnagel et al., 2019). Exposure to elevated levels of fine particulate matter (PM2.5) and ground-level ozone has been associated with increased risks of ischemic heart disease, stroke, chronic obstructive pulmonary disease, and lung cancer (Cohen et al., 2017; Burnett et al., 2018). Moreover, indoor air pollution resulting from the use of solid fuels for cooking and heating purposes has been identified as a significant contributor to respiratory infections and adverse birth outcomes (Smith et al., 2014).

While the existing body of literature underscores the grave consequences of air pollution on public health, there remains a pressing need for comprehensive analyses that enable comparisons of air pollution-related mortality patterns across diverse geographical and socioeconomic contexts. This study seeks to contribute to the current understanding by providing a broad and in-depth examination of air pollution-related mortality trends on a global scale, encompassing multiple regions, countries, and development levels.

Methodology
Data Source and Preprocessing

The analysis utilizes a comprehensive dataset containing air pollution-related death rates for various regions, countries, and socioeconomic development levels spanning the period from 1990 to 2017. The dataset encompasses information on total deaths attributed to air pollution, as well as deaths specifically linked to indoor air pollution, outdoor (ambient) air pollution, and ozone exposure. Extensive data cleaning and transformation steps were undertaken, including handling missing values, creating subsets based on regions and income levels, and aggregating data at different levels to facilitate meaningful comparisons.

Statistical Analysis and Visualization

To analyze trends in air pollution-related death rates over time, robust linear regression models were employed. Visualizations, such as line plots and subplots, were generated to facilitate the exploration of patterns and enable the comparison of trends across different regions

and countries. Additionally, these trained regression models were leveraged to make projections for future air pollution-related death rates, providing valuable insights into potential scenarios.

Results
Regional Trends

The analysis revealed significant variations in air pollution-related death rates across different regions. For instance, regions such as Southern Sub-Saharan Africa and South Asia exhibited consistently higher death rates compared to other regions like North America and Western Europe (Figure 1). These disparities can be attributed to factors such as differences in

urbanization levels, industrialization, and the prevalence of solid fuel use for cooking and heating.

Country-level Analysis

At the country level, the study identified several nations exhibiting increasing trends in air pollution-related deaths. These countries included India, China, Pakistan, and Nigeria. Potential factors contributing to these alarming trends may include rapid urbanization, industrialization, and inadequate environmental regulations, as well as reliance on solid fuels for cooking and heating in some regions. For instance, in India, the air pollution-related death rate increased from 93.3 per 100,000 population in 1990 to 119.5 per 100,000 in 2017 (Figure 2).

Deaths Attributed to Air Pollution
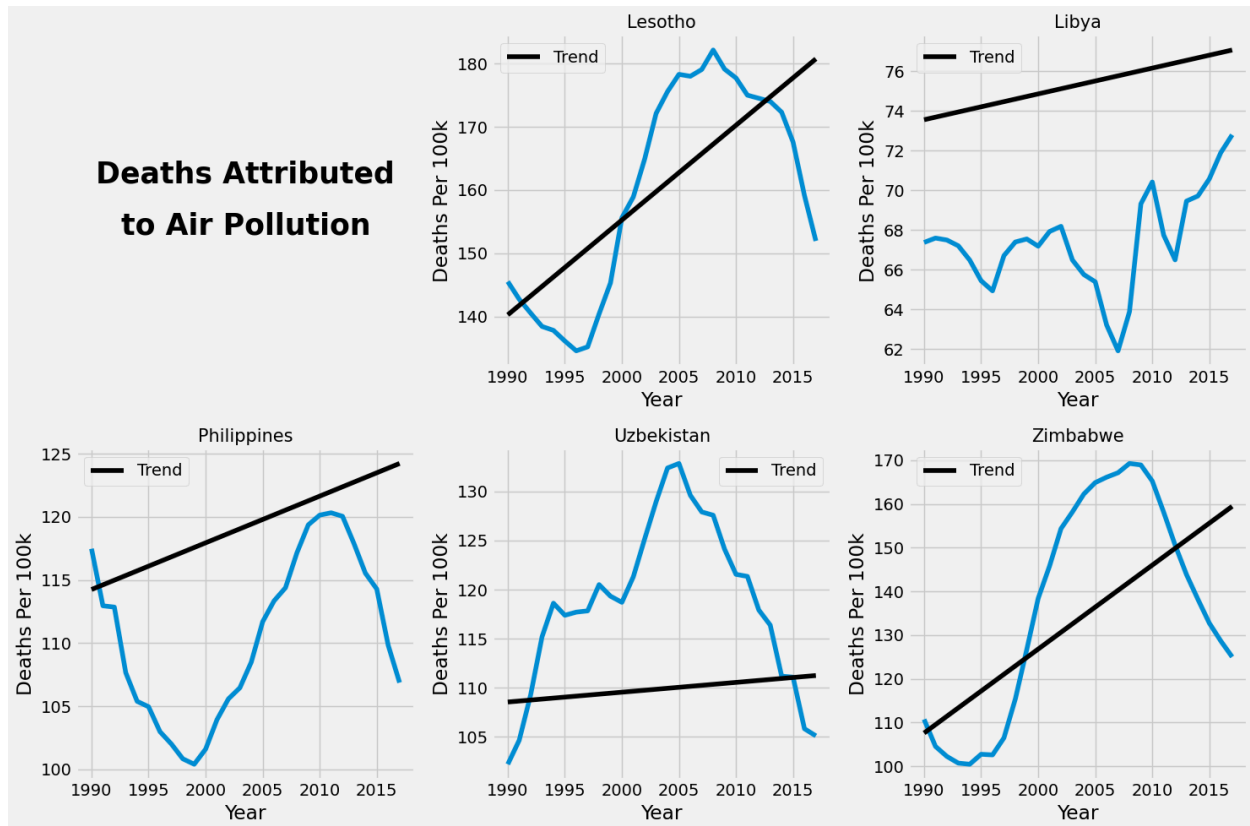
Socioeconomic Factors

The analysis explored the relationship between air pollution-related death rates and socioeconomic development levels, as measured by the Socio-demographic Index (SDI). Findings indicated that countries with lower SDI levels, which reflect lower income and education levels, generally experienced higher air pollution-related death rates. For instance, countries classified as "Low SDI" had an average death rate of 120 per 100,000 population in 2017, compared to 30 per 100,000 for "High SDI" countries. This disparity can be attributed to various factors, including limited access to clean energy sources, inadequate healthcare infrastructure, and lower levels of environmental regulation and enforcement in less developed regions.

Future Projections

Leveraging the trained regression models, projections were made for future air pollution-related death rates up to the year 2068. The analysis revealed an encouraging trend, with death rates projected to continue decreasing until approximately 2058-2059 before nearing zero. (Figure 4). If we continue with this pace for the next 40 years we will see that the death rates will be going down drastically.

Future Deaths
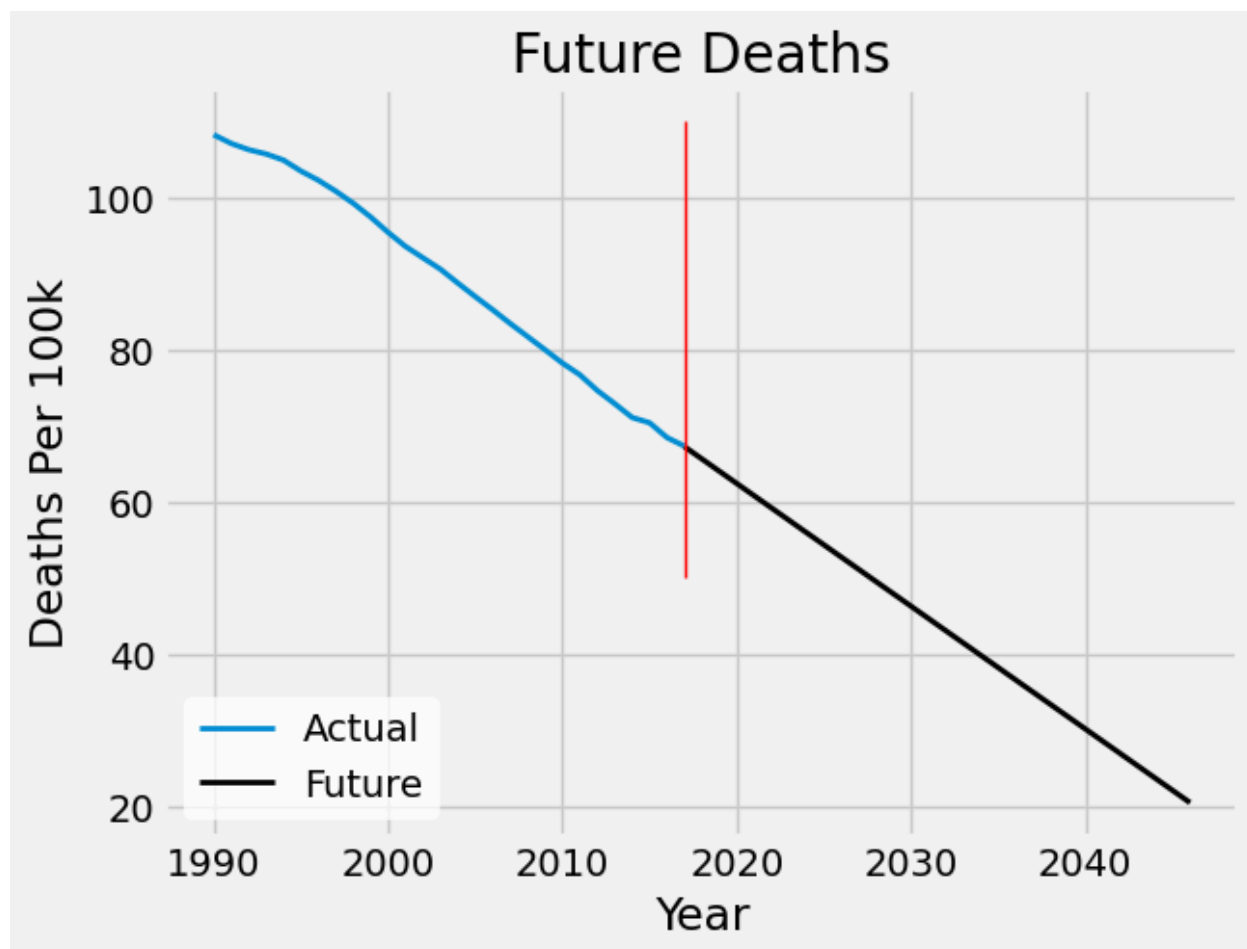

```
                        OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.995
Model:                            OLS   Adj. R-squared:                  0.995
Method:                 Least Squares   F-statistic:                     5068.
Date:                Fri, 22 Mar 2024   Prob (F-statistic):           2.48e-31
Time:                        00:27:11   Log-Likelihood:                -37.831
No. Observations:                  28   AIC:                             79.66
Df Residuals:                      26   BIC:                             82.33
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        3324.9240     45.453     73.151      0.000    3231.494    3418.354
x1             -1.6151      0.023    -71.192      0.000      -1.662      -1.568
==============================================================================
Omnibus:                        6.349   Durbin-Watson:                   0.195
Prob(Omnibus):                  0.042   Jarque-Bera (JB):                4.589
Skew:                          -0.928   Prob(JB):                        0.101
Kurtosis:                       3.699   Cond. No.                     4.97e+05
==============================================================================
```

Discussion

The findings of this study underscore the pervasive and far-reaching impact of air pollution on human health, with significant variations observed across different regions, countries, and socioeconomic development levels. Identifying nations and regions exhibiting increasing trends in air pollution-related deaths, such as India, China, Pakistan, and Nigeria, highlights the urgent need for targeted interventions to address the underlying drivers of this public health crisis.

Rapid urbanization, industrialization, and reliance on solid fuels for cooking and heating have been identified as key contributing factors to the rising air pollution levels and associated mortality rates in many developing and newly industrialized nations. These factors are often compounded by inadequate environmental regulations, limited access to clean energy sources, and insufficient healthcare infrastructure, particularly in low-income regions.

It is crucial to acknowledge the disparities observed across different socioeconomic contexts, as air pollution disproportionately affects vulnerable populations with limited access to healthcare and environmental protection measures. This underscores the need for a comprehensive approach that addresses the sources of air pollution and the underlying social determinants of health, such as poverty, education, and access to clean energy.

The projected zero deaths in global air pollution is around 2059, as revealed by the study's future projections. At this rate, the Earth's pollution will go down and the deaths will reach near zero.

Acknowledgments

I want to thank my mentor, Brian Lewis, for all his help with this research project and paper. Brian's knowledge of data analysis and coding was very valuable. His guidance, useful feedback, and commitment to helping me improve as a researcher made a big difference. I appreciate Brian's mentorship throughout this process.

Works Cited

Burnett, R., Chen, H., Szyszkowicz, M., Fann, N., Hubbell, B., Pope, C. A., ... & Spadaro, J. V. (2018). Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. Proceedings of the National Academy of Sciences, 115(38), 9592-9597.

Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., ... & Forouzanfar, M. H. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. The Lancet, 389(10082), 1907-1918.

Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N. (Nil), ... & Zhong, M. (2018). The Lancet Commission on pollution and health. The Lancet, 391(10119), 462-512.

Schraufnagel, D. E., Balmes, J. R., Cowl, C. T., De Matteis, S., Jung, S. H., Mortimer, K., ... & Wuebbles, D. J. (2019). Air pollution and noncommunicable diseases: A review by the Forum of International Respiratory Societies' Environmental Committee, Part 1: The damaging effects of air pollution. Chest, 155(2), 409-416.

Smith, K. R., Bruce, N., Balakrishnan, K., Adair-Rohani, H., Balmes, J., Chafe, Z., ... & Rehfuess, E. (2014). Millions dead: how do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. Annual review of public health, 35, 185-206.

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R. T., Haines, A., & Ramanathan, V. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. Proceedings of the National Academy of Sciences, 116(15), 7192-7197.

World Health Organization. (2021). Air pollution. https://www.who.int/health-topics/air-pollution

United Nations Environment Programme. (2019). Air pollution and human health: the latest evidence and impact assessment. https://www.unenvironment.org/resources/publication/air-pollution-and-human-health-latest-evidence-and-impact-assessment

Apte, J. S., Marshall, J. D., Cohen, A. J., & Brauer, M. (2015). Addressing global mortality from ambient PM 2.5. Environmental Science & Technology, 49(13), 8057-8066.

These additional references cover various aspects of air pollution and its health impacts, including global burden estimates, methodological approaches, policy implications, and reviews from authoritative organizations like the World Health Organization and the United Nations Environment Programme.

Cardiovascular Diseases Affecting Pregnancy: A Systematic Analysis By Shubhay Mishra, Mannat Srivastava, Jawad Azeem, Breanne Graham, Inaya Amin

Abstract

This systematic review examines findings from surveys, longitudinal studies, and various other medical literature to propose a cardiovascular aspect of pre/postpartum maternal fitness, with a specific focus on abortion. These studies appear to support the idea that abortion is a necessary, healthy way to circumvent common cardiovascular issues, namely, congenital heart disease (CHD), peripartum cardiomyopathy (PPCM), pulmonary hypertension (PH), and severe preeclampsia (SP). This review was created on a basis of the paucity of synthetic reviews comparing several aspects of pregnancy within the aforementioned lens.

Introduction

The topic of abortion is a pivotal nexus where ethics, legality, and medical necessity converge. However, despite the significance of the abortion debate and its high visibility in the public sphere, the discussion of its medical implications relies on incomplete information. Specifically, the range of medical conditions that are widely understood to make abortion medically necessary fail to include background stresses such as cardiovascular disease. A greater understanding is needed of the impact of cardiovascular disease on morbidity in pregnancy, as well as the relevance of abortion to those concerns.

Cardiovascular disease is the primary cause of pregnancy-related mortality in the United States (1). Patients with existing cardiovascular diseases that go into pregnancy have an increased risk of inherited cardiac genetic disorders, increased symptoms of the condition, and acute cardiovascular decompensation. The fetus will have risks of growth restriction and premature delivery. These complications also increase the risk for antenatal and perinatal mortality (2). Pregnancy is associated with major physical undertakings of the maternal body as maternal heart rate increases by 10 to 15 beats per minute and red cell mass increases by 20 to 30%.

In this investigation, we delve into the interplay between cardiovascular diseases, postpartum fitness, and mental health. Moreover, we seek to elucidate how congenital heart disease, severe preeclampsia, peripartum myopathy, and pulmonary hypertension influence the likelihood and severity of pregnancy complications. Furthermore, we examine the spectrum of alternatives to abortion available to circumvent these complications, addressing their efficacy and implications. By conducting a comprehensive systematic review of medical literature, case studies, and ethical considerations, we aim to gauge the impact of abortion on managing cardiovascular disease-related pregnancies. Additionally, we scrutinize the necessity and feasibility of legal and medical safeguards for mothers and infants in situations where abortion or carrying to term are not viable options due to cardiovascular diseases, thus contributing to the discourse surrounding legal and medical protections in such cases. Based on our findings, we

contend that there should be greater legal protections for abortions in order to prevent development or exacerbation of cardiovascular diseases in pregnant women.

Methods

Data was collected from a total of 50 studies from several countries to investigate specific parameters related to termination, including its effectiveness, the severity of diseases associated with it, and the various alternatives to abortion. The range of publication years for the studies included in our review extended from 2007 to 2022. Selecting studies involved a two-part screening process involving first a reviewer determining whether or not a given study included the following information, followed by another reviewer determining whether or not the study included significant methodological errors or conflicts of interest. In terms of inclusion criteria, we considered studies that addressed the effectiveness of abortion, the severity of diseases necessitating abortion, mental health pertaining to peripartum, or the discussion of alternatives to abortion within the specified timeframe. Studies not meeting these criteria, as well as studies that failed the screening process, were excluded from our analysis. Data extraction from the selected studies involved the compilation of pertinent information, i.e number of successful abortions, fitness as reported by individuals who have undergone abortion, and such information as reported by medical professionals. Successful abortion was defined as the complete expulsion of all products of pregnancy (3). To assess the significance of our findings, we employed statistical analyses, specifically the one-way ANOVA test and a Kruskal-Wallis test, to determine the statistical significance of observed differences and relationships across relative mortality, available alternatives, and mental health. We used R (Version 4.2.3) to implement these statistical tests.

Section I (Overview of Diseases):
1.1

Congenital Heart Disease (CHD) is a diverse group of structural heart abnormalities that are present at birth, affecting the heart's structure and function. These conditions result from abnormal development of the heart during fetal growth, and they can vary widely in complexity and severity. CHD manifests as a range of defects, such as atrial or ventricular septal defects, patent ductus arteriosus, and complex conditions such as Tetralogy of Fallot (Centers for Disease Control and Prevention [CDC], 2023) (4). The disease occurs in roughly 0.8% of births in the United States, or roughly 30,000 babies (Uebing et al., 2006) (5). The symptoms and clinical manifestations of CHD can be highly variable, from mild or asymptomatic cases to severe and life-threatening ones. Depending on the specific defect, individuals with CHD may experience symptoms such as cyanosis (bluish skin discoloration), shortness of breath, fatigue, and poor growth (6) (Stanford Medicine, 2023). CHD is often hereditary. Feti of pregnant women with CHD have a risk of CHD of approximately 3%-12% (Uebing et al., 2006) (7), which is as much as 1400% of the general population. The management of CHD often requires a multidisciplinary approach, involving pediatric cardiologists, cardiac surgeons, and other specialists. Due to the

focus of this review on maternal health, we focus on "grown-up congenital heart disease" or GUCH (Uebing et al., 2006) (8).

1.2

Peripartum Cardiomyopathy (PPCM) is a rare but potentially life-threatening cardiac disorder that affects women during the peripartum period, typically defined as the last month of pregnancy and the first five months postpartum. This condition is characterized by the development of heart muscle weakness and impaired cardiac function, which can lead to a range of symptoms. Women with PPCM may experience symptoms such as shortness of breath, fatigue, swelling of the legs and ankles, rapid or irregular heartbeat, and chest discomfort. PPCM often occurs in previously healthy women, but it is more commonly observed in those with certain traits, such as advanced maternal age, multiple pregnancies, hypertension, obesity, and pre-existing heart conditions(9) (Penn Medicine , 2022). The death rate associated with PPCM varies but can be as high as 5-10%, making it a significant concern. The diagnosis of PPCM involves a comprehensive assessment, including a review of the patient's medical history, a physical examination, and a series of medical tests. Echocardiography, or a heart ultrasound, is a fundamental diagnostic tool for PPCM, allowing healthcare providers to assess the heart's structure and function, with a particular focus on left ventricular ejection fraction (LVEF) reduction, typically below 45%. Additionally, electrocardiograms, blood tests measuring cardiac biomarkers like brain natriuretic peptide (BNP) and troponin, and chest X-rays may be employed to aid in the diagnosis(10) (Kimura et al., 2019). In some cases, cardiac magnetic resonance imaging (MRI) may be recommended for a more detailed assessment. Early diagnosis is crucial, given that the symptoms of PPCM can overlap with those of other common pregnancy-related conditions. The disease is most prevalent in Asian and African countries. It affects roughly 1 in 2000 pregnancies worldwide.

1.3

Pulmonary Hypertension (PH) is a complex and potentially life-threatening condition characterized by high blood pressure in the pulmonary arteries, which are the vessels that carry blood from the heart to the lungs. PH can be idiopathic (of unknown cause) or associated with other medical conditions such as connective tissue diseases, congenital heart defects, and chronic lung diseases. Common forms of PH include pulmonary arterial hypertension, chronic thromboembolic pulmonary hypertension, and pulmonary hypertension due to left-sided heart and lung disease (11).This condition can lead to a range of symptoms, including shortness of breath, fatigue, chest pain, and fainting. The severity and prognosis of PH can vary widely, and the death rate associated with PH is dependent on factors such as the underlying cause, the degree of pulmonary artery pressure elevation, and the response to treatment. In severe cases, untreated or poorly managed PH can lead to right heart failure and a significantly increased risk of mortality. A threshold value that is used to determine whether or not a patient has PH is a mean pulmonary arterial pressure greater than 20 mmHg (12). However, more recent studies

have instead suggested mild pulmonary hypertension defined as 25-49 mmHg mean arterial pressure, and severe cases greater than 50 mmHg (13). Although PH has a high death rate, it is fortunately rare, occuring in roughly 97 cases per million (14, 15).

1.4

Severe preeclampsia (SP) is a multisystem disorder characterized by high blood pressure, proteinuria, kidney damage, and other signs of organ damage/failure as a result of endothelial cell damage (16). In this review, a patient is considered to have severe preeclampsia if their systolic blood pressure exceeds 160 mmHg or if their diastolic blood pressure exceeds 110 mmHg. The exact cause of SP is unclear, but one contributing factor may be the development of abnormal placenta, in which uterine placental arteries become fibrous (17). Preeclampsia develops after roughly 24 weeks of gestation, or, in some cases, 6 weeks after delivery (18). Patients exhibiting gestational hypertension or an already compromised autoimmune condition such as lupus before conception are more likely to develop the disease after 20 weeks of pregnancy (19). Left untreated, preeclampsia exacerbates and can lead to serious — even fatal — complications for both the mother and baby. Treatment includes careful monitoring and medications to lower blood pressure and mitigate other complications. Preeclampsia may also develop after delivery, a condition known as postpartum preeclampsia.

There is no cure for preeclampsia except for delivering the baby and the placenta. The placenta is crucial for the health of the baby, as it provides oxygen and nutrients from the mother's blood and removes waste products like carbon dioxide via the mother's blood. (20). If the mother has severe preeclampsia, high blood pressure can limit the amount of oxygen and nutrients that the baby receives, gradually starving them of oxygen and nutrients. This growth restriction threatens the life of the baby, necessitating an early or premature delivery. SP affects up to 1% of pregnancies (21).

The following figure shows the percentage of individuals who passed away due to each given condition, taken from audits from the past two decades.

Figure 1. Percent of Deaths among CHD, SP, PPCM, and PH
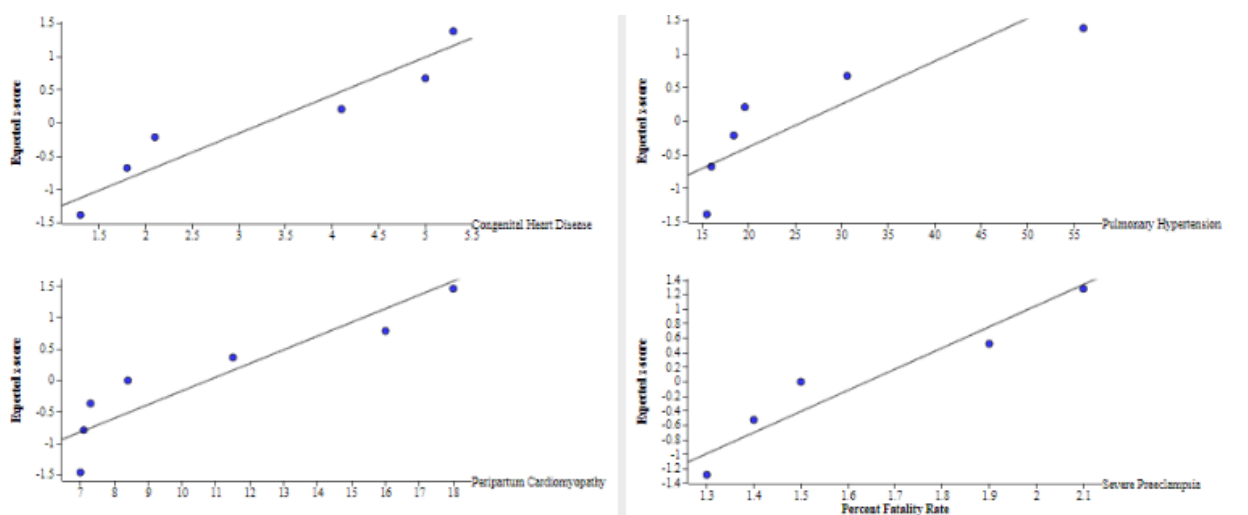
Section II (Treatments and Application of Termination)
2.1

The prognosis of previously mentioned cardiovascular diseases is primarily through cardiac catheterization and echocardiography. Echocardiography involves the use of ultrasound which allows examination of the heart. It is considered a safe procedure, and has no known risks. Cardiac catheterization entails inserting a catheter into certain nodes on the body, such as the groin, arm, or neck. The catheter is threaded throughout the bloodstream from the node into the trunk artery and finally into the heart (22). Although catheterization serves as an important initial role in deducing the radix of such conditions, it must be followed up with medication, many of which can cause harmful side effects. This in turn may lead to exacerbation of extant cardiovascular conditions.

Regarding abortion, while not all of these side effects are avoided, such complications are rare. These complications are generally limited to heavy bleeding and infection. The latter is prevented with the use of antibiotics, as they are ingested prior to procedure (23). Many cite abortion as a progenitor of profound mental health issues, such as depression. Empirical evidence of whether or not this is true is divided. Section III can be referenced for further information on this topic.

2.2

As previously mentioned, treatment of CHD varies. Abortion has been contraindicated due to the risk of heavy bleeding, which a CHD - lesioned heart may not maintain. However, it has been shown to be effective in cases where the decision to terminate has been made in the first trimester (24). Often called the "safe" method of contraception, progestogen-only pills have in reality have a higher risk of failure than "combined" or ethinyl estradiol and norethindrone-based treatments (25). On the other hand, ethinyl estradiol and norethindrone-based pills pose risks for individuals with thromboembolism related conditions. Thus no method of contraception is ideal for pregnant individuals. In such cases, intake of combined pills may lead to cyanosis, arrhythmia, and Fontan-type circulation, among other effects (26).

The most common type of CHD, ventricular septal defect, is typically treated by antibiotic prophylaxis during the prepartum period. Once the pregnancy has been completed, reparative surgery is performed (27). Other common types of CHD atrial septal defects, which are often accompanied by thrombosis, and thus treated by venous thromboprophylaxis (VTE), followed by reparative surgery; coarctation, which holds potential hazards of endarteritis, congestive heart failure, as well as preeclampsia, and is treated using β-blockers, followed by reparative surgery; and Tetralogy of Fallot, which manifests as arrhythmias, endocarditis, and right ventricular failure, which is treated by antibiotic prophylaxis, preterm delivery, or, if needed, abortion (28, 29).

2.3

The treatment of PPCM is affected by comorbidities, including CHD. Among these comorbidities is ventricular dysfunction, which must be treated before prognostication(30). Prospects in the treatment of PPCM include the dopamine agonist bromocriptine, which lowers prolactin, and the phosphodiesterase inhibitor pentoxifylline, which functions as a vasodilator (31, 32, 33). Alongside these treatments, β-blockers are used to induce bradycardia, and diuretics, such as hydrochlorothiazide and furosemide assist in fluid retention (34, 35, 36). Termination can serve as an important and necessary step in the treatment of PPCM, due to ease of administration of medicaments, although it does not serve as prophylaxis (37, 38). Necessity of termination is impacted by etiology of PPCM (39). PPCM has a likelihood of up to 50% of recurring (40). However, estrogen-based pills to prevent future pregnancy are contraindicated due to the possibility of thromboembolism, a similar deterrent to termination as CHD, as well as water retention (41, 42). Sterilization procedures are ergo favored, notably via copper intrauterine devices (IUDs), or levonorgestrel releasing IUDs (43).

2.4

Treatment of PH depends on the specific type, i.e. pulmonary arterial hypertension, chronic thromboembolic pulmonary hypertension (CTEPH), and pulmonary hypertension due to left-sided heart and lung disease (PH-LHD) (44). The understanding of pulmonary arterial hypertension, or PAH, has seen Brobdingnagian advances over the past 20 years, and thus five classes of medications are now available: phosphodiesterase-5 inhibitors, soluble guanylate cyclase stimulators, prostacyclin analogues, prostacyclin receptor agonists and endothelin receptor antagonists (45). Though these medications have vastly decreased the mortality rate of PAH, the age-standard mortality rate of PH per million has steadily increased since 2003 (46). Treatment of CTEPH is surgical (47). The primary surgical procedure is pulmonary endarterectomy (PEA) with deep hypothermic circulatory arrest (DHCA) (48). Other treatments have been proposed, but they have not yet been properly tested, such as percutaneous pulmonary angioplasty (49). Some studies have suggested that PAH treatments may act as a treatment due to the involvement of PH-LHD with the endothelial pathway, and thence phosphodiesterase-5 inhibitors have been proposed as treatments (50, 51). Unfortunately, the methodology of proponents of PAH treatments for PH-LHD contains several caveats, including small sample sizes and no random sampling, making application of these studies currently unfeasible in a clinical setting (52).

Despite the aforesaid medications and improvements in the treatment of PH, pregnancy is highly contraindicated in women with a diagnosis of PH, and it is thus recommended to terminate the pregnancy (53). Terminating pregnancy in these women requires a specialized multidisciplinary team, including a pulmonary hypertension specialist, an anesthetist, and a gynecologist, in a tertiary center due to associated risks (54).

2.5

Little progress has been made in the way of curing severe preeclampsia, possibly as a result of poor understanding of the condition, or the composite nature of SP (55, 56). Considerations for treatment of SP include blood pressure, platelet function, renal function, and liver function, as well as cessation of possibly teratogenic angiotensin converting enzyme (ACE) inhibitors (57). In cases where SP threatens to develop PH, antihypertensive medication must be administered (58). Such medications include labetalol, hydralazine, or nifedipine (59). Preventing eclampsia is typically initially approached via effectuation of $MgSO_4$, which is an anticonvulsant and is used to prevent emergency seizures (60). In most cases pregnancy termination is not required. The decision to abort pregnancy is based primarily due to gestational age, due to the degenerative nature of SP. Delivery is possible for mild to moderate preeclampsia patients for up to the 37th week of gestation, and for SP patients the 34th week of gestation (61). Subsequent to these marks, termination is advised to prevent maternal central nervous system hemorrhage, hepatic rupture, and renal failure (62). Additionally, abortion has been shown to reduce the risk of future preeclampsia by as much as 59% (63).

The following graph shows the abortion rates of pregnancy with the above four diseases.
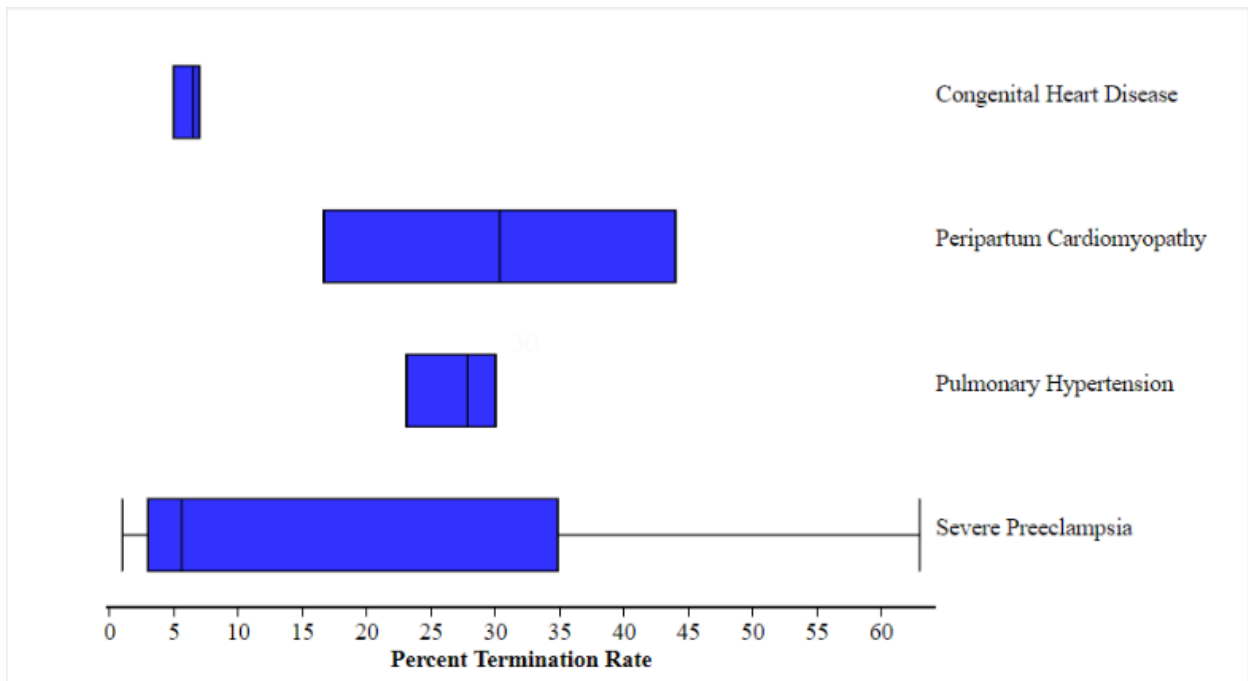
Figure 2. Percent Rate of Termination in CHD, PPCM, PH, and SP

Section III (Abortion and Mental Health)

Many have cited abortion as a major cause of mental health issues, and this fuels much of the debate surrounding the issue. Research on this topic is hindered by severe methodological issues (64). Additionally, due to the nature of the issue, differences in culture are pervasive. A

United Kingdom study (n=500) indicated that abortion had a correlation with only 1.5-5.5% of the overall rate of mental disorders observed postpartum (65). The same study cites the prevalent presence of confounding variables – among these, the fact that several abortion outcomes are associated with elective abortion – calling into question studies that involve the correlation of antenatal depression and other mental health issues with abortion. Another study (n=882) found that 80% of women do not experience psychological problems after two years postabortion (66). Those who did tended to have prior histories of depression(67). Yet another study (n=422) in New Zealand found that pregnancy termination increased observance of mental issues by a factor of 91%, specifically in abortions within the demographic of 15-18 years of age. This was drastically less observed in the other two demographics of 18-21 and 21-25, although both displayed a significant increase in depression, suicidal ideation, and drug use (68). The following graph displays the average relative rates of antenatal depression compared with standard pregnancy as a positive control, taken from studies performed in the last fifteen years:
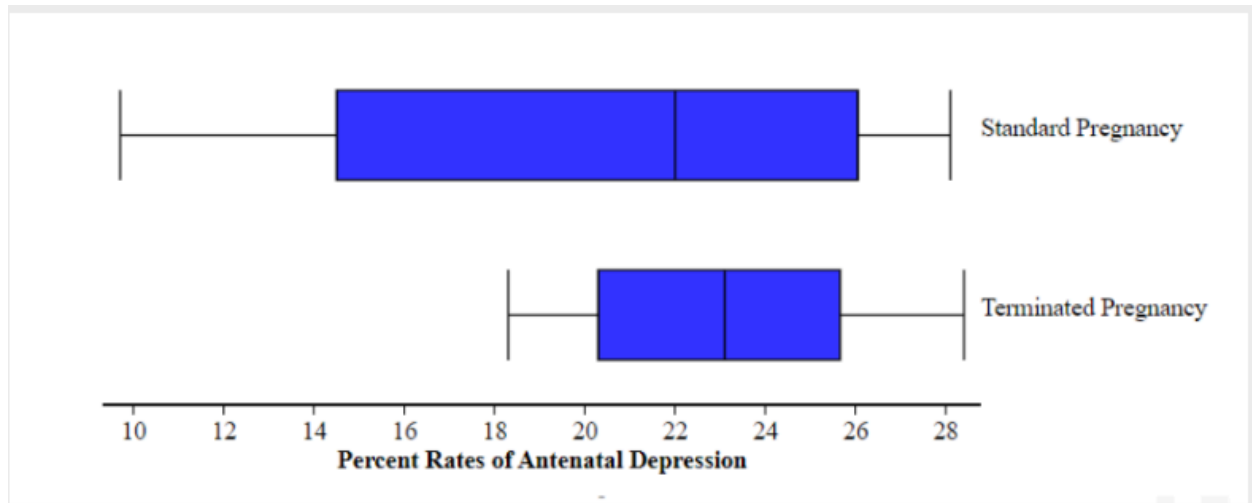
Figure 3. Relative Percent Rates of Antenatal Depression

This compilation of data supports a different viewpoint: Although the median percentage of antenatal depression is slightly higher in terminated pregnancies, the more significant facet is that the rate of depression in standard pregnancies depicts a much higher deviation from the measure of center than abortions. This, as well as summary statistics, will be further scrutinized in the results and discussion section.

Section IV (Results & Discussion)
Our first analysis analyzed the individual death rates of each of the four diseases.

Table 1. Percent Fatality Rate Summary

Group Name	Mean	SD	Min	Q1	Med	Q3	Max
Congenital Heart Disease	3.267	1.744	1.3	1.8	3.1	5	5.4
Peripartum Cardiomyopathy	10.757	4.573	7	7.1	8.4	16	18
Pulmonary Hypertension	26.017	15.685	15.5	16	19	30.6	56
Severe Preeclampsia	1.64	0.344	1.3	1.35	1.5	2	2.1

Something important to note is that while these results can be used as a measure of fatality, they do not necessarily indicate the severity of the diseases. While the median of severe preeclampsia is the lowest, it has a rate of comorbidities that exceeds 13% (69). Another noteworthy slant is that these figures are not indicative of the total mortality of each individual affliction, due to the fact that they are expressed as a percent. Thus, this data is best interpreted within the context of the total deaths caused by each disease. A Kruskal-Wallis test was performed to extract a paradigm of the extent to which the afflictions were statistically significant among themselves under the assumption of non-normal distributions. The following information was obtained:

Table 2. Kruskal-Wallis Test of Analysis No. 1

H	P-value	df
19.525	<0.001	3

Due to the high H-value and significant P-value (<0.05), the data was deemed significant. We then performed a one-way ANOVA test ($\alpha = 0.95$) to account for the possibility of a normal distribution. The following information was obtained:

Table 3. Analysis of Variance of Analysis No. 1

	df	Sum of Squares	Mean Square	F-value	P-value
Group	3	2149.329	716.443	10.449	<0.001
Error	20	1371.311	68.566		

Total	23	3520.64			

Note that each group corresponds to a specific cardiac condition. Pulmonary hypertension has a noticeably outlying fatality rate and standard deviation. This leads to the question of how this condition is skewed, either by socioeconomic factors, geographic location, or other factors. One study (n=4576) cited African Americans as 41% more likely to have pulmonary hypertension, as well as an increased 21% mortality rate when compared to Caucasians (70). On the other hand, a prior study concluded that Caucasians had decreased survival rates at a five-year follow-up when compared to African Americans (71).

Our third analysis examined differences in mental health. The following data was obtained:

Table 4. Mental Health Summary4

Pregnancy Type	Mean	SD	Min	Q1	Med	Q3	Max
Standard	20.363	6.821	9.7	14.5	22	26.05	28.1
Terminated	20	23	18.3	18.5	22.4	26.4	28.4

As mentioned before in Section III, the median of percentage depression with abortion is only slightly higher, however, the standard deviation reflects a 43% decrease between standard and terminated pregnancies. There are several possible reasons for this odd trend. The first and most obvious is that terminations are far less common than standard pregnancies, and as such, if the data is expressed as a normal distribution, the tails would appear much wider. The other notable characteristic between the two categories is that the minimum value of the aborted category is roughly double that of standard pregnancies. It is dubious as to why this observation may be perceived. We contend that the 9.7% minimum of standard pregnancies is an outlier. We performed a one-way ANOVA ($\alpha = 0.95$) to determine whether or not the percentage rate of depression between the two categories is significant. The analysis and interpretation are summarized below.

Table 5. Analysis of Variance of Analysis No. 3

	df	Sum of Squares	Mean Square	F-value	P-value
Group	1	29.976	29.976	1.014	0.331
Error	14	414.059	29.576		
Total	15	444.034			

The F-value and P-value reveal that both groups are not significantly different. The F-value is only 0.014 greater than 1. The P-value well exceeds 0.05. In other words, there is no statistical correlation between abortion and antenatal depression. This conclusion is corroborated by prior studies (72, 73, 74, 75, 76).

This review contained two major limitations. The first and most obvious limitation is that our data may be skewed due to the fact that trends in maternal mortality have changed over time, with the CDC citing a four-year high in 2021 (77). The second limitation was that, due to the cast of this review, it is debatable whether or not the findings can be generalized to all pregnancy-complicated cardiovascular ailments. Further research on more cardiovascular diseases that coincide with pregnancy may shed light onto the antecedent assertion.

Section V (Limitations)

Section V (Conclusion)

The lack of suitable alternatives for managing cardiovascular issues during pregnancy, an indeterminate correlation between adverse mental health and termination, and the inherent avertible nature of maternal mortality in many cases underscore the necessity of abortion as a viable option for all pregnant individuals. This systematic review not only showcases the imperative for legal protections surrounding abortions, particularly concerning mental health characteristics but also highlights the need to dispel stereotypes and stigma over this contentious issue and make informed decisions. It is important, however, to acknowledge the limitations of this review, such as the uncertainty of being able to apply our findings to all cardiovascular issues during pregnancy and the possibility of our data being skewed due to changing maternal mortality rates over time. We recommend that future research focuses on a wider range of cardiovascular diseases.

Works Cited

[2]Adam, K. (2017). Pregnancy in women with cardiovascular diseases. *Methodist DeBakey Cardiovascular Journal*, *13*(4), 209. https://doi.org/10.14797/mdcj-13-4-209

[12]Afify, H., Kong, A., Bernal, J., & Elgendy, I. Y. (2022). Pulmonary hypertension in pregnancy: Challenges and solutions. *Integrated Blood Pressure Control*, *Volume 15*, 33-41. https://doi.org/10.2147/ibpc.s242242

[42, 43] Anant Agrawal, & Sanket Saraiya. (2022). Peripartum Cardiomyopathy. *Parul University Journal of Health Sciences and Research*, *1*(1), 52–60. Retrieved from https://pujhsr.paruluniversity.ac.in/index.php/home/article/view/1

[33]Annamaraju, P., & Baradhi, K. M. (n.d.). *Pentoxifylline*. StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK559096/

[59]Awaludin, A., Rahayu, C., Daud, N. A. A., & Zakiyah, N. (2022). Antihypertensive medications for severe hypertension in pregnancy: A systematic review and meta-analysis. *Healthcare*, *10*(2), 325. https://doi.org/10.3390/healthcare10020325

[16]Bolte, A. C., van Geijn, H. P., & Dekker, G. A. (2001). Management and monitoring of severe preeclampsia. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *96*(1), 8-20. https://doi.org/10.1016/s0301-2115(00)00383-3

Brar, S. S., Khan, S. S., Sandhu, G. K., Jorgensen, M. B., Parikh, N., Hsu, J.-W. Y., & Shen, A. Y.-J. (2007). Incidence, mortality, and racial differences in peripartum cardiomyopathy. *The American Journal of Cardiology*, *100*(2), 302-304. https://doi.org/10.1016/j.amjcard.2007.02.092

[17]Brosens, I., Brosens, J. J., Muter, J., Puttemans, P., & Benagiano, G. (2019). Preeclampsia: The role of persistent endothelial cells in uteroplacental arteries. *American Journal of Obstetrics and Gynecology*, *221*(3), 219-226. https://doi.org/10.1016/j.ajog.2019.01.239

[77]Center for Disease Control and Prevention. (2023, March 16). *Maternal mortality rates in the United States, 2021* (D. L. Hoyert, Author).

[69]Curiel-Balsera, E., Prieto-Palomino, M., Muñoz-Bono, J., Ruiz de Elvira, M., Galeas, J., & Quesada García, G. (2011). Analysis of maternal morbidity and mortality among patients admitted to obstetric intensive care with severe preeclampsia, eclampsia or HELLP syndrome. *Medicina Intensiva (English Edition)*, *35*(8), 478-483. https://doi.org/10.1016/j.medine.2011.11.005

Curry, R., Fletcher, C., Gelson, E., Gatzoulis, M., Woolnough, M., Richards, N., Swan, L., Steer, P., & Johnson, M. (2012). Pulmonary hypertension and pregnancy—a review of 12 pregnancies in nine women. *BJOG: An International Journal of Obstetrics & Gynaecology*, *119*(6), 752-761. https://doi.org/10.1111/j.1471-0528.2012.03295.x

cyanotic congenital heart defects. (n.d.). https://stanfordhealthcare.org/medical-conditions/blood-heart-circulation/congenital-heart-defects/types/cyanotic-congenital-heart-defects.html

[31]Desplantie, O., Tremblay-Gravel, M., Avram, R., Marquis-Gravel, G., Ducharme, A., & Jolicoeur, E. M. (2015). The medical treatment of new-onset peripartum cardiomyopathy:

A systematic review of prospective studies. *Canadian Journal of Cardiology*, *31*(12), 1421-1426. https://doi.org/10.1016/j.cjca.2015.04.029

Dolk, H., Loane, M., & Garne, E. (2011). Congenital heart defects in europe. *Circulation*, *123*(8), 841-849. https://doi.org/10.1161/circulationaha.110.958405

Duran, N., Günes, H., Duran, I., Biteker, M., & Özkan, M. (2008). Predictors of prognosis in patients with peripartum cardiomyopathy. *International Journal of Gynecology & Obstetrics*, *101*(2), 137-140. https://doi.org/10.1016/j.ijgo.2007.11.007

Elkayam, U. (2011). Clinical characteristics of peripartum cardiomyopathy in the United States: Diagnosis, prognosis, and management. *Journal of American College of Cardiology*, *58*(7), 659-670.

[40]Elkayam, U., Tummala, P. P., Rao, K., Akhter, M. W., Karaalp, I. S., Wani, O. R., Hameed, A., Gviazda, I., & Shotan, A. (2001). Maternal and fetal outcomes of subsequent pregnancies in women with peripartum cardiomyopathy. *New England Journal of Medicine*, *344*(21), 1567-1571. https://doi.org/10.1056/nejm200105243442101

[35]Ernst, M. E., & Fravel, M. A. (2022). Thiazide and the thiazide-like diuretics: Review of hydrochlorothiazide, chlorthalidone, and indapamide. *American Journal of Hypertension*, *35*(7), 573-586. https://doi.org/10.1093/ajh/hpac048

[4]*Facts about tetralogy of fallot*. (n.d.). https://www.cdc.gov/ncbddd/heartdefects/tetralogyoffallot.html

[71]Farber, H. W., Miller, D. P., Poms, A. D., Badesch, D. B., Frost, A. E., Rouzic, E. M.-L., Romero, A. J., Benton, W. W., Elliott, C. G., McGoon, M. D., & Benza, R. L. (2015). Five-Year outcomes of patients enrolled in the REVEAL registry. *Chest*, *148*(4), 1043-1054. https://doi.org/10.1378/chest.15-0300

[65]Fergusson, D. M., Horwood, L. J., & Boden, J. M. (2008). Abortion and mental health disorders: Evidence from a 30-year longitudinal study. *British Journal of Psychiatry*, *193*(6), 444-451. https://doi.org/10.1192/bjp.bp.108.056499

[68]Fergusson, D. M., John Horwood, L., & Ridder, E. M. (2005). Abortion in young women and subsequent mental health. *Journal of Child Psychology and Psychiatry*, *47*(1), 16-24. https://doi.org/10.1111/j.1469-7610.2005.01538.x

[14]Galiè, N., Humbert, M., Vachiery, J.-L., Gibbs, S., Lang, I., Torbicki, A., Simonneau, G., Peacock, A., Vonk Noordegraaf, A., Beghetti, M., Ghofrani, A., Gomez Sanchez, M. A., Hansmann, G., Klepetko, W., Lancellotti, P., Matucci, M., McDonagh, T., Pierard, L. A., Trindade, P. T., . . . Hoeper, M. (2015). 2015 esc/ers guidelines for the diagnosis and treatment of pulmonary hypertension. *European Heart Journal*, *37*(1), 67-119. https://doi.org/10.1093/eurheartj/ehv317

Ghulmiyyah, L., & Sibai, B. (2012). Maternal mortality from preeclampsia/eclampsia. *Seminars in Perinatology*, *36*(1), 56-59. https://doi.org/10.1053/j.semperi.2011.09.011

Greutmann, M., Tobler, D., Kovacs, A. H., Greutmann-Yantiri, M., Haile, S. R., Held, L., Ivanov, J., Williams, W. G., Oechslin, E. N., Silversides, C. K., & Colman, J. M. (2014).

Increasing mortality burden among adults with complex congenital heart disease. *Congenital Heart Disease*, *10*(2), 117-127. https://doi.org/10.1111/chd.12201

Hameed, A. B., Lawton, E. S., McCain, C. L., Morton, C. H., Mitchell, C., Main, E. K., & Foster, E. (2015). Pregnancy-related cardiovascular deaths in california: Beyond peripartum cardiomyopathy. *American Journal of Obstetrics and Gynecology*, *213*(3), 379.e1-379.e10. https://doi.org/10.1016/j.ajog.2015.05.008

[11, 44]Hoeper, M. M., McLaughlin, V. V., Dalaan, A. M. A., Satoh, T., & Galiè, N. (2016). Treatment of pulmonary hypertension. *The Lancet Respiratory Medicine*, *4*(4), 323-336. https://doi.org/10.1016/s2213-2600(15)00542-1

[32]Holt, R. I. G., Barnett, A. H., & Bailey, C. J. (2010). Bromocriptine: Old drug, new formulation and new indication. *Diabetes, Obesity and Metabolism*, *12*(12), 1048-1057. https://doi.org/10.1111/j.1463-1326.2010.01304.x

[36]Huang, X., Dorhout Mees, E., Vos, P., Hamza, S., & Braam, B. (2016). Everything we always wanted to know about furosemide but were afraid to ask. *American Journal of Physiology-Renal Physiology*, *310*(10), F958-F971. https://doi.org/10.1152/ajprenal.00476.2015

[47, 49]Jenkins, D. P., Madani, M., Mayer, E., Kerr, K., Kim, N., Klepetko, W., Morsolini, M., & Dartevelle, P. (2012). Surgical treatment of chronic thromboembolic pulmonary hypertension. *European Respiratory Journal*, *41*(3), 735-742. https://doi.org/10.1183/09031936.00058112

[48]Jenkins D. (2015). Pulmonary endarterectomy: the potentially curative treatment for patients with chronic thromboembolic pulmonary hypertension. *European respiratory review : an official journal of the European Respiratory Society*, *24*(136), 263–271. https://doi.org/10.1183/16000617.00000815

Jortveit, J., Øyen, N., Leirgul, E., Fomina, T., Tell, G. S., Vollset, S. E., Eskedal, L., Døhlen, G., Birkeland, S., & Holmstrøm, H. (2015). Trends in mortality of congenital heart defects. *Congenital Heart Disease*, *11*(2), 160-168. https://doi.org/10.1111/chd.12307

[18]Karrar, S. A., & Hong, P. L. (n.d.). *Preeclampsia*. StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK570611/

[51]Katz, S. D., Balidemaj, K., Homma, S., Wu, H., Wang, J., & Maybaum, S. (2000). Acute type 5 phosphodiesterase inhibition with sildenafil enhances flow-mediated vasodilation in patients with chronic heart failure. *Journal of the American College of Cardiology*, *36*(3), 845-851. https://doi.org/10.1016/s0735-1097(00)00790-7

[55, 57, 60]Kenny, L., English, F., & McCarthy, F. (2015). Risk factors and effective management of preeclampsia. *Integrated Blood Pressure Control*, 7. https://doi.org/10.2147/ibpc.s50641

Kerpen, K., Koutrolou-Sotiropoulou, P., Zhu, C., Yang, J., Lyon, J.-A., Lima, F. V., & Stergiopoulos, K. (2019). Disparities in death rates in women with peripartum cardiomyopathy between advanced and developing countries: A systematic review and meta-analysis. *Archives of Cardiovascular Diseases*, *112*(3), 187-198. https://doi.org/10.1016/j.acvd.2018.10.002

Khairy, P., Ionescu-Ittu, R., Mackie, A. S., Abrahamowicz, M., Pilote, L., & Marelli, A. J. (2010). Changing mortality in congenital heart disease. *Journal of American College of Cardiology*, *56*(14), 1149-1157.

Khusen, D. (2016). Factors influencing maternal mortality from severe preeclampsia and eclampsia. *Indonesian Journal of Obstetrics and Gynecology*. https://doi.org/10.32771/inajog.v36i2.293

[30, 34, 37, 41]Kim, M.-J., & Shin, M.-S. (2017). Practical management of peripartum cardiomyopathy. *The Korean Journal of Internal Medicine*, *32*(3), 393-403. https://doi.org/10.3904/kjim.2016.360

[10]Kimura, Y., Kato, T., Miyata, H., Sasaki, I., Minamino-Muta, E., Nagasawa, Y., Numao, S., Nagano, T., Higuchi, T., & Inoko, M. (2019). Factors associated with increased levels of brain natriuretic peptide and cardiac troponin I during the peripartum period. *PLOS ONE*, *14*(2), e0211982. https://doi.org/10.1371/journal.pone.0211982

Kolte, D., Lakshmanan, S., Jankowich, M. D., Brittain, E. L., Maron, B. A., & Choudhary, G. (2018). Mild pulmonary hypertension is associated with increased mortality: A systematic review and meta‑analysis. *Journal of the American Heart Association*, *7*(18). https://doi.org/10.1161/jaha.118.009729

[61, 62]Lambert, G., Brichant, J. F., Hartstein, G., Bonhomme, V., & Dewandre, P. Y. (2014). Preeclampsia: an update. *Acta anaesthesiologica Belgica*, *65*(4), 137–149.

[45]Lan, N., Massam, B., Kulkarni, S., & Lang, C. (2018). Pulmonary arterial hypertension: Pathophysiology and treatment. *Diseases*, *6*(2), 38. https://doi.org/10.3390/diseases6020038

Lopez, K. N., Morris, S. A., Sexson Tejtel, S. K., Espaillat, A., & Salemi, J. L. (2020). US mortality attributable to congenital heart disease across the lifespan from 1999 through 2017 exposes persistent racial/ethnic disparities. *Circulation*, *142*(12), 1132-1147. https://doi.org/10.1161/circulationaha.120.046822

Madden, B. (2009). Pulmonary hypertension and pregnancy. *International Journal of Obstetric Anesthesia*, *18*(2), 156-164. https://doi.org/10.1016/j.ijoa.2008.10.006

[64]Major, B., Appelbaum, M., Beckman, L., Dutton, M. A., Russo, N. F., & West, C. (2009). Abortion and mental health: Evaluating the evidence. *American Psychologist*, *64*(9), 863-890. https://doi.org/10.1037/a0017497

[66, 67, 72]Major, B., Cozzarelli, C., Cooper, M. L., Zubek, J., Richards, C., Wilhite, M., & Gramzow, R. H. (2000). Psychological responses of women after first-trimester abortion. *Archives of General Psychiatry*, *57*(8), 777. https://doi.org/10.1001/archpsyc.57.8.777

[1]Mehta, L. S., Warnes, C. A., Bradley, E., Burton, T., Economy, K., Mehran, R., Safdar, B., Sharma, G., Wood, M., Valente, A. M., & Volgman, A. S. (2020). Cardiovascular considerations in caring for pregnant patients: A scientific statement from the american heart association. *Circulation*, *141*(23). https://doi.org/10.1161/cir.0000000000000772

[29]Meijer, J. M. (2005). Pregnancy, fertility, and recurrence risk in corrected tetralogy of fallot. *Heart*, *91*(6), 801-805. https://doi.org/10.1136/hrt.2004.034108

[13, 15]Meng, M.-L., Landau, R., Viktorsdottir, O., Banayan, J., Grant, T., Bateman, B., Smiley, R., & Reitman, E. (2017). Pulmonary hypertension in pregnancy. *Obstetrics & Gynecology*, *129*(3), 511-520. https://doi.org/10.1097/aog.0000000000001896

Mielniczuk, L. M., Williams, K., Davis, D. R., Tang, A. S., Lemery, R., Green, M. S., Gollob, M. H., Haddad, H., & Birnie, D. H. (2006). Frequency of peripartum cardiomyopathy. *The American Journal of Cardiology*, *97*(12), 1765-1768. https://doi.org/10.1016/j.amjcard.2006.01.039

[63]Mohamedain, A., Rayis, D. A., AlHabardi, N., & Adam, I. (2022). Association between previous spontaneous abortion and preeclampsia: A case–control study. *BMC Pregnancy and Childbirth*, *22*(1). https://doi.org/10.1186/s12884-022-05053-8

[50]Moraes, D. L., Colucci, W. S., & Givertz, M. M. (2000). Secondary pulmonary hypertension in chronic heart failure. *Circulation*, *102*(14), 1718-1723. https://doi.org/10.1161/01.cir.102.14.1718

[3]Moreno-Ruiz, N., Borgatta, L., Yanow, S., Kapp, N., Wiebe, E., & Winikoff, B. (2007). Alternatives to mifepristone for early medical abortion. *International Journal of Gynecology & Obstetrics*, *96*(3), 212-218. https://doi.org/10.1016/j.ijgo.2006.09.009

Naidu, P., Grigg, L., & Zentner, D. (2017). Mortality in adults with congenital heart disease. *International Journal of Cardiology*, *245*, 125-130. https://doi.org/10.1016/j.ijcard.2017.05.132

Pauli, J. M., & Repke, J. T. (2015). Preeclampsia. *Obstetrics and Gynecology Clinics of North America*, *42*(2), 299-313. https://doi.org/10.1016/j.ogc.2015.01.007

[9]*Peripartum cardiomyopathy*. (n.d.). https://www.pennmedicine.org/for-patients-and-visitors/patient-information/conditions-treated-a-to-z/peripartum-cardiomyopathy

[54]Pieper, P. G., Lameijer, H., & Hoendermis, E. S. (2014). Pregnancy and pulmonary hypertension. *Best Practice & Research Clinical Obstetrics & Gynaecology*, *28*(4), 579-591. https://doi.org/10.1016/j.bpobgyn.2014.03.003

[23]*Possible medical risks or complications of abortion*. (n.d.). https://health.alaska.gov/dph/wcfh/Pages/informedconsent/abortion/risks.aspx

[19]*Pre-eclampsia*. (n.d.). United Kingdom National Health Service. https://www.nhs.uk/conditions/pre-eclampsia/

[20]*Pregnancy - preeclampsia*. (2022, May 25). BetterHealth. https://www.betterhealth.vic.gov.au/health/healthyliving/pregnancy-preeclampsia

[73]Quinton, W. J., Major, B., & Richards, C. (2001). Adolescents and adjustment to abortion: Are minors at greater risk? *Psychology, Public Policy, and Law*, *7*(3), 491-514. https://doi.org/10.1037/1076-8971.7.3.491

[53]Regitz-Zagrosek, V., Roos-Hesselink, J. W., Bauersachs, J., Blomström-Lundqvist, C., Cífková, R., De Bonis, M., Iung, B., Johnson, M. R., Kintscher, U., Kranke, P., Lang, I. M., Morais, J., Pieper, P. G., Presbitero, P., Price, S., Rosano, G. M. C., Seeland, U., Simoncini, T., Swan, L., . . . De Backer, J. (2018). 2018 ESC guidelines for the

management of cardiovascular diseases during pregnancy. *European Heart Journal*, *39*(34), 3165-3241. https://doi.org/10.1093/eurheartj/ehy340

[56]Roberts, J. M., & Bell, M. J. (2013). If we know so much about preeclampsia, why haven't we cured the disease? *Journal of Reproductive Immunology*, *99*(1-2), 1-9. https://doi.org/10.1016/j.jri.2013.05.003

Saxena, N., Bava, A., & Nandanwar, Y. (2016). Maternal and perinatal outcome in severe preeclampsia and eclampsia. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, 2171-2176. https://doi.org/10.18203/2320-1770.ijrcog20162086

[74]Schmiege, S., & Russo, N. F. (2005). Depression and unwanted first pregnancy: Longitudinal cohort study. *BMJ*, *331*(7528), 1303. https://doi.org/10.1136/bmj.38623.532384.55

[46]Singh, H., Agarwal, L., Jani, C., Bhatt, P., Hartley, A., Shalhoub, J., Kurman, J. S., Omari, O. A., Ahmed, A., Marshall, D. C., & Salciccioli, J. D. (2023). Pulmonary hypertension associated mortality in the united states from 2003 to 2020: An observational analysis of time trends and disparities. *Journal of Thoracic Disease*, *15*(6), 3256-3272. https://doi.org/10.21037/jtd-22-1468

[38, 39]Sliwa, K., Hilfiker‑Kleiner, D., Petrie, M. C., Mebazaa, A., Pieske, B., Buchmann, E., Regitz‑Zagrosek, V., Schaufelberger, M., Tavazzi, L., van Veldhuisen, D. J., Watkins, H., Shah, A. J., Seferovic, P. M., Elkayam, U., Pankuweit, S., Papp, Z., Mouquet, F., & McMurray, J. J. (2010). Current state of knowledge on aetiology, diagnosis, management, and therapy of peripartum cardiomyopathy: A position statement from the heart failure association of the european society of cardiology working group on peripartum cardiomyopathy. *European Journal of Heart Failure*, *12*(8), 767-778. https://doi.org/10.1093/eurjhf/hfq120

[76]Steinberg, J. R., & Russo, N. F. (2008). Abortion and anxiety: What's the relationship? *Social Science & Medicine*, *67*(2), 238-252. https://doi.org/10.1016/j.socscimed.2008.03.033

[75]Taft, A. J., & Watson, L. F. (2008). Depression and termination of pregnancy (induced abortion) in a national cohort of young australian women: The confounding effect of women's experience of violence. *BMC Public Health*, *8*(1). https://doi.org/10.1186/1471-2458-8-75

[5, 6, 7, 8, 24, 25, 26]Uebing, A., Steer, P. J., Yentis, S. M., & Gatzoulis, M. A. (2006). Pregnancy and congenital Heart disease. *BMJ (Clinical research ed.)*, *332*(7538), 401–406. https://doi.org/10.1136/bmj.332.7538.401

[27, 28]Uebing, A., Gatzoulis, M. A., Kaisenberg, C. von, Kramer, H.-H., & Strauss, A. (2008). Congenital heart disease in pregnancy. *Deutsches Ärzteblatt International*. https://doi.org/10.3238/arztebl.2008.0347

[52]Vachiéry, J.-L., Adir, Y., Barberà, J. A., Champion, H., Coghlan, J. G., Cottin, V., De Marco, T., Galiè, N., Ghio, S., Gibbs, J. S. R., Martinez, F., Semigran, M., Simonneau, G., Wells, A., & Seeger, W. (2013). Pulmonary hypertension due to left heart diseases. *Journal of the*

American College of Cardiology, 62(25), D100-D108. https://doi.org/10.1016/j.jacc.2013.10.033

Verheugt, C. L., Uiterwaal, C. S. P. M., van der Velde, E. T., Meijboom, F. J., Pieper, P. G., van Dijk, A. P. J., Vliegen, H. W., Grobbee, D. E., & Mulder, B. J. M. (2010). Mortality in adult congenital heart disease. *European Heart Journal, 31*(10), 1220-1229. https://doi.org/10.1093/eurheartj/ehq032

[58]Wagner, L., M.D. (n.d.). Diagnosis and management of preeclampsia. *American Family Physician*. https://www.aafp.org/pubs/afp/issues/2004/1215/p2317.html

[70]Yang, B. Q., Assad, T. R., O'Leary, J. M., Xu, M., Halliday, S. J., D'Amico, R. W., Farber‑Eger, E. H., Wells, Q. S., Hemnes, A. R., & Brittain, E. L. (2018). Racial differences in patients referred for right heart catheterization and risk of pulmonary hypertension. *Pulmonary Circulation, 8*(2), 1-9. https://doi.org/10.1177/2045894018764273

[22]Yannopoulos, D., Bartos, J. A., Aufderheide, T. P., Callaway, C. W., Deo, R., Garcia, S., Halperin, H. R., Kern, K. B., Kudenchuk, P. J., Neumar, R. W., & Raveendran, G. (2019). The evolving role of the cardiac catheterization laboratory in the management of patients with out-of-hospital cardiac arrest: A scientific statement from the american heart association. *Circulation, 139*(12). https://doi.org/10.1161/cir.0000000000000630

Zomer, A. C., Vaartjes, I., Uiterwaal, C. S., van der Velde, E. T., van den Merkhof, L. F., Baur, L. H., Ansink, T. J., Cozijnsen, L., Pieper, P. G., Meijboom, F. J., Grobbee, D. E., & Mulder, B. J. (2012). Circumstances of death in adult congenital heart disease. *International Journal of Cardiology, 154*(2), 168-172. https://doi.org/10.1016/j.ijcard.2010.09.015

Compressed LLMS are Effective Classifiers By Ryan Lung

Abstract

There have been massive strides in natural-language-processing in recent years, largely due to the widespread adoption of the self-attention mechanism in large language models (LLMs). However, this improvement in model output has come at the cost of a prohibitively large memory and computing demand for most devices. Specialized external computing hardware, such as GPUs and TPUS, are required to effectively run these models, which can cost from a few hundred dollars to tens of thousands (NVIDIA H100). These issues only compound when applied to a mobile device setting, where the hardware and storage issues become glaringly obvious. However, LLMs on mobile devices have a vast spread of applications, with an essential one being text classification. With the amount of time youth spend on social media, there is a wealth of potential red flags that could suggest declining mental health. A lightweight and accurate model is vital for detecting these users and getting them help. We fine-tune an emotion text-classification model using Google's BERT model. We find that we can retain much of the performance of BERT even after utilizing a combination of quantization and pruning, accurately classifying text with a fraction of the computational cost of the original model. With these steps toward improving efficiency of LLMS, it becomes easier to serve a large user base quickly while lowering costs.

Introduction

The number of emergency department visits related to mental health has been steadily rising throughout the United States, with the largest increasing trend found among adolescents.[1] American youths spend six to nine hours on media related activity, such as Instagram, Snapchat, etc. contributing to a wealth of potential red flags via online messages.[2] An easy-to-run, accurate model therefore becomes essential for detecting worrisome signs of declining mental health.

Accessibility is pressing when it comes to urgent issues like mental health struggles. 40% of all children will meet criteria for a mental health condition by the age of 18.[3] This urgency is even heightened by the surge in demand for mental health resources after COVID-19. Six in ten practitioners reported they no longer had any openings for new patients, and two-thirds of psychologists reported seeing an increase in the severity of symptoms among patients.[4] With the lack of availability from professional psychologists, supplemental resources for people who need help are crucial.

We aim to fine-tune and then compress BERT into an accurate emotion classification model that can be used for a variety of purposes, like an emotionally aware chatbot or detecting users that display signs of being at risk. The challenge is finding the maximal compression and pruning possible while minimizing loss of accuracy. To achieve this, we evaluate the performance of the quantization method GPTQ at different compression scales, along with the pruning method Wanda (Pruning with Weights and activations) at different pruning percentages.

With the rise of the transformer architecture, many natural language processing tasks such as text generation and classification of text have made massive strides. However, these powerful LLMs remain largely inaccessible to mobile users and casual PC users, where it is impractical to run models with billions of parameters locally with limited memory and computation. This remains a problem even when serving users through an API, allowing computation to be done from external servers with plenty of resources. When apps have thousands to millions of users, it becomes difficult to scale with expensive GPU clusters, and any improvements to efficiency and runtime are crucial. This research aims to address these issues by experimenting with different compression methods to shrink the footprint of large models to a fraction of their original size. These compression methods are quantization and pruning. Quantization is a technique that involves setting various model parameters to a lower bit-length. Pruning involves zeroing out certain weights, creating a model with sparser weights. Though this can reduce accuracy, it reduces memory, compute time, and storage space for parameters, letting these powerful models run faster.

GPTQ is a recent quantization method building on layer-wise quantization methods.[5] It builds on the Optimal Brain Quantizer framework from the "Optimal Brain Compression" paper.[6] It quantizes the BERT-Mini model in a matter of seconds using an RTX 3080 GPU. Wanda is a recent pruning method that builds on magnitude pruning, by simply accounting for the input activation along with the weight, calculating a combined score per each weight-input combination. It is also highly efficient and works with a single forward pass.[7] Notably, they also focus on having the pruning groups based on individual output nodes in contrast to per-layer or over the entire model. This means that the weights are only pruned in comparison to each other within the scope of each output node, versus over the entire layer or model.

Magnitude Pruning

Magnitude pruning is a method that simply removes the weights beneath a selected magnitude threshold in the model, completely ignoring the input activation.[8] Despite this flaw and the simplicity of the approach, it still has been used to create very sparse models at a surprisingly effective level and remains an important baseline.[8] There has not been much empirical evidence for why this method should be so effective.

Wanda

Previous research into pruning on LLMs has improved our understanding of these complex models, with Dettmers et. al discovering that LLMS with around six-billion parameters had certain input features that caused noticeable performance drops when zeroed out.[9] This is the inspiration for the Wanda method, where activations are also taken into account along with the weight, in order to not neglect these large values.[7] They give the compelling example that a weight may be small, but the input may be very large, which would give the small weight much more importance than a larger weight that may have a smaller combined output given a small input. They find that this pruning method notably improves autoregressive performance over magnitude pruning. It is also much simpler to implement than SparseGPT, a competitor pruning method with previous state-of-the-art performance, achieving similar scores across different

metrics. Interestingly, the authors find that the reduction of the SparseGPT pruning metric as seen in eq 2 leads to an extremely similar metric as the one used in Wanda, as seen in eq 1. The reduction of the SparseGPT pruning metric is merely the Wanda pruning metric squared.

$$\mathbf{S}_{ij} = |\mathbf{W}_{ij}| \cdot \|\mathbf{X}_j\|_2 \tag{1}$$

$$\text{GPTQ} \quad \mathbf{S}_{ij} \stackrel{\lambda=0}{=} \left[|\mathbf{W}|^2 / \text{diag}\left((\mathbf{X}^T\mathbf{X})^{-1} \right) \right]_{ij} \stackrel{\text{diagonal}}{\underset{\text{approx.}}{=}} \left[|\mathbf{W}|^2 / \left(\text{diag}(\mathbf{X}^T\mathbf{X}) \right)^{-1} \right]_{ij} = \left(|\mathbf{W}_{ij}| \cdot \|\mathbf{X}_j\|_2 \right)^2 \tag{2}$$

We utilize quantization via the "GPTQ" quantization method.[5] It builds on layer-wise quantization methods, specifically the Optimal Brain Quantizer (OBQ) method from the "Optimal Brain Compression" paper.[6] Layer-wise quantization involves individually quantizing each layer of a neural network as a group while adjusting the other unquantized weights within the layer to avoid losses in performance. They create an objective of minimizing the squared error of the quantized matrix of weights relative to the original weights. The OBQ method builds on this by separating the layer-wise quantization into a row-wise computation, after the observation that the squared error loss is equivalent to the sum of squared errors over each row of the weight matrices. Weights are quantized individually, where the weight with the least drop in performance is selected in greedy order. Every other unquantized weight in the row is then updated to offset the performance loss from the quantization. Per each row, using the inverse Hessian derived from the squared-error objective, they obtain formulas to find the greedy-optimal weight to quantize next along with the optimal update of all weights. To efficiently avoid recalculating the inverse Hessian completely at each step, they remove the row and column of the Hessian where the weight is quantized via one step of Gaussian elimination. They find speedups of 4x with only 1% accuracy loss on CPU inference.[6] However, OBQ's runtime scales cubically according to the input, making it incredibly expensive to scale to models with parameters in the billions.[7] OBQ takes 1 hour to fully quantize ResNet-50 with twenty-five million parameters on a single GPU.

However, with optimizations found in the GPTQ paper, they manage to achieve "more than three orders of magnitude computational speedup".[7] First, the GPTQ method ignores the greedy weight quantization order per each row in a layer. It instead picks the weight in each row using a fixed column order as seen in Figure 1, finding similar performance while speeding up the process by several orders of magnitude on larger models.[7] This is because the layer inputs are the same for all rows, which allows the inverse Hessian to be the same for all rows. This means that the inverse Hessian update must be calculated only once per column in the weights of a layer.

They also realize that there is still a memory-bottleneck that makes their improvements lackluster. They make the observation that future columns are irrelevant to the current column, as the final quantization rounding is on a per-column basis. This means they can then use a "lazy-batching" update to work on a block of only 128 columns at a time, keeping the updates constrained to those columns and their corresponding inverse Hessian block.[7] This behavior is

depicted in Figure 2. Once a full block has been processed, then the global update of the inverse Hessian and weight matrices take place. Even though this does not reduce the amount of compute, it brings an order of magnitude speedup in practical use.

Finally, they aim to avoid numerical inaccuracies, which they find are almost guaranteed on a few layers given a model with billions of parameters. When the inverse Hessian becomes indefinite, the authors find that the algorithm updates the unquantized weights in incorrect directions, leading to terrible quantization of a layer. Although for smaller models, using dampening (adding a small constant, 1% of the average diagonal value, to diagonal elements of the Hessian) seems to avoid this issue, larger models need a better approach. In order to solve this, the authors realize they can use a more "numerically-stable method" to precompute the inverse Hessian without largely increasing memory consumption.[7] They find that the row removal in OBQ is essentially a Cholesky decomposition, which is more robust and leads to an additional speedup with an optimized Cholesky kernel. Thus, the utilization of the Cholesky decomposition along with a dampening constant allows GPTQ to effectively quantize large models without issue.
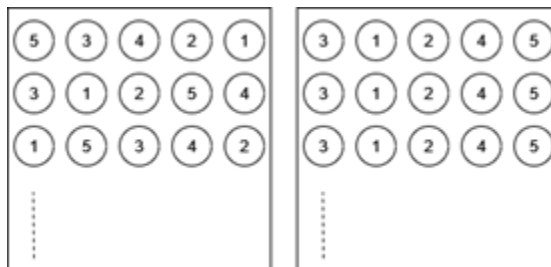
Figure 1: Left: the OBQ row-specific order quantization on a layer's weights. Each row has its own independent order based off the greedy-optimal weight to quantize. Right: the GPTQ column-wise order quantization on a layer's weights. The order of quantization in each row is the same. This significantly improves runtime.
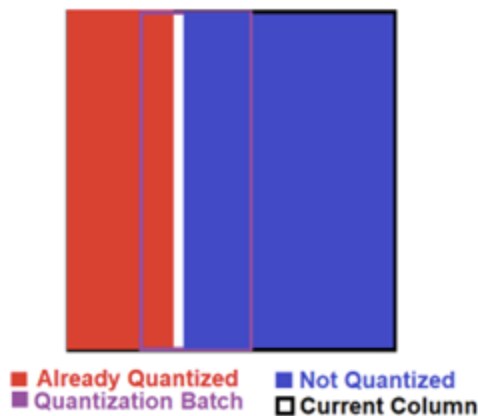
Figure 2: Utilizing lazy-batching, only a certain number of columns are being quantized at a time within a block, in order to improve the memory bottleneck.

Goal

Prior research has largely focused on either using quantization or pruning. We aim to use these two methods in conjunction for an even higher degree of compression, while still maintaining a high degree of accuracy. There has been work into deeper compression using a combination of methods.[10] However, it has been shown that these techniques, such as magnitude pruning, result in a massive loss of performance on LLMs, even at low sparsity levels.[11] We aim to see if these results hold true with a finetuned model. We use recent, highly performing methods to gauge the effectiveness of these compression methods on a benchmark or task that they were not tested on. Wanda and GPTQ have only tested their methods with autoregressive models, on text generation benchmarks. However, we finetune BERT to use it as a classification model instead. This aims to provide more insight into the behaviors and performance of compressed LLMs after finetuning them on a downstream task. Finetuned LLMs have a variety of uses in the text-classification domain, outside of emotion classification.

Methods

Dataset

The dataset is a series of labeled Twitter posts that displayed one of six emotions: sadness, happiness, love, anger, fear, or surprise.[13]

The dataset is made up of 20000 labeled examples total, pre-sorted with a 16000 training, 2000 test, and 2000 validation split. There are 4666 examples for sadness, 5362 examples for happiness, 1304 examples for love, 2159 examples for anger, 1937 examples for fear, and 572 examples for surprise in the training set. For the validation set, there are 550 examples for sadness, 704 examples for happiness, 178 examples for love, 275 examples for anger, 212 examples for fear, and 81 examples for surprise. In total, there are 5759 examples for sadness, 6761 examples for happiness, 1641 examples for love, 2709 examples for anger, 2373 examples for fear, and 719 examples for surprise.

The data is made up of tweets with the phrase "I feel _", categorizing the self-identified emotion and saving the complete message. This guarantees a high level of label accuracy, as the emotions are realized by the user themself. However, this could also mean an overreliance on the phrase for classification, causing performance to decrease drastically on user text where it is not present. Some labels are also on sentences where the emotion appears unclear, meaning there the parts of the training data may not be objective. A more varied, human-labeled dataset may improve model accuracy in practical application.

text	label
i feel that it is something that will never really be resolved	1 (happiness)
i am struggling to enjoy the things i used to love i go out and surround myself with people despite that all i really want to do is isolate myself from everyone and hide under the duvet i feel lonely and apathetic to almost everything	0 (sadness)

around me	
i feel threatened by people who actually learned stuff in college	4 (fear)

BERT Mini

A smaller BERT model trained by Google, with a hidden layer size of 256 and 4 encoder layer stacks.[14] We finetune the model with a learning rate of 2e-4 over 6 epochs on the dataset. Over learning rates from 1e-3 to 1e-5, we find the best model performance when fine-tuning with a learning rate of 2e-4.

GPTQ

An efficient one-shot quantization method that builds on the previous layer-wise Optimal-Brain Quantizer (OBQ) method. It achieves massive speedups over the OBQ method through various optimizations. First, the order within individual rows is ignored, and the entire column of weights is quantized in a set order. For practical implementation, they realize that this improvement does not effectively utilize the GPU because of a memory-bottleneck. They fix this through a lazy-batch update, where only a select number of columns are updated at a time. The final change they make is reformulating the row and column removal equation into a Cholesky decomposition, to avoid inaccuracies through an indefinite matrix.

Wanda

Short for "Weights and activations", a recent pruning method that is both simple to implement and efficient. Through a single forward pass, it computes a score for each weight using both the input activation and the magnitude of the weight for a metric. After all the scores then prunes every weight below a designated threshold percent. The pruning happens sequentially, where the next layer receives the inputs from the pruned layer before it. We use the C4 dataset as input to the model.

Results and Discussions

Visualizations

For all the representations, the final output logits of the 6-dimensional classifier are mapped to a 2-dimensional tensor using the t-SNE (t-distributed Stochastic Neighbor Embedding) method.[12] t-SNE is a nonlinear dimensionality reduction algorithm, which allows us to separate data that cannot be separated by a straight line. They use gradient descent on a KL Divergence criterion function to minimize the difference between the low level and original distributions, eventually returning an accurate low-dimension representation of the data. The points on the lower dimension view are then colored with the ground truth label from the dataset.
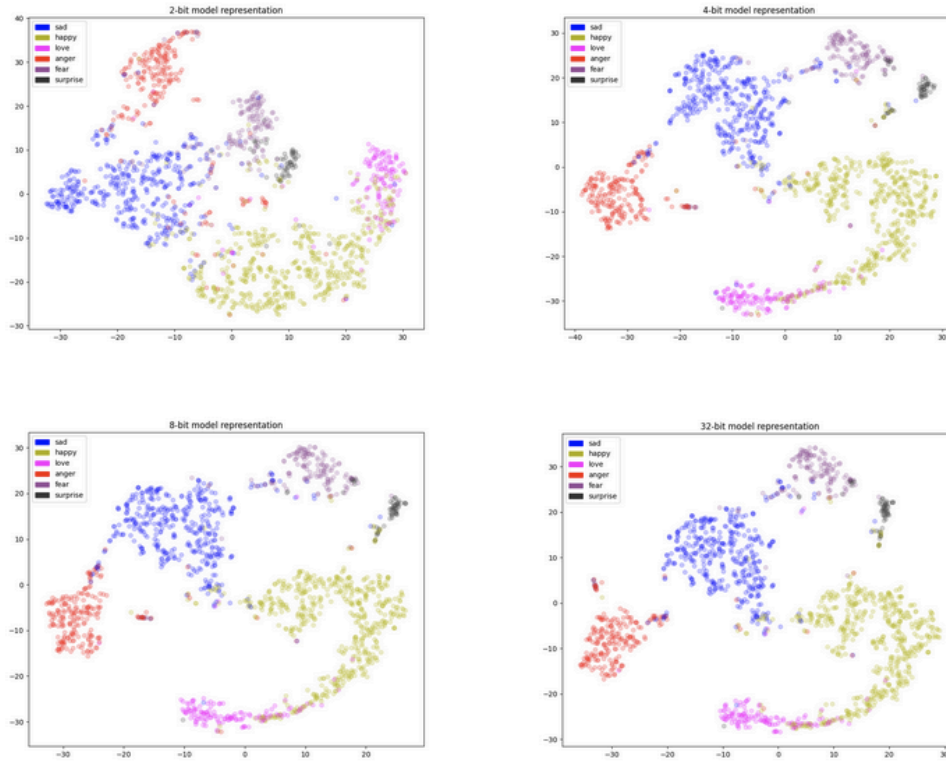
Figure 3: The classification layer output logits represented in two dimensions with t-SNE, colored with their ground truth label.

From Figure 3, it appears that even at 2-bit quantization, the model still manages to create a meaningful representation of the input data, splitting classes into distinct categories. Comparing the 2-bit and 4-bit model representations, the 2-bit representation appears sparser and more prone to making classification errors. We find that the 2-bit representation appears very different to the 4-bit, 8-bit, and 32-bit representations, suggesting that 4-bit quantization is the minimum quantization level that remains similar to the original model using GPTQ. It also possibly reflects the large loss of accuracy of the 2-bit model relative to the other quantized models.

Quantization and Pruning Accuracy
Quantization Only
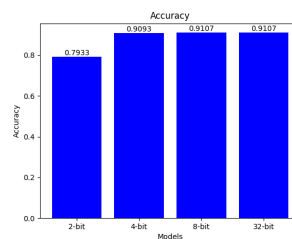
Figure 4: The accuracy of the models utilizing only quantization.

Magnitude Pruning
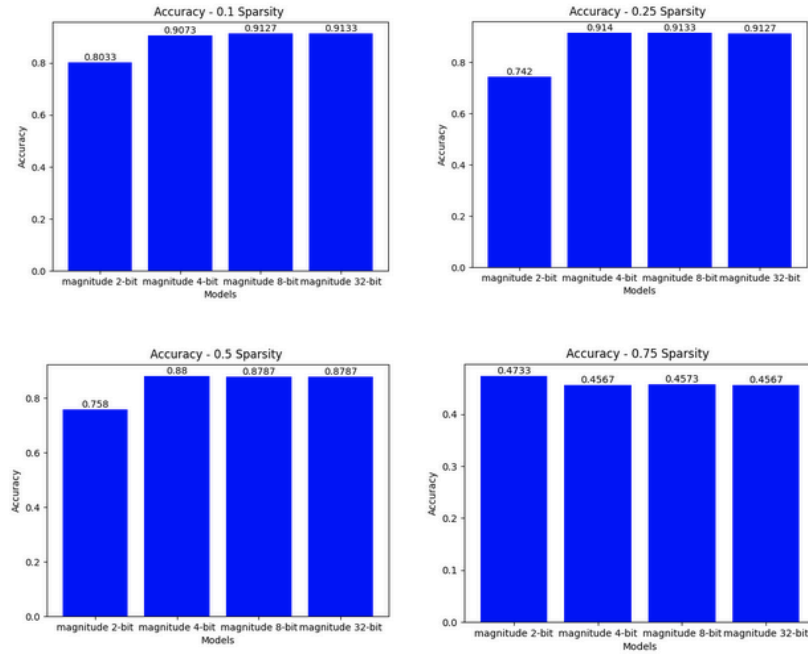
Figure 5: The accuracy of the quantized models using magnitude pruning before quantization, with 10%, 25%, 50% and 75% of the model's weights being pruned respectively.
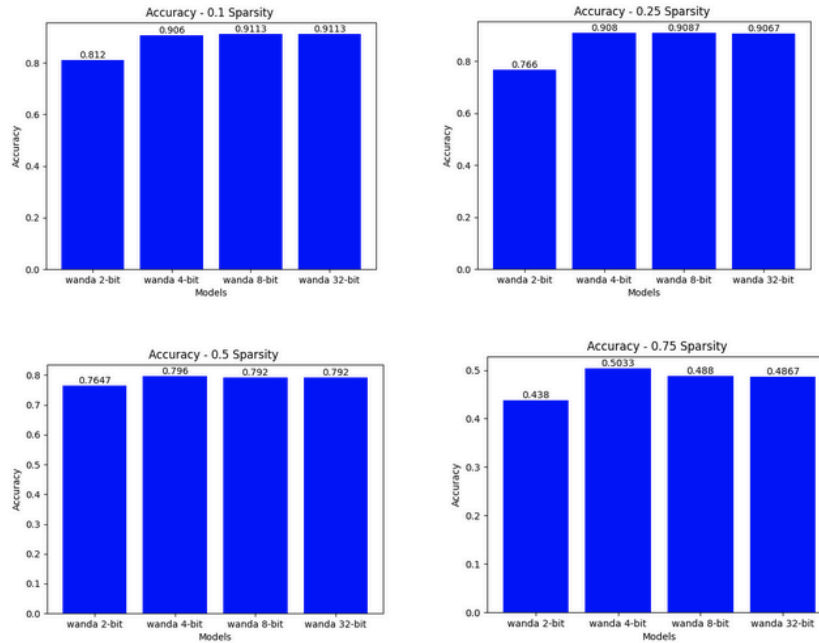
Wanda Pruning

Figure 6: The accuracy of the quantized models using Wanda pruning before quantization, with 10%, 25%, 50% and 75% of the model's weights being pruned respectively.

Wanda Pruning (variant)
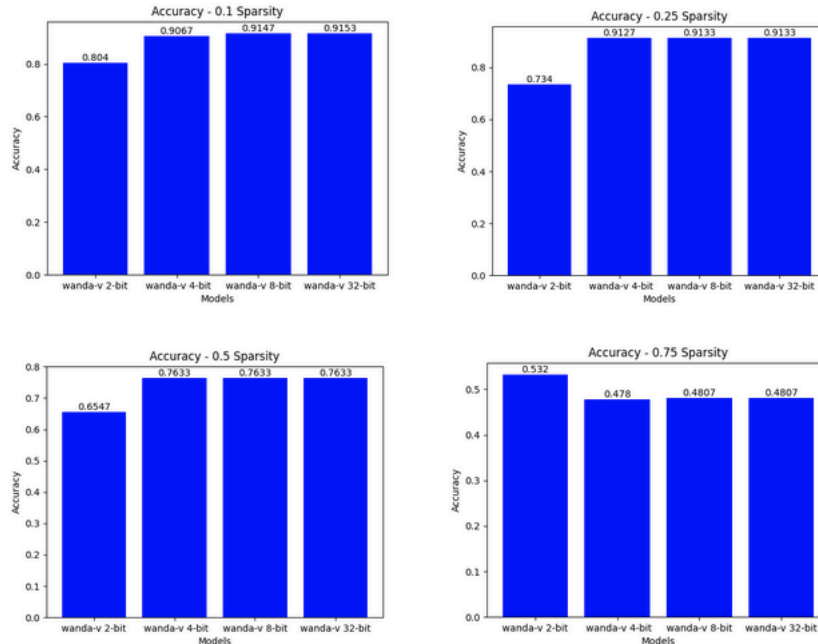
Figure 7: The accuracy of the quantized models using Wanda pruning with the variant before quantization, with 10%, 25%, 50% and 75% of the model's weights being pruned respectively.

Figure 4 supports the theory that 2-bit quantization greatly decreases the accuracy of the model. The 2-bit model suffers a massive drop in performance relative to the other quantized models. Meanwhile, the 4-bit, 8-bit, and 32-bit models remain very similar in performance, suggesting that even at 4-bit quantization, performance remains largely unaffected for classification.

These results suggest that Wanda pruning generally does not improve accuracy over the baseline magnitude pruning method at 0.1, 0.25, and 0.5 sparsity levels, as seen in Figure 5 and Figure 6. However, Wanda does outperform magnitude pruning at the 2-bit level most of the time and does better at 0.75 sparsity. Figure 7 shows that the Wanda variant method included in the authors' code outperforms Wanda at the 0.1 and 0.25 sparsity levels, even outperforming magnitude pruning at the 0.1 sparsity level, however it falls short at higher sparsity levels. Interestingly, despite achieving significantly better performance on autoregressive benchmarks compared to magnitude pruning, Wanda is not nearly as effective when a model is finetuned for classification. This could be due to how different the task of text generation is to classification. Metrics like perplexity and zero-shot evaluation (providing a model with a prompt and task in natural language and evaluating performance) may be more strict on the quality and readability of output. Classification models could be more robust and less dependent on individual weights than autoregressive models. In particular, magnitude pruning remains effective, retaining approximately 88% accuracy even at 0.5 sparsity and 4-bit quantization.

Runtimes
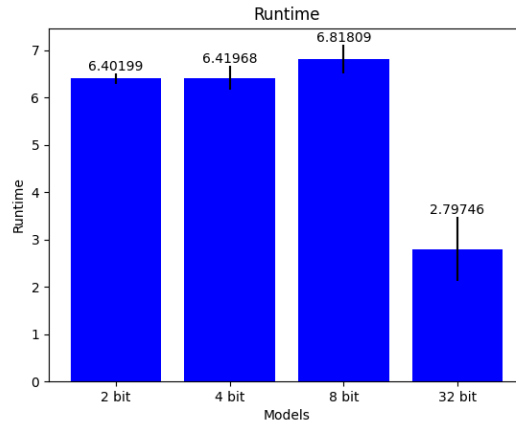
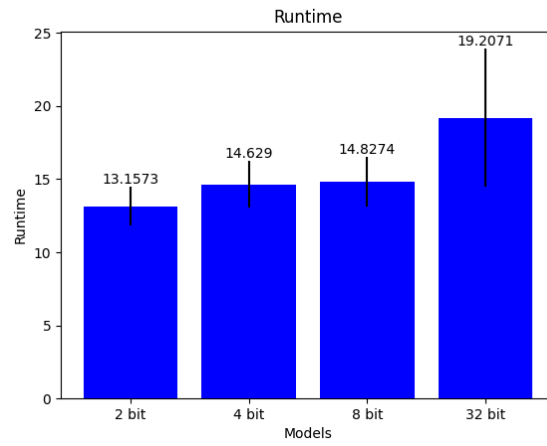Figure 8: The runtime of the quantized models given a batch size of 1.

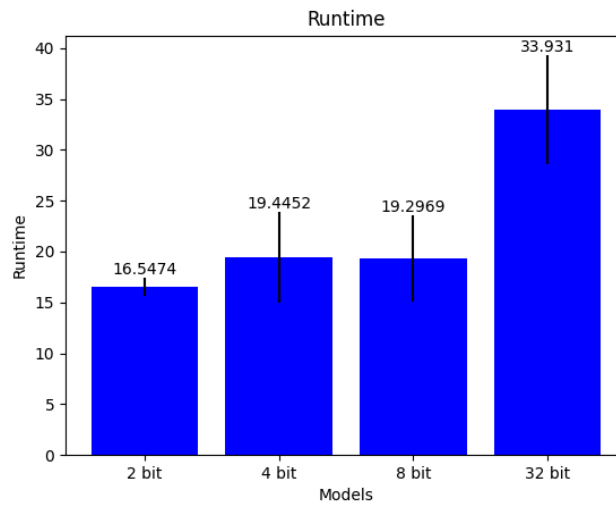Figure 9: The runtime of the quantized models given a batch size of 32

Figure 10: The runtime of the quantized models given a batch size of 64.

These runtimes have been averaged over 300 iterations and run on different batch sizes. Interestingly, although the 32-bit model outperforms the quantized model on a batch size of 1 as seen in Figure 8, on higher batch sizes it quickly begins to fall behind, as in Figure 9 and Figure 10. Therefore, when only working with single-batch data, it may be better to use the original model if computation cost is not of concern. However, the 4-bit and 8-bit models still show competitive accuracy at much lower runtimes.

Conclusion

From this work, it appears that even highly compressed, pruned LLMs remain effective at text classification tasks. We find that magnitude pruning, contrary to previous results, is a high-performing method on a fine tuned model, achieving only 3% loss of accuracy at 0.5 sparsity and 4-bit quantization. This drop in performance will likely be mitigated after additional training, as seen in the GPTQ paper. This suggests that language modeling may be a much more delicate task than classification, requiring careful pruning of weights, whereas the fine tuned model still maintains strong overall performance despite using magnitude pruning. It appears you can prune a sizable portion of weights and the performance will not suffer terribly with a classification model. The relative consistency of performance across extreme compression levels suggests that compression techniques on LLMs are still effective when fine-tuned for classification. In fact, these fine tuned models may be more robust to compression than their autoregressive counterparts.

The quantized BERT models accurately map different classes with clear and distinct representations. The model's errors are largely interpretable, with the classifying layer having a neatly ordered latent space. With these findings, it appears that these compressed models can run on mobile devices with few drawbacks. However, when it comes to single-batch inference, it may be better to use the full model. These findings encourage that quantized and pruned models should always be considered along with their larger counterparts when it comes to sequence classification tasks, especially with limited computing resources.

Works Cited

1. Bommersbach, T. J.; McKean, A. J.; Olfson, M.; Rhee, T. G. National Trends in Mental Health–Related Emergency Department Visits among Youth, 2011-2020. *JAMA* **2023**, *329* (17), 1469. https://doi.org/10.1001/jama.2023.4809.

2. Crone, E. A.; Konijn, E. A. Media Use and Brain Development during Adolescence. *Nature Communications* **2018**, *9* (1). https://doi.org/10.1038/s41467-018-03126-x.

3. Shim, R.; Szilagyi, M.; Perrin, J. M. Epidemic Rates of Child and Adolescent Mental Health Disorders Require an Urgent Response. *Pediatrics* **2022**, *149* (5). https://doi.org/10.1542/peds.2022-056611.

4. Bethune, S. *Increased need for mental health care strains capacity*. Apa.org. https://www.apa.org/news/press/releases/2022/11/mental-health-care-strains.

5. Frantar, E.; Ashkboos, S.; Hoefler, T.; Alistarh, D. *GPTQ: Accurate Post-Training Quantization for Generative Pre-trained Transformers*. arXiv.org. https://doi.org/10.48550/arXiv.2210.17323.

6. Frantar, E.; Singh, S. P.; Alistarh, D. *Optimal Brain Compression: A Framework for Accurate Post-Training Quantization and Pruning*. arXiv.org. https://doi.org/10.48550/arXiv.2208.11580.

7. Sun, M.; Liu, Z.; Bair, A.; Zico, K. J. A Simple and Effective Pruning Approach for Large Language Models. *arXiv (Cornell University)* **2023**. https://doi.org/10.48550/arxiv.2306.11695.

8. Gale, T.; Elsen, E.; Hooker, S. The State of Sparsity in Deep Neural Networks. *arXiv:1902.09574 [cs, stat]*

9. Dettmers, T.; Lewis, M.; Belkada, Y.; Zettlemoyer, L. *LLM.int8(): 8-bit Matrix Multiplication for Transformers at Scale*. arXiv.org. https://arxiv.org/abs/2208.07339 (accessed 2024-03-28).

10. Han, S.; Mao, H.; Dally, W. J. Deep Compression: Compressing Deep Neural Networks with Pruning, Trained Quantization and Huffman Coding. *arXiv:1510.00149 [cs]* **2016**.

11 Frantar, E.; Alistarh, D. Massive Language Models Can Be Accurately Pruned in One-Shot. *arXiv:2301.00774 [cs]* **2023**.

12 Com, L.; Hinton, G. Visualizing Data Using T-SNE Laurens van Der Maaten. *Journal of Machine Learning Research* **2008**, *9*, 2579–2605.

13 Saravia, E.; Liu, H.-C. T.; Huang, Y.-H.; Wu, J.; Chen, Y.-S. *CARER: Contextualized Affect Representations for Emotion Recognition*. ACLWeb. https://doi.org/10.18653/v1/D18-1404.

14 Devlin, J.; Chang, M.-W.; Lee, K.; Toutanova, K. *BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding*. arXiv.org. https://arxiv.org/abs/1810.04805.

CyberSecurity in IoT Devices - A Literature Review By Nayan P Raj

Abstract : The Internet of Things (IoT) has transformed the way we interact with the physical world, enabling seamless connectivity and automation across various domains. However, this proliferation of interconnected devices has also introduced unprecedented cybersecurity challenges. This research paper presents a comprehensive literature review about what IoT is, its uses and cybersecurity concerns.

Key Words : **Internet of Things (IoT), IoT Devices, Cybersecurity**

Firstly, what is meant by Internet of Things? According to Amazon Web Services, the term IoT, which stands for Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves. A slightly more in-detail definition might be that Internet of Things is a term used to describe devices with sensors, processing ability, software and other technologies that enable the device to connect and exchange data with other devices and systems over the Internet or other communication networks, with little human intervention, taken from Wikipedia. Basically, it is any piece of technology that helps in communication between devices and the cloud, making life easier for humanity. However, the term Internet of Things (IoT) often misguides people to think that the devices and systems that come under this category must be connected to the public internet; they only need to be connected to a network and individually addressable. Therefore, the term has been considered a misnomer. The Internet of Things integrates the fields of electronics, communication and computer science engineering.

The term 'Internet of Things (IoT)' was coined in 1999, by computer scientist Kevin Ashton. However, the first ever 'IoT device', a toaster which could be controlled over the internet, was invented in 1990 by John Romkey. Now, the term 'Internet of Things (IoT)' is used to encompass a broad category of devices that we use daily, from laptops and mobile phones to the popular smart-home assistants such as Amazon Echo, Apple HomePod and Google Home. The development of all these devices to help us has come with its pros and cons. The pros include a wider network of connectivity, ease with which many activities are completed (examples being paying bills online, shopping online,etc.) and much more. However, these advantages are accompanied by the cons of IoT devices. Location tracking (stalking), cyberattacks, hacking, etc. are some of the many cons of IoT devices. Therefore, we have to use the technology available to us, to the fullest, being fully aware of how the same technology is being exploited to retrieve information unethically and to breach cybersecurity., cousin unrest in the world. Cybersecurity, according to Amazon Web Services, is the protection of internet-connected systems such as hardware, software and data from cyberthreats. The practice is used by individuals and enterprises to protect against unauthorized access to data centers and other computerized systems.
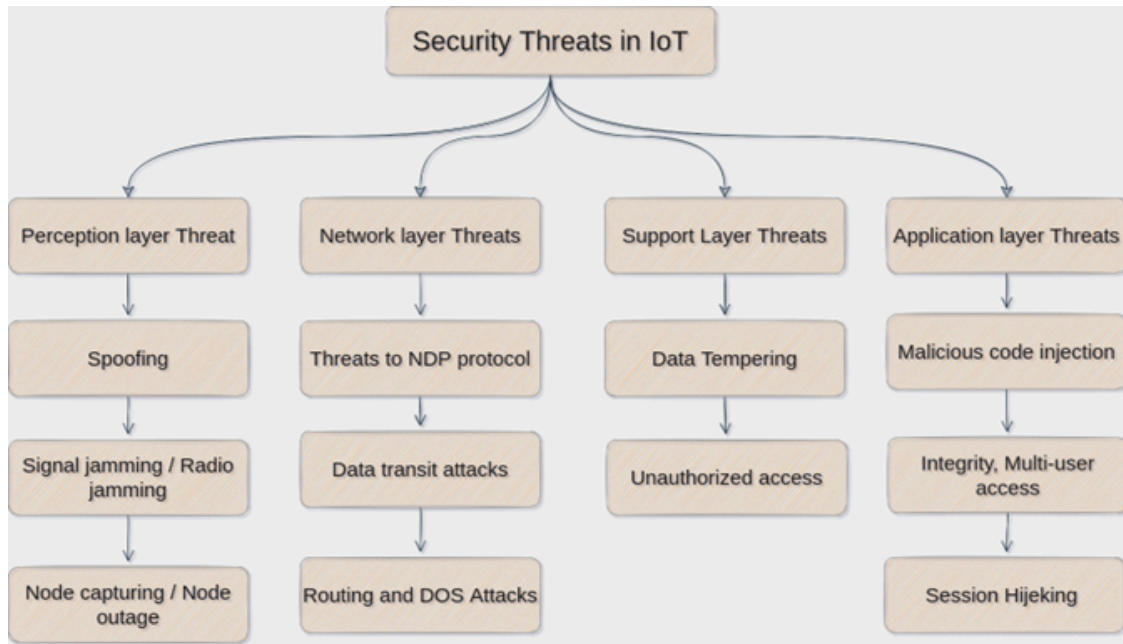
Image has been taken from www.google.com.

Some common IoT cyber attacks include, but are not limited to, password cracking, Device Spoofing, Distributed denial of Service (DDoS) attacks and Man-in-the-Middle (MitM) attacks. Although IoT devices have potential in various fields, they are not being used for fear of security. One such field where IoT devices have potential for development is the medical field. Implantable pacemakers come under the banner of IoT devices. In 2017, the FDA announced that they had discovered a serious vulnerability in implantable pacemakers made by St. Jude Medical. The in-built transmitter was found to be the vulnerability in the pacemakers. Once attackers gained access to the pacemaker's transmitter, they were able to alter its functioning, deplete the battery, and even administer potentially fatal shocks. This incident made people research further into the disadvantages of IoT devices and prevent any such incidents of hacking pacemakers. Dubbed as the largest DDoS attack ever to take place, The Mirai Botnet hack took place in October 2016. The attack targeted a DNS service provider Dyn, using a botnet(A botnet is a group of Internet-connected devices, each of which runs one or more bots) of IoT devices. Once the botnet successfully infected a vulnerable IoT gadget, it automatically searched the internet for other vulnerable devices. Whenever it found one, the malware used the default name and password to login into the device, install itself, and repeat the process. This attack demonstrated the significance of creating strong and complex passwords for devices before adding them to the network. Other incidents of IoT cybersecurity breach include The TRENDnet Webcam Hack, which taught us not to take security for granted and to install a VPN on home routers, and The Owlet Wi-Fi Baby Heart Monitor incident , from which we understood that one unprotected or underprotected device can make the entire house vulnerable.

Ease of device hacking has various factors, from weak passwords and unsecured cloud storage to lack of encryption and physically tampering with the device. The different kinds of IoT cybersecurity risks include weak authentication, low processing power, gaps between mobile networks, legacy assets and various others.

In this paper, we will look at the existing literature on the topic of Internet of Things (IoT) devices and cybersecurity, in relation to them. Now we will consider some previous literature on similar topics as this paper (CyberSecurity in IoT Devices). The papers mentioned here have been referenced at the end of this paper with its title, access link and date of publishing.

1. <u>CyberSecurity: A Review of Internet of Things (IoT) Security Issues, Challenges and Techniques :</u> This paper analyzes previous works in the field of IoT cybersecurity, quoting contributions of some researchers, specifying them by name, from the perspective and understanding of the topic in 2019. The paper uses tables and images to explain information about the IoT model and the threats to each layer of IoT. Visual representation of the information, in the forms of bar graphs, flowcharts and lists, enhance the reader's understanding of the topic. This paper gives some techniques to overcome security threats, highlighting the contribution of recent researchers in the field to share the liability of knowledge. Blockchain has been considered as a possible solution to the issues of cybersecurity of IoT devices.

2. <u>Internet of Things (IoT) Cybersecurity Research: A Review of Current Research Topics :</u> This paper conducts an extensive literature review by exploring relevant articles from five major academic databases to understand and clarify the status and the potential research directions regarding the issues of cybersecurity in IoT. This review identifies cybersecurity countermeasures and the techniques of IoT that have been employed in diversified industries and highlights the challenges and opportunities for interested researchers and practitioners. The paper states that a new methodology of IoT cybersecurity has to be developed to meet the security, reliability and privacy requirements of the devices. This paper also uses tables and flowcharts to illustrate the point being made in the various sections.The conclusion talks about the resourcefulness of IoT for humans today and the status of cybersecurity with respect to IoT devices in 2018 and the scope for future development. The paper ends with the proposal of "a possible four-layer cybersecurity infrastructure."

3. <u>Role of Artificial Intelligence in the Internet of Things (IOT) Cybersecurity :</u> This review paper compiles information from several other surveys and research papers regarding IoT, AI, and attacks with and against AI and explores the relationship between these three topics with the purpose of comprehensively presenting and summarizing relevant literature in these fields. It discusses the contributions and uses of AI in cybersecurity and

then looks into certain types of IoT Cyberattacks, including botnet, physical attacks,Man-in-the-Middle attacks and Denial of Service attacks,etc, from understanding of AI and its contributions to this field, developed in 2021. Once again, a table has been used to summarize the different types of IoT attacks and the methods of protecting devices from the same. Facts and figures from the analyzed and referenced works are seen in the first few paragraphs. Flow charts have been used to show the connectivity of the system to the cloud, etc.

4. Cyber security — IoT : The primary focus of this research work, published in May 2017, is to secure IoT solutions from device cloning attacks and sensitive data exposure. The paper mainly deals with explaining the structure of IoT devices and how they function. This paper is once again a review of previous works surrounding the same or similar topics. Images in this paper show structures such as system architecture and a flow chart showing the authentication process. Plausible solutions to device cloning attacks and sensitive data exposure have been identified, in this paper.

5. The Internet of Things cybersecurity examination : This paper presents the results of an IoT examination from the cybersecurity point of view. This paper, published in April 2017, happens to be the oldest paper referenced in this literature review. The paper is split into different sections. The first section describes the potential cybersecurity threats to IoT devices . The second talks about the tools used to perform the investigation. The third section provides some statistical data in the form of pie charts, tables and an interesting figure of the world map with the rate of IoT devices listening on port 23. The results of the investigation show how future IoT cyberattacks could be launched from DVRs,routers and IP cameras.

6. A Comprehensive Study of the IoT Cybersecurity in Smart Cities : This paper reviews previous works on cyberattacks on smart cities, based on understanding from 2020. It starts by introducing IoT as a crucial component for the development of smart cities. The paper's introduction includes the uses of IoT in cities and how there has been an increase in the number and uses of IoT devices in recent years. The paper also includes a list of different types of cyberattacks in smart cities. It talks about the effects cyberattacks could have on smart cities and possible measures that can be taken to prevent such attacks in the future.

7. A Critical Cybersecurity Analysis and Future Research Directions for the Internet of Things: A Comprehensive Review : This paper, published in 2023, is one of the latest papers referenced in this literature review. It discovers a path to safety of IoT devices against cyberattacks with the use of Artificial Intelligence(AI) and Machine Learning (ML), looking into the risk factors. The introduction of this paper talks about what IoT is and its development, followed by the consequences of IoT attacks, should any occur. This

paper has multiple flow charts and tables with IoT architecture, structure of the systems and information with regard to wireless IoT systems. It also contains a table that stands out : one that gives information on the "Threats to Security of IoT Devices." The paper also briefly looks into past literature, which suggests IoT security of various tiers. The conclusion of the paper states that there is a positive correlation between the development of IoT and the associated security risks.

8. <u>A Modern Analysis of Aging Machine Learning Based IoT Cybersecurity Methods :</u> The paper talks about three security algorithms that are used in 2021 (RF,KNN & SVM) and how these are used and must be developed with new data to be able to prevent cyber attacks. The paper further analyzes the effectiveness of RFs, SVMs, and KNNs forIoT cybersecurity against modern datasets.In Section II of the Paper, the author of this paper references papers on similar topics, summarizes and,sometimes, elaborates on what is written in that paper. Section 3 discusses,in detail, the dataset and algorithms we use in this article. Multiple tables with dataset and information used in the course of this testing have been displayed. Graphs with accuracy rates are also displayed.This study found the RF algorithm to be the best performing. It boasts high accuracy in intrusion and malware detection. SVM was found to work more optimally with the RBF kernel. KNN was found to be the second-best performing algorithm, accuracies of which were within 3% of those of the RF algorithm.

9. <u>Internet of Things (IoT) Cybersecurity: Literature Review and IoT Cyber Risk Management :</u> This paper, published in 2020, reviews the IoT cybersecurity technologies and presents a four-layer IoT cyber risk management network, which includes IoT cyber ecosystem layer, the IoT cyber infrastructure layer, the IoT cyber risk assessment layer, and the IoT cyber performance layer.The paper also explains the above mentioned structure and its components in detail. The visual representation in this paper includes information about the four-layer network, an example risk matrix and IoT cybersecurity cost benefit analysis, among others. This paper concludes that the technology of IoT has developed and is a crucial part in various sectors of the world. It goes on to state that absence of a cyber cyber risk management framework makes it difficult for organizations to make effective decisions on the topic of IoT cybersecurity. It states that this study fills a gap in the IoT cybersecurity risk management and intends to promote further interest for anyone who is interested in the IoT cybersecurity risk management.

10. <u>Analyzing IOT users' mobile device privacy concerns: Extracting privacy permissions using a disclosure experiment :</u> This paper, which was published in 2020, was taken from a science journal. In this paper, a disclosure experiment that captured the user's actual disclosure behavior was executed, using the enhanced APCO model. The authors have provided visual representations of the research model and varying levels of IoT exposure.

Representation of the result of the model with a full dataset as well as tables with statistics are also part of the paper. The paper concludes by stating that as the number of IoT devices increases, the importance of educating the consumers about their sharing of knowledge, unintentionally. Educational effort must include visual representation of how "data is collected and controlled in addition to the inherent risks in sharing personal information across devices and networks."

All the above mentioned papers have similarities and differences. While some papers are literature reviews, just like this one, that helped me broaden my understanding of Internet of Things (IoT) and its cybersecurity, others are papers that detail experiments or findings that could possibly help future developers achieve their goal of improving cybersecurity for IoT devices. Most of the papers reference previous literature surrounding the same or similar topics. Some differences I noticed in the papers was that multiple solutions were suggested instead of just a single solution, that would be effective in all cases. Having read all the above papers, I believe that Blockchain technology is probably the most effective solution to combat cyberattacks. More research is required to confirm that Blockchain is the best solution to IoT cybersecurity. My future work could include a more detailed analysis of how the Blockchain technology can be used in IoT devices for its ensured cybersecurity.

Image has been taken https://www.mdpi.com/2076-3417/13/13/7432
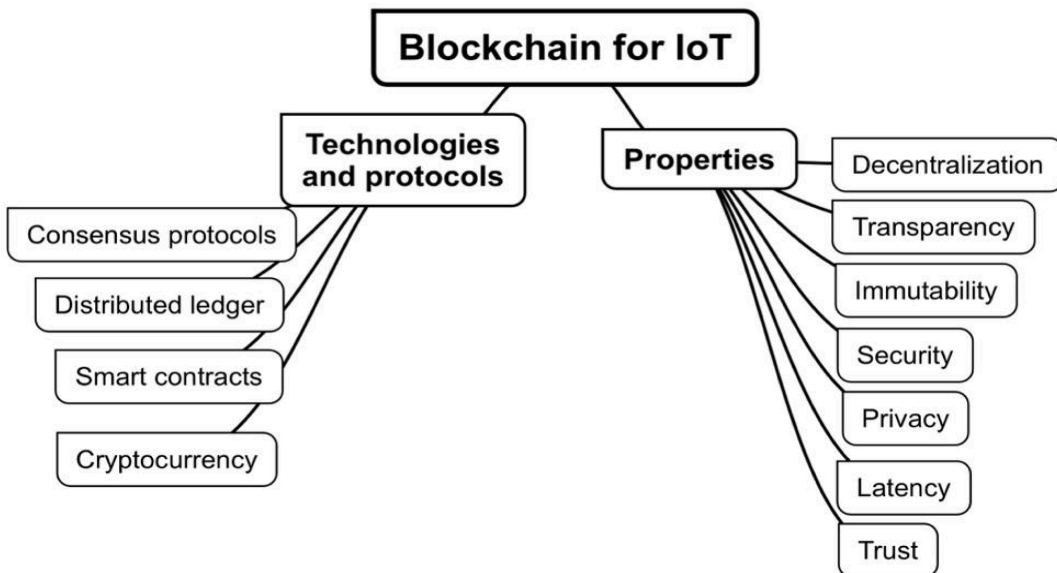
Works Cited

[1] Abdullah, Aishah, et al. "CyberSecurity: A Review of Internet of Things (IoT) Security Issues, Challenges and Techniques." *2019 IEEE.*

[2] Lu, Yang, and Li Da Xu. "Internet of Things (IoT) Cybersecurity Research: A Review of Current Research Topics." *2019 IEEE.*

[3] Kuzlu, Murat, et al. "Role of Artificial Intelligence in the Internet of Things (IoT) Cybersecurity." *2021 Springer Link.*

[4] Naik, Swapnil, and Vikas Maral. "Cybersecurity - IoT." *2017 IEEE.*

[5] Prokofiev, Anton O., et al. "The Internet of Things cybersecurity examination." *2017 IEEE.*

[6] Andrade, Roberto Omar, et al. "A Comprehensive Study of the IoT Cybersecurity in Smart Cities." *2020 IEEE.*

[7] Tariq, Usman, et al. "A Critical Cybersecurity Analysis and Future Research Directions for the Internet of Things: A Comprehensive Review." *2023 Sensors.*

[8] Strecker, Sam, et al. "A Modern Analysis of Aging Machine Learning Based IoT Cybersecurity Methods."

[9] Lee, In. "Internet of Things (IoT) Cybersecurity: Literature Review and IoT Cyber Risk Management." *2020 Future Internet.*

[10] Menard, Philip, and Gregory J. Bott. "Analyzing IOT users' mobile device privacy concerns: Extracting privacy permissions using a disclosure experiment." *2020 ScienceDirect.*

Finding the Recognition in the Xenophobia World: Mental Health Challenges of Asian Immigrants in Dilemma By Zhuoer (Zoey) Chen

Discrimination, alienation, and hate crimes have plagued Asian Americans for generations. During the pandemic, President Trump and his supporters used racist political language to blame COVID-19 on Asian groups, triggering xenophobia that rapidly swept across America. In 2020, hate crimes against Asian Americans grew by nearly 150 percent, leading to almost 4000 cases (Kimmy 2018). The journey of immigrants is often intertwined with courage and dreams. However, underneath tensions follow right after, particularly in mental health. From my own perspective, I sometimes felt unconfident due to the deep-rooted historical stereotypes and contemporary challenges faced by Asian Americans. Many Asian Americans like myself wonder what reasons cause people to have unfriendly attitudes and even hostilities toward Asian American groups, exposing us to vulnerability.

As I delve into the depths of American history, I can discover Asian Americans, especially first-generation immigrants, have faced many challenges. Anti-Asian discrimination snowballed after the Japanese government attacked Pearl Harbor in 1940. The U.S. government was furious and turned to Japanese American civilians as scapegoats. As a result, 20,000 Japanese Americans were forced to leave their homes for internment camps, carrying only what they could hold. They lived inside barbed-wire fences and beneath guard towers. They lost their freedom and most of their belongings, and their sole alleged "crime" was a simple one: their ancestors were Japanese, which stands as a reminder of the dilemma of dual identity faced by Asian communities. In the internment, the names of Japanese Americans were no longer important. Instead, each family received a five-digit number to be worn as a tag around their necks, which became who they were. All Japanese American citizens, including the first-generation immigrant, the *Issei*, or even their children, the *Nisei*, who were too little to understand what was going on, have to go to the Interment as well for many years without any other choices. The photographer Getty then states, "Even the offspring who never experienced the camp—the third generation, the fourth generation—it's an ongoing trauma" (Getty 2022). This sense of depravement and insecurity is almost ingrained in their DNA, passing from generation to generation, causing the Asian community to feel detached from the main American society since they were treated as foreigners by their fellow Americans.

These scars reveal a painful truth to Japanese Americans: from the perspective of the world, you are American, but from the perspective of the US government, you don't belong to our community. A study of Japanese Americans' political participation found that Japanese Americans who were interned were significantly less likely to report interest in politics, even two decades after World War II, than those who were not interned and had no family members who were interned (Ratner 2020). Additionally, this historical trauma has passed through generations, contributing to a collective memory that shapes the mental health of Asian immigrants. Asians feel that their cultural identity is threatened, leading to identity confusions and conflicts. Furthermore, they could feel marginalized and isolated in the face of exclusion and discrimination, which increases their risk of feeling lonely and socially abandoned.

Therefore, immigrant people will struggle to find a sense of belonging, leading to mental health issues. This dilemma really made me think about immigrant identity and belonging, evocating my own experience last summer. I flew alone from Boston to New York to visit my sister. The Uber driver was very talkative, and we had an ongoing conversation. He looked at me from the rear mirror, suddenly switched topics and asked me, "Where are you coming from?" I said, "I'm from Boston." He paused for a few seconds and asked again, "No, I'm asking where are YOU from, not where are you flying from?" I quickly realized he was asking about my hometown and replied, "Oh, I am from China." Later, when I went home, I recalled this scenario. Yes, I was indeed from China, but why did he question that I was not from Boston in the first place and judge me solely on my appearance and race? Can an Asian person not be from Boston? In my case, I am from China, and I am comfortable telling him that. However, I can imagine him questioning all other Asian people like what he did to me. What should my fellow Asian American, who could have lived in the US for generations, reply to him? Just as what happened to the Japanese American community 100 years ago, a lot of American people still have not learned the fact that Asian Americans could also live on this land and be native to this land like them. What happened to me on that day was only from one person, but the same attitude and behavior are commonly seen in society. The Japanese Americans were treated unfairly by the whole of American society, including the government, and today, despite numerous efforts, I am not confident to state that things have become any better.

In conclusion, the ongoing mental health challenges of Asian Americans highlight an issue that is never adequately addressed in society. Spanning over a century, from the historical mistreatment of Japanese Americans to present-day personal experiences, repeated instances of discrimination, whether subtle or overt, continue to perpetuate a sense of "otherness" among Asian Americans, contributing to identity conflicts and mental health struggles within the Asian American community. It is time for society to confront and address these never-solved issues to move beyond mere apology toward meaningful action. What we should do is to understand histories, respect multiculturalism, and build commitment to foster an inclusive environment where every individual's identity and heritage are valued. Only then can we hope to heal the wounds of the past and build a more equitable and empathetic society.

Work Cited

Brown, Krissy. "Ansel Adams at the Manzanar Relocation Center - C&I Magazine." *Cowboys and Indians Magazine*, 29 Jan. 2018, www.cowboysindians.com/2018/01/ansel-adams-at-the-manzanar-relocation-center/.

George, Alice. "Eighty Years after the U.S. Incarcerated 120,000 Japanese Americans, Trauma and Scars Still Remain." *Smithsonian Magazine*, 11 Feb. 2022, www.smithsonianmag.com/smithsonian-institution/eighty-years-after-us-incarcerated-japanese-americans-trauma-scars-remain-180979519/. Accessed 1 Feb. 2024.

Ratner, Sam. "The Long-Lasting Scars of Japanese American Internment." *The World from PRX*, 28 July 2020, www.google.com/url?q=theworld.org/stories/2020-07-28/long-lasting-scars-japanese-american-internment&sa=D&source=docs&ust=1706845494849923&usg=AOvVaw0yWWRT9T_aBTrbKXc7MxAV. Accessed 2 Feb. 2024.

Yam, Kimmy. "Anti-Asian Hate Crimes Increased by Nearly 150% in 2020, Mostly in N.Y. And L.A., New Report Says." *NBC News*, 9 Mar. 2021, www.nbcnews.com/news/asian-america/anti-asian-hate-crimes-increased-nearly-150-2020-mostly-n-n1260264.

Politics of Reconstruction By Regan Shee

Abstract

This paper studies the similarities and differences between different political movements in the time period following the Civil War. For my research, I reviewed many forms of literature on the different political movements between the 1860s and 1890s, including the Populist movement, the Progressive Movement, and the African American movement in the South. From these works, I concluded that although all these movements had different ultimate objectives, whether that be challenging commanding monopolies or spreading Protestant values of purity, they all shared a similar goal of redefining our society and all seemed to conclude that the best way to achieve this goal was by banding together, just like political movements today. Yet, the biggest similarity is that these movements transformed the political landscape for a short time and although they weren't ultimately successful, they continue to inspire modern political movements. My interpretation will provide a bigger outlook on what happened in the aftermath of the Confederates' defeat and will shed light on how political movements back then have translated to today.

Introduction

Eric Foner's preface in *A Short History of Reconstruction* details a history of public perception of Reconstruction. The Dunning School Interpretation of Reconstruction said that after the Civil War, the South readily accepted defeat, yet President Johnson's attempts at Reconstruction were heavily opposed by corrupt Radical Republicans, who tried to severely punish the South for their actions during the war. This interpretation was accepted until the 1960s, where the Civil Rights movement destroyed any traditional viewpoint similar to the Dunning School. A new interpretation arose that Johnson was a racist and that Radical Republicans were heroes of black rights who heavily supported Reconstruction efforts in the South[28].

This new interpretation created results that are similar to that of other political movements in the same time period, which were how Southern society was remodeled in the form of new class structures and new labor systems and how a state embodying reform arose. These two results were the basis of the ultimate goals for political movements in this time period. All striving for social and political reform to create a better society in America. This paper aims to answer this question: What are the similarities and differences between the various political movements after the Civil War?

The Direct Aftermath of the American Civil War

Foner then details the instant impact of the Civil War in his chapter "The World the War Made". With the signing of the Emancipation Proclamation in 1863 and the passing of the 13th

---

[28] Eric Foner, "Preface," in *A Short History of Reconstruction*, (New York: Harper & Row 1990).

amendment soon after, 3 million slaves were immediately freed[29]. Slave labor had played a massive role in the nation's development, including producing the cotton that fueled the Industrial Revolution and dividing the nation into two sides arguing its morality. With the signing of the proclamation, blacks began a journey of redefinition of their place in society. The Civil War had exposed the Southern institution that was slavery and now, it had practically destroyed it.

Even before the war had ended, the South was experiencing difficulties with its own people[30]. Consider the Upcountry Southerners, who never had many slaves to begin with, but still supported the South's social class structure as long as slavery didn't affect their local independence. Upcountry Southerners still supported the Confederacy, even when war began.

Confederate Policies, which were mostly molded in the interest of the planter class rather than Yeomen like the upcountry, caused social tension to rise. High taxation caused poverty to descend in the Upcountry and thus caused riots. The biggest symbol of the Upcountry's anger was the draft law, which dictated that for every 20 slaves on a plantation, one white man could be kept out of serving in the military[31]. This meant that in areas with low slave populations like the Upcountry, residents had to witness their fellow citizens being conscripted into a war they hardly endorsed, while wealthy planters remained untouched at home.

Resistance brewed within Confederate ranks, as upwards of 100,000 soldiers abandoned their posts, their initial enthusiasm that had brought them into war now was replaced by resistance, anger, and disillusion[32]. As the war drew to a close, military devastation swept across the land, leaving the Southern economy in ruin. From the ashes emerged Republican leaders, attempting to lead the South into a better future with Reconstruction.

The North heavily contrasted the South. The Civil War actually created opportunities for monopolies to prosper. Railroads carried troops and supplies to the frontlines, the meat-packing industry flourished from supplying the army's food, and even woolen mills boomed from supplying the Army's uniforms[33]. Before the war, the Homestead Act offered free land to settlers and the Land Grant College Act assisted in establishing agricultural and mechanical colleges.

Of particular note was the birth of a modern American state. The government had an expanded income, bureaucracy, and responsibilities, and thus, a new sense of nationalism emerged. Paradoxically, the Civil War served to coalesce the national identity[34].

However, not all aspects of the transformation were benign. Resistance to emancipation still existed and soon, they would come back for revenge. A specific event, the New York Draft Riot, highlighted resistance to Republicans and attempts at reform.

Dr. John Torrey, a professor of chemistry at Princeton in New Jersey at the time, witnessed firsthand the terror and destruction of the riots. He described men "who were tearing

---

[29] Eric Foner, "The World the War Made," in *A Short History of Reconstruction*, (New York: Harper & Row 1990), under "The Coming of Emancipation".
[30] Foner, "The World the War Made," under "The Inner Civil War".
[31] Foner, "The World the War Made," under "The Inner Civil War".
[32] Foner, "The World the War Made," under "The Inner Civil War".
[33] Foner, "The World the War Made," under "The North's Transformation".
[34] Foner, "The World the War Made," under "The North's Transformation".

up rails, cutting down telegraph poles, & and setting fire to buildings"[35]. At one point, the rioters, who Torrey described as "furious as demons"[36], set fire to a colored Orphanage, turning the building into nothing but ashes. The fate of the 300 orphans who had lived there were not known[37]. The biggest targets of the rioters were Republican symbols of a new order, including the mansion of a rich Republican supporter. With such violence happening in the North's territory, the question emerged: how could a divided North revitalize the South?

Racism remained entrenched, with discrimination toward black Americans enduring. Despite gaining freedom, they were barred from suffrage and an education, consigned to low living standards. Clearly, America had a lot of work to do in Reconstruction.

African Americans In The South

Steven Hahn's chapter "Of Paramilitary Politics" from *A Nation Under Our Feet: Black Political Struggles in the Rural South from Slavery to the Great Migration* describes the emergence of the KKK against Radical Republican efforts to revitalize the south.

Radical Reconstruction had begun in the South. As previously mentioned, newly freed black Americans were granted numerous new privileges, including the right to vote and an education. Universal suffrage for black Americans marked the possibility to elect black officeholders to police forces and state governments, marking a bigger African American footprint in politics. Education enabled black Americans to acquire literacy, a symbol of empowerment and rejection of slavery in the now emancipated world. These two new rights hugely benefited the black community and gave hope for a brighter future as more and more black Americans embraced these freedoms. Unfortunately, they also became the target of the KKK and white leagues[38].

After the war had ended, the KKK and white leagues had emerged from the scorched South. The reason behind their creation was apparently radical Republican leadership for their political illegitimacies, as they claimed that these newly freed black Americans were unfit to vote for themselves. Of course, racism and a sense of white supremacy were also culprits of their creations, resulting from a large connection to the old Southern confederacy[39].

Speaking of the Confederacy, the Klan and the Confederacy were very much connected. Confederate mobilization was only possible because of previously established local paramilitary organizations or, in other words, militias. These militias ultimately became the culprits for the terror inflicted on black Americans, as Klan "camps" were roughly the same size as that of a militia and most of white Southerners who joined were veteran confederate soldiers.

Geographically, Klan activity usually appeared where Republican supporters were found, which were usually towns with African Americans as the majority of the inhabitants. Then, Klan

---

[35] John Torrey, "An Eyewitness Account of the New York Draft Riots," *The Mississippi Valley Historical Review* 47, no. 3 (1960): 476, https://doi.org/10.2307/1888878.
[36] Torrey, "Eyewitness Account of New York Draft Riots," 476.
[37] Torrey, "Eyewitness Account of New York Draft Riots," 476.
[38] Steven Hahn, "Of Paramilitary Politics", in *A Nation Under Our Feet: Black Political Struggles in the Rural South from Slavery to the Great Migration*, (Cambridge: The Belknap Press of Harvard University Press, 2003), 276.
[39] Hahn, "Of Paramilitary Politics", 269-71.

members tried everything they could to resist Reconstruction. They intimidated Republican supporters, murdered local Republican leadership, and terrorized black American towns. 26 schools were even burned in an attempt to limit black empowerment[40]. As African Americans watched these horrors unfold, they realized that the old confederacy still remains in the South.

Of course, efforts were made to combat these new paramilitary organizations. Republican supporters began to suspect Klan members into leaving and some towns even started mobilizing in order to defend themselves from Klan attacks. Political leadership finally took notice and began to create state militias, particularly South Carolina and Texas. These state militias, which comprised many black troops, made thousands of arrests in retaliation of Klan attacks. However, some of these efforts proved ineffective. For example, Klan activity was so effective that the Republican majority was overturned and democrats were able to take control of North Carolina's state legislature, even removing its governor from office in the process[41].

Finally, the federal government stepped in to pass the Enforcement Acts of 1870-1871, which made political harassment and terrorism officially federal offenses. Some arrests were made and part of the Klan's organization had been impacted. Yet, the damage had already been done. Party mobilization fell back and Republican voters refused to vote out of fear of Klan actions. The withdrawal of federal troops officially doomed black militias to decades of racist prejudice. What had once put the Republican party as a major political influence in the South now disappeared into the darkness with the end of Reconstruction.

This didn't mean that African American resistance to paramilitary institutions had disintegrated entirely, yet there were already signs of a return to the traditional South. A fitting representation would be the Colfax Massacre of 1873, which is documented in Joel Sipress's *From the Barrel of a Gun: The Politics of Murder in Grant Parish*.

Colfax was a plantation in Red River Valley, Louisiana. Henry Clay Warmoth, the Republican governor of Louisiana, was the "chief architect[42]" of the party's hope to "build a truly biracial Republican party around a program of nationalism, modernization, and economic development"[43]. William Ward, a black Civil War veteran, was a captain of an all black state militia in Colfax. A Republican radical, Ward was characterized by his boldness and resistance to superior authority, even arming and drilling his militia company against his superior's orders[44]. At some point, Ward was even commanded to disband the company, yet he refused.

Warmoth can be seen as the cause of the massacre. He had hoped for a unification of all "Races, Creeds and Political Opinions"[45]. Thus, he, with the aid of Liberal Republicans, united with democrats to nominate a fusion ticket. From a distance, this would look like a good idea to unite the state under one banner. However, what this really did was create a sense of betrayal for both sides.

---

[40] Hahn, "Of Paramilitary Politics", 276.
[41] Hahn, "Of Paramilitary Politics", 285.
[42] Joel M. Sipress, "From the Barrel of a Gun: The Politics of Murder in Grant Parish," Louisiana History: The Journal of the Louisiana Historical Association 42, no. 3 (2001): 306, http://www.jstor.org/stable/4233762.
[43] Sipress, "From the Barrel of a Gun," 306.
[44] Sipress, "From the Barrel of a Gun," 312-13.
[45] Sipress, "From the Barrel of a Gun," 315.

When the state elections began, voter fraud was so frequent that "to this day, it is unclear which side actually received the most votes"[46]. In the end, Republican William Pitt Kellogg was able to take the position of Governor. Knowing there would be resistance from fusionist supporters, Kellogg agreed to nominate fusionist candidates for some positions in government.

Fearing a fusionist takeover of Colfax, Republican officeholders in Grant Parish seized the courthouse and called to take the parish offices by armed force. Ward was informed that a reputed Klan leader James Hadnot planned to attack Colfax, replace the Republican officials with fusionist ones, and hang Ward. Consequently, Ward formed a group of deputies to defend the courthouse. Unfortunately, of the over 400 men, women, and children encamped in the courthouse, only roughly 80 of them were armed[47]. Thus, Ward left Colfax soon after to ask for reinforcements.

On April 13, the courthouse was besieged by over 300 white men, commanded by Sheriff Columbus Nash.[48] Nash promised safe passage for the freedpeople in the courthouse if they gave up their weapons, but they refused. After exchanging fire for 2 hours, the surrounding "posse" fired a cannon into the courthouse, panicking the defenders and causing them to scramble. After another hour, the courthouse was burned to the ground and 40 black men were taken prisoner. Later, some members of the posse marched a group of prisoners out and executed them.

How does this represent the African American movement in the South during Reconstruction? Although they fought to save what rights they had, African Americans were unable to secure their form of justice due to constant attacks by white paramilitary forces, such as the KKK or the White leagues that terrorized black communities. In the end, the only result the massacre produced was dead black Americans. Nine white men were put on trial for white aggression, but they were promptly acquitted and one Supreme Court member even declared part of the Enforcement Acts to be unconstitutional[49]. Ward's effort was all for nothing.

The withdrawal of federal troops in April of 1877 symbolized the end of the protection of the rights of Southern African Americans and the end of Reconstruction. The KKK continued to terrorize black Americans for years to come and state organized violence became common. To African Americans, a return to the old system had begun.

Yet, it would be foolish to assume that this movement had no impact whatsoever. The African American spirit was very much alive and would resurface in the 60s with the Civil Rights movement. Even today, part of the Black Lives Matter movements seem to have drawn inspiration from the Reconstruction era black Americans. Although the movement was only temporary, it represented the spirit of African Americans that fought for justice, law, and order. The era of Reconstruction symbolized a step in the right direction and although it failed, its desire for social change would carry into the oncoming years.

The Populist Movement

---

[46] Sipress, "From the Barrel of a Gun," 316.
[47] Sipress, "From the Barrel of a Gun," 318.
[48] Sipress, From the Barrel of a Gun," 319.
[49] Hahn, "Of Paramilitary Politics," 295.

In Elizabeth Sander's chapter "Farmers in Politics 1873-1896" from *Relations of Rescue: The Search for Female Moral Authority in the American West, 1874-1939*, the Populist movement's origins and impact are analyzed, from the creation of organizations like The Farmers Alliance to the downfall of political parties like the Greenback party.

After the Civil War had ended, farmers held the most numerous classes in the workforce, even toppling workers in railroads or factories. Yet, Midwest and Southern farmers were to begin an era of struggle. While northeastern farmers had the privilege of rapidly expanding urban markets with diverse produce and easily accessible transportation lines, Southern and Midwest farmers faced the risks of one-crop dependency, transportation monopolies, and debt burdens. Essentially, one bad harvest could ruin a farmer's financial plans[50].

It's important to understand why farmers were in such poverty to begin with. As Sanders mentions, the rising amount of debt farmers owed could have indicated increased international competition and production, but they were also the result of federal decisions[51]. For example, the national government created a national banking system that seemed biased against agriculture and to demonetize silver, the latter of which is important since farmers wanted the silver standard to pay debts easier.

An infamous result of such financial troubles was the sharecropping system, in which a landowner would allow a farmer to live on his land, being that the farmer gives up a share of the crop as "rent". This system clearly brought landowner's to an advantage, as entrapping both black and white tenants became incredibly easy. Farmers were forced to purchase supplies for a share of their crop, and, due once again to high interest rates, those farmers fell even farther into debt. Both black and white men fell into this "slave system".

With a loss of income mixed with a feeling of loss of independence, political movements and organizations were quickly created to help financially troubled farmers. The Patrons of Husbandry, or the Grange, was founded by Oliver H. Kelley, a Minnesota farmer. The organization quickly caught popularity, and several different chapters were opened. These chapters helped in a variety of ways, from funding farm equipment to offering life insurance for farmers. At its peak, membership reached over 750,000 members and 11.2 percent of the entire population engaged in agriculture were members[52], showing the success of the organization.

Although the Grange itself was not directly involved with politics, members were supported in being politically vocal. Many were involved in conventions and meetings and some joined other associations that endorsed political nominations. For example, a farmers uprising in 1873, which was the result of the enactment of a railroad commission law in Illinois, formed a Farmers' Club to push for their demands and even stopped the reelection of the chief justice who had presided over the voiding of the previous 1871 law[53].

---

[50] Elizabeth Sanders, "Roots of Reform" in *Farmers in Politics 1873-1896*. In *Roots of Reform: Farmers, Workers, and the American State, 1877-1917*, (Chicago: University of Chicago Press, 1999), 105-107
[51] Sanders, "Roots of Reform", 103.
[52] Sanders, "Roots of Reform", 105-107.

[53] Sanders, "Roots of Reform," 107.

As the movement went on, political activism increased. In the West, most were concerned with enforcement of railroad laws, civil-service reform, and economy in government and began reform movements. In the Midwest, state laws regulating railroads and legislation letting governments closely supervise power corporations were the outcome of reform movements.

The Grange became the first massive national reform occupational organization and its influence led to the creation of other farmer organizations. Thus began the Populist movement, a political movement born from the poverty stricken farmers of the Midwest and the South.

A notable organization that the Grange helped in influencing was The Southern Farmers Alliance. The alliance was committed to assisting smaller farmers who were members. Like the Grange, the alliance encouraged members to be more politically active and supported cooperations and camaraderie with other organizations.

The Alliance grew tremendously, in part thanks to its system of lecturers. Dispersed around the South, these lecturers spread the concepts and goals of the Alliance, allowing a network of county alliances. As its creator S. O. Daws planned, the strategy was to use the alliances that were connected by the lecturers as a foundation for a massive cooperative movement to break the hold merchants had on the South. This strategy worked incredibly, with the number of sub alliances reaching over 1,650 and membership over 92,00 by the end of 1885[54].

In 1882, a Texas State Alliance was created from 140 sub alliances[55]. A few years later, a devastating drought to the state caused extreme loss of crops and livestock. The alliance were able to organize a relief effort and due to the growth of the Texas labor organization, Alliance members were convinced that the Knights of Labor and the Farmers Alliance should join forces. Thus, the focus shifted from yeomen farmers to include workers. Cooperation had led to an entrance into class politics.

In May of 1891, the People's Party was launched off the back of the Farmers Alliance, effectively springing the Populist movement into politics for good[56]. At the launching, fourteen hundred reformers included everything from Greenbackers to prohibitionists. Yet, support for a third party campaign was mixed and some state alliances refused to endorse it.

At the Omaha Platform in July of 1892, the party described its principles, which included the disapproval of the demonetization of silver, graduated income tax, and, in general, the end of oppression and poverty in America[57]. From the platform, it would seem that the Populist movement had expanded way past the sole focus of the farmer and now had moved to all laborers across the country. The hopes of the working class seemed to embody the party.

In the polls, however, they were less successful. Despite appeals to vote for the nominees James Weaver of Iowa and James G. Fields of Virginia for presidency, the Populist movement ideals were ridiculed in the press and Democrats attacked Populist support by voter fraud and

---

[54] Sanders, "Roots of Reform", 119.
[55] Sanders, "Roots of Reform," 119.
[56] Sanders, "Roots of Reform," 128.
[57] Sanders, "Roots of Reform," 131.

criticism towards the candidates. In the end, the Populists finished with 8.5 percent of the popular vote, better than the previous Greenback party, but still far from enough[58].

Populists tried again in 1896, nominating the young William Jennings Bryan. Given that the principle of the return to the silver standard made common footing for all laborers to join forces against monopolies and corporations, support from laborers quickly came. Because of this, businessmen began to desperately convince their workers and customers of the consequences of Bryans vote, including wage reductions and refusal of mortgages. Although the north was continuously won by Republicans regardless, this spread of fear surely helped strengthen the impact.

Despite Republican continuous success, Bryan refused to concede any votes and continued to campaign in Northern cities, from the likes of Philadelphia to Boston. By the end of it, Bryan should have been exhausted, considering that he traveled thousands of miles to perform six hundred speeches in total[59]. In his speeches, Bryan emphasized the party as an opening in which urban workers could apply class objectives. Yet, when the votes were counted, Bryan was far short of the Presidency. The dream of a populist president leading a farmer-labor partnership was destroyed and whatever was left of the Populist movement was lost. Industrialization began to erode southern populism and the Democrat party would be less committed to labor and domestic reform.

This movement had a strange ending. It was short lived and didn't succeed. Despite over 20 years of building up Populism, the movement fell flat on its face in the election of 1896 and never stood up again. Of course, it was able to help the shortcomings of midwest and southern farmers, but only temporarily. Once the movement was over, the circumstances surrounding the creation of the movement in the first place returned. Industrialization, the very thing that prompted Populist activism, returned to destroy whatever was left of Populism.

One thing to add was that the Populists had one major problem throughout the course of its growth, which was how to include everyone, regardless of race or ethnicity, in their mission for justice. Gregg Cantrell's journal *Our Very Pronounced Theory of Equal Rights to All: Race, Citizenship, and Populism in the South Texas Borderlands* analyzes the peculiar case of Ricardo Rodriguez, whose denial for US citizenship sparked controversy.

In 1896, Rodriguez, being a Mexican immigrant, decided to apply for US citizenship in San Antonio, Texas[60]. There to challenge the application were Populist attorney Theodore McMinn, and Republican attorney Andrew Jackson Evans. Their reasoning that Ricardo was not white and therefore ineligible for US citizenship. At a first glance, this case seems like the typical racism of the time.

However, this case would have long lasting effects. For context, the Populist movement sought to gain more support from Mexican and Tejano voters in the south of Texas. Democrats

---

[58] Sanders, "Roots of Reform," 134.
[59] Sanders, "Roots of Reform," 142.
[60] Gregg Cantrell, "Our Very Pronounced Theory of Equal Rights to All": Race, Citizenship, and Populism in the South Texas Borderlands," The Journal of American History 100, no.3 (2013): 663, http://www.jstor.org/stable/44308758.

were still able to win county elections with a majority, yet the overshadowing issue was mass voter fraud. There was suspicion that non-citizen Means were bribed or coerced into coming to vote for Democrats. Because of this, McMinn had even written publicly, advocating for a legal test of Mexican naturalization[61].

According to Cantrell, it's clear that McMinn and Evans had set up their legal action as a test case. Rodriguez had appeared in court with the necessary documents and a legal counsel, even though he lived in poverty and both would be difficult to obtain with money. It was even reported that McMinn and Evans had been waiting at the courthouse for Rodriguez to apply. Using this evidence, it would make the case seem like Rodriguez was hired as an actor.

Thus, as Cantrell says, it seems that McMinn had orchestrated the event to "render the alien suffrage laws a dead letter"[62]. Of course, racism could still be a factor in this case. After all, McMinn was a white man who benefited from white supremacy. Yet, McMinn continuously denied having racial prejudice toward Mexican immigrants and perhaps he was just attempting to destroy Democratic voter fraud. He just wasn't aware that his argument would have consequences for years to come.

The decision sparked a fire of outrage from both Mexican and Populist communities. The editor of a Spanish language news article labeled McMinn and Evans "enemies of the Mexican" and some Mexicans even threatened to attack and kill "gringos" for oppressing them[63]. Populists were quick to cut ties with McMinn, claiming that anything that could allow prejudice between races and different communities are opposed by the Populist movement. All in all, everyone seemed to oppose the disfranchisement of Mexicans.

Populists never seemed to be able to solve this problem. That is, how to achieve justice against opponents, that being Democrats or other parties, were so quick to use injustice to garner votes and steal elections. Reformers just like McMinn sought equal political rights, but were hampered with the social climate. Corruption stood in the doorway of Populism and Populism never could get it out of the way to achieve justice.

The Progressive Movement

Daniel T. Rodgers' "In Search of Progressivism" analyzes the interpretations of the Progressive Movement and analyzes what created the movement in the first place.

In the 1970s, historian Peter Filene began to attack the idea that the Progressive movement was one, big coherent movement or even a movement at all. Those labeled Progressives never shared a common party and each individual political movement was split on issues like women suffrage and direct democracy. Thus, he argued that by destroying this assumption, one could see that the movement was really "an era of shifting, ideologically fluid, issue-focused coalitions, all competing for the reshaping of American society."[64]

---

[61] Cantrell, "Our Very Pronounced Theory," 678.
[62] Cantrell, "Our Very Pronounced Theory," 678.
[63] Cantrell, "Our Very Pronounced Theory," 679.
[64] Daniel T. Rodgers, "In Search of Progressivism", *The Promise of American History: Progress and Prospects* 10, no. 4 (1982): 114, https://doi.org/10.2307/2701822.

Of course, the question was why did so many groups advocating for change to American society pop up at the same time? To start off, the era of Progressivism started at about the same time of a decline in voting and less of those loyal to a specific party. Parties had failed to maintain their previous position of being the only way which Americans could directly affect the policies of government. Then, it would make sense that citizens began turning to politically active pressure groups.

Rodgers then claims that all Progressive movements drew on 3 different ideas: the rhetoric of anti monopolism, an emphasis on the social nature of humans, and social efficiency[65].

Anti monopolism was the oldest of the three. It's safe to say that middle class Americans were taken off guard by the quick rise of finance capitalism. Monopolies quickly became exposed to the likes of middle class Americans and many were not happy with the disproportionate concentration of wealth to different classes. What's different about Progressives was that the so-called "octopus" had all of a sudden gained the attention of political insiders. Thus, Progressives shared a common disdain for monopolies as a whole.

The social nature of humans was closer to that of the Progressive era. A portion of the Progressive movement was an attack on traditional interpretations and assumptions, that which were specific to autonomy. Many Progressives replaced these concepts with social cohesion. According to Rodgers,, the emphasis on the social nature of humans was more related to "churches and university lecture halls"[66]. This idea was not exclusive to America and was more international.

The final idea, social efficiency, was also international. Some progressives never could accept the "bureaucratic language of budgets, human costs and system"[67]. So when they turned to social efficiency, they could avoid the confusing language of philosophy and pieties and the social disorder of Progressives into words. Of the three, social efficiency was the last to appear in the movement and lasted way after the Progressive era ended.

These three ideas provided the basis of how the Progressive movements functioned. All, or at least most, Progressive movements had different ideologies, were oriented around different issues, and advocated for different changes to American society. Yet, they all were built around the same concepts and the same era. It can be easy to mistake the Progressive movements as one coherent movement, but that assumption is just not true.

To provide a clearer picture of what Progressive Movements were like, it's important to look at the advocacy of female moral authority in several different locations. Peggy Pascoe's chapter "Institutional Origins" from *Relations of Rescue: The Search for Female Moral Authority in the American West* details the search for female moral authority, beginning in Protestant Churches and stretching from San Francisco to Denver.

The main idea of this search was that women should be characterized by purity and piety. In the aftermath of the Civil War, Protestant Evangelism burst onto the scene, reviving charitable organizations and creating more independent women headed organizations. Evangelical women

---

[65] Rodgers, "In Search of Progressivism," 123.
[66] Rodgers, "In Search of Progressivism," 126.
[67] Rodgers, "In Search of Progressivism", 126.

broke away from organizations led by men and formed their own societies focused on the injustice of objectifying women. This new wave of women's vocation led them westward.

In Connecticut, The Indian Association promoted a more civilized home-life on reservations[68]. There, they would help lead church services, teach children, and many other activities beneficial to the tribes there. The association even announced a project revolving around a program which allowed Indian Couples to borrow money to build houses on reservations. So many applied for this program that it was adopted by the national Indian Association.

In San Francisco, Presbyterian women created a Chinese Mission Home to shelter Chinese prostitutes[69]. Mrs. John Gulick, the woman behind the development of the home, garnered enough interest for local women to form the California Branch of the Woman's Foreign Missionary Society[70]. The development of this project happened in a time of Chinese poverty so severe that parents often sold their daughters into prostitution to pay their debts. As they came in, these prostitutes were targeted for racial hostility. Thus, the sheltering of these Chinese prostitutes proved very controversial.

In Salt Lake City, Protestant women targeted Mormon polygamy, as they saw it as a representation of male control over a society. To these women, polygamy undermined female moral authority and reduced women to nothing more than enslaved wives. This symbol became the struggle for political control of Salt Lake City. Protestant women in Salt Lake City were a small minority who did not have the money to establish a refuge for Mormon women as presbyterian women in San Francisco did. Then, Angie Newman, a member of the Women's Christian Temperance movement, helped form the Industrial Christian Home Association, an organization which was "not very abundant in financial resources, but rather spirit"[71]. However, the formation struck opposition from local officials and particularly men. Soon, the home was vastly criticized and mocked. Although Congress approved a plan for a new building to attract more residents, the project was insisted to be supervised by men and by the time it opened, it attracted very few refugees.

Something to note about these women organizations was that no matter where they established their organizations, opposition from local male leaders was a factor. As a result, this era of the search for female moral authority was characterized as a growing tension between men and women. These organizations reflected women's anger toward male control in society, a control that can be seen in women being denied the right to vote until the 19th amendment was passed in 1919[72]. It is plausible that organizations like these inspired the feminist movements that are seen in contemporary America.

---

[68] Peggy Pascoe, "Institutional Origins," in *Relations of Rescue: The Search for Female Moral Authority in the American West, 1874-1939*, (New York: Oxford University Press, 1990), 8.
[69] Pascoe, " Institutional Origins," 13.
[70] Pacoe, "Institutional Origins," 13.
[71] Pascoe, "Institutional Origins," 24.
[72] The 19th amendment passed during the tail end of the Progressive movement, which is widely agreed to have concluded by 1920.

Similarities and Differences Between the Political Movements

Obviously, every movement differed in what they were attempting to achieve specifically. African Americans wanted freedom from the tortures and intimidation of the KKK, Populists wanted to strike back at monopolies and capitalism that unfairly put them into poverty, and Progressive women wanted to associate women with piety and purity, while also striking back at the male control in social orders. Moreover, they approached solving their individual issues in different ways. For example, African Americans began resisting KKK attacks through armed defense, while Populists created a political party to help the Populist cause.

Yet, the similarities of these movements are not as apparent. The more evident ones were that they burst onto the scene suddenly, as the impact of the Civil War was great and had reverberations for decades to come. They also all decided that the best approach toward solving their issues was to form a union, a union filled with political leaders and advocates for societal change. However, this can be said about most political movements.

The underlying theme is that although they didn't really succeed in solving their issues in the time they existed, these movements have inspired modern advocates for similar issues. Although they failed and were subjugated to widespread racism for a long period of time, The African Americans effort to repel the KKK inspired the Civil Rights movement to take place and even parts of the Black Lives Matter movements today. In spite of failing to achieve bigger political power in the form of a presidency, the Populist movement helped inspire agricultural reforms in the future, like crop subsidies and union protection. And despite being constantly opposed and combated by men in communities, the efforts of Progressive women have inspired the modern feminist movements that advocate for equal pay and equal rights. These modern movements ultimately achieved what the post-Civil War movements failed to.

Conclusion

In short, the political movements in the post-Civil War era were short, but they helped cultivate new movements in the future which ultimately achieved in solving their respective issues. The African American movement, Populist movement, and Progressive women's movement failed to do what they set out to do, but they inspired future generations to solve these issues. This interpretation should be emphasized when analyzing contemporary political movements, as the history behind the organizations and groups which lead the movement often distinguishes the political ideologies behind each respective movement.

There are also many questions related to Reconstruction not answered yet. Was justice preserved or forgotten with the impact of these political movements? Did federal leadership do enough to unify a disjoined country after years of war? And can these political movements be used to influence future political decisions? Answering these questions could shed light on an era fixated on justice, advocacy, and preservation, while also influencing how we move forward in contemporary America. Modern America is a country divided by political parties and policies, so learning from Reconstruction could provide guidance for how to move in the present.

Works Cited:

Cantrell, Gregg.*"Our Very Pronounced Theory of Equal Rights to All": Race, Citizenship, and Populism in the South Texas Borderlands."* The Journal of American History 100, no. 3 (2013): 663–90. http://www.jstor.org/stable/44308758.

Dupree, A. Hunter, and Leslie H. Fishel. "An Eyewitness Account of the New York Draft Riots, July, 1863." *The Mississippi Valley Historical Review* 47, no. 3 (1960): 472–79. https://doi.org/10.2307/1888878.

Foner, Eric. *A Short History of Reconstruction* (New York: Harper Perennial Modern Classics, 2015).

Hahn, Steven. *A Nation Under Our Feet: Black Political Struggles in the Rural South from Slavery to the Great Migration* (Cambridge: The Belknap Press of Harvard University Press, 2003).

Pascoe, Peggy. "*Institutional Origins.*" in *Relations of Rescue: The Search for Female Moral Authority in the American West, 1874-1939* (New York: Oxford University Press, 1990).

Rodgers, Daniel T. "In Search of Progressivism." *Reviews in American History* 10, no. 4 (1982): 113–32. https://doi.org/10.2307/2701822

Sanders, Elizabeth. "*Farmers in Politics 1873-1896.*" In *Roots of Reform: Farmers, Workers, and the American State, 1877-1917"* 1st ed. (Chicago: University of Chicago Press, 1999).

Sipress, Joel M. "From the Barrel of a Gun: The Politics of Murder in Grant Parish." *Louisiana History: The Journal of the Louisiana Historical Association* 42, no. 3 (2001): 303–21. http://www.jstor.org/stable/4233762.

Criticizing the Flaw in the Social Class System By Yoobin (Annika) Song

In Shakespeare's play, *Othello*, both blatant and subtle class distinctions are evident throughout the story, highlighting the importance of class in the characters' lives. The play

explores the themes of jealousy, love, and betrayal, but also reflects the social hierarchy of the time. Each character's status and social class play a significant role in how they interact with one another and this is evident in the power dynamics within the play. Shakespeare explores the themes of jealousy, the outsider, and love in *Othello* to criticize the inequity in the social system at the time.

Iago's relationship with Othello mainly reflects the theme of jealousy due to his social status. In Act 1 Scene 1, Iago does not have good intentions toward Othello; he is upset that Othello chooses Cassio over him to be the lieutenant of the Venetian army. He is also a racist character who believes that Othello should not be in his position due to his race. Iago at the start mentions how he does not like Othello because he did not get a promotion, which he explains to Roderigo in the opening scene. However, in his explanation to Roderigo, Iago's complaint highlights the deeper reason for his anger. He feels that Othello should have selected him to be lieutenant because he was next in line and had put in the hard work. However, Othello chose to promote a man who already had social standing and had never once stood on the battlefield. Shakespeare uses the theme of jealousy through Iago to emphasize the flaw in the social class system at this time:

> we cannot all be masters, nor all masters
> cannot be truly followed
> …Others there are
> who, trimmed in forms and visages of duty,
> keep yet their hearts attending on themselves,
> and, throwing but shows of service on their lords…
> Were I the Moor I would not be Iago." (Shakespeare I.I. 50-65)

Iago's jealousy towards Othello ends up leading to him ruining Othello's life and his own life due to a rumor. He blatantly admits that he is not a loyal follower and that he is only following Othello for his purpose. The themes of jealousy and discrimination are portrayed through the words Iago uses to describe Othello, such as "Moor" and "black ram." Shakespeare uses Iago's jealousy and discrimination in words to tell a message to the audience of the flawed social system.

In Shakespeare's play *Othello*, the theme of the outsider is portrayed through the experiences of Othello. As a black man in a predominantly white society, Othello is constantly reminded of his outsider status. He puts up with racist comments and insults, and his marriage to Desdemona is disapproved of by both her father and other characters in the play. In the article, "The Improvisation of Power," Greenblatt mentions how "the blackness—the sign of all that the society finds frightening and dangerous—is the indelible witness to Othello's permanent status as an outsider, no matter how highly the state may value his services or how sincerely he has embraced its values" (Greenblatt 45). Due to his race, he is always considered an outsider, which ends up impacting how his ability as a general is viewed. Without being aware, Othello talks

about his unfair experience with the whole situation. Though he is a general, his self-esteem starts to go down after having to encounter all these problems:

> Haply, for I am black
> And have not those soft parts of conversation
> That chamberers have, or for I am declined
> Into the vale of years—yet that's not much—. (Shakespeare III.III.305-7)

This quote highlights not only Othello's sense of isolation but also the flawed social system in which he exists. He doubts his ability to have conversations with people due to his race and, in turn, starts doubting his abilities. He claims that the only reason why he is not better at this is because "I am black." The fact that he is judged solely on his race reflects the prejudices and inequalities that existed during Shakespeare's time.

Shakespeare uses the universal disapproval of Othello's marriage to Desdemona to critique the flaw of the social hierarchy using the theme of love. When Brabantio finds out about the marriage between the two, he is very unhappy about it. He even says to one of his Kinsmen that Othello has either possessed Desdemona or he has stolen her. He also tells Othello, "She has deceived her father, and may thee" (Shakespeare I.III.331). To Brabantio, Desdemona's decision to marry a man out of their social hierarchy is the same as a betrayal to him. He is in shock that she would marry a person who is not only not in her social class but so far removed from it. For all of Othello's rank and status, he is still a black man. He will never truly belong no matter how high his social rank becomes. In the article "The Improvisation of Power," Greenblatt claims that "her marriage choice is, for Brabantio, an act of astonishing disobedience, explicable only as the somnambulistic behavior of one bewitched or drugged" (Greenblatt 45). Brabantio refuses to believe that their marriage is true solely due to Othello's race. Shakespeare includes the theme of forbidden love in *Othello* to emphasize how flawed the social hierarchy system was at his time.

Shakespeare criticizes the social class system by using the themes of jealousy, the outsider, and forbidden love. Through Iago's relationship with Othello, Othello's experience with being a general, and the disapproval of Othello's marriage to Desdemona sends a message to the audience of how the social class system is not just. Not only did the flaw in the social class system exist during Shakespeare's time, but it is also still a problem in the current day.

Is There an Inelastic Demand for Religion as a Commodity? By Arianna Majumder.

Introduction.

Religion indubitably holds an influential role in our society. Two censuses taken five years apart (2012[1] and then again in 2017[2]) by the Pew Research Center consistently display that approximately 4 out of 5 people globally adhere to a religion, strictly or not.

Apart from most of the world's population comprising various religious inclinations, religion has the power to fuel conflicts at a large scale, which primarily arise due to the differing beliefs and values held by the aforementioned range of religious inclinations. A prime example of this is the ongoing Israel-Palestine conflict, which although it contains a multitude of causes, has pertinent religious roots.

Aside from this, the significance of religion is also applicable to more everyday scenarios. As emphasised by Dr. Shanjendu Nath in his paper regarding religion and its role in society, even important steps of life like birth and death are usually marked by religious rites and ceremonies, which can, in turn, contribute to the "control" religion has over society[3]. Without delving into the very specific instances of religion's power in contemporary society, I would like to assume that the extent of its influence has been established. So now let's move on to asking: what exactly determines the power religion has? Or rather, what influences the "demand" for religion?

In the context of the following discussion, I will be referring to religion in the form of theism, with the implication that it enforces an "internal moral enforcement mechanism."[4]

The Demand for Religion.

The reasoning behind having any religious inclination is highly subjective. Freud, for instance, famously referred to religion as an "illusion," a way to create comfort in reality and maybe exaggerate the chances of a favorable outcome[5]. It is helpful to keep in mind that due to his atheist inclination, his grasp on the motives to follow religion might come off as slightly critical of those who choose to do so. In this case, while seeking comfort in religion is a highly plausible personal motive to follow it, religious people were likely to be more in touch with reality than Freud viewed them to be.

Data from the International Social Survey Program (ISSP) provides the perspective of religious individuals for opting into religion, which primarily includes personal motives such as the aforementioned sense of security, as well as an improvement in quality of life[6]. Moreover, it highlights another aspect: social, which suggests religion can be used as a mode of fostering friendships and fitting into a close-knit community.

While personal and social motives are often highlighted, there exists also the economic motive. The earliest noted discussion of this is by Adam Smith in the "Wealth of Nations," who interlinks the social and economic motives for religion through his "human capital" model. It is backed by the data from the ISSP and suggests that following a religion may benefit the social standing of an individual, which enhances the value of their "human capital" and can in turn improve said individual's financial standing as well as employment prospects. Through this, it can be inferred that the economics of religion is not a novel concept.

The demand for a religious inclination, as discussed, contains a multitude of motives. With the increasing commodification of religion in modern society, will the sheer magnitude of demand to follow a religion apply to these "commodities"? Or more aptly put, can the power and influence of religion translate to an inelastic demand for these religious commodities?

The Increasing Commodification of Religion and its Potentially Inelastic Demand.

It is common knowledge that with the creation of a commodity comes a certain level of demand for the commodity, and depending upon its nature, a certain level of elasticity of demand for the commodity. In recent times there has been a notable increase in the commodification of sentimentalities carried within people, and religion is no exception to this. However, there have been minimal studies conducted regarding the elasticity of this demand. In the following discussion, two prominent examples of the commodification of religion will be used to discuss this apparent inelasticity and examine these instances.

A study published in the Journal of Population Economics[7] investigates the effects of the imposition of a "church tax" on the membership of a church to gauge its inelasticity of demand. The way religion is being commodified here is the church tax itself when the use of a church for religious purposes- which is normally free of cost- is being charged a certain fee. The figure that the researchers produced at the end was an elasticity of -0.01: highly inelastic. What this number proves is that an individual's devotion to religion may not be fazed by an economic barrier (of sorts), and perhaps the influence religion holds can overpower this seemingly minute fee. This, hence, contributes to an inelastic demand.

Another case that hints at a potential inelastic demand for religion involves the sudden heightened demand for Thai amulets in 2007[8]. While this commodification of Buddhism was criticized by certain monks for going against some of the fundamentals of the religion (like rejecting materialism), the general population felt otherwise, spending up to 10,000 Bahts on them (worth about 148 pounds back then but over 200 pounds today). In 2007, this was more than the monthly income of several Thais, indicating an importance that could very well translate to inelastic demand (though the exact data regarding Thai wages in 2007 is unavailable, making this calculation difficult).

This heavy demand was alleged to be the result of political uncertainty in Thailand during this era, the amulets providing a sense of relief and security to the citizens. This aligns with an aforementioned personal perspective toward demand for religion- a sense of security- and is an exemplification of this concerning a religious commodity. It also suggests that the reasons for the demand for religion may be strong enough to influence an inelastic demand for it as a commodity.

The Ramifications.

The potentially inelastic demand for religion as a commodity can have a positive connotation since it can display the dedication of religious individuals, at least to a particular degree. However, if the reasons for the demand for religion are powerful enough to create this inelastic demand, it could lead to these individuals' faith being preyed upon by profit-seeking firms. As proven by the case of the Thai amulets, it is certainly possible to charge overly high prices for religious goods and continue to generate demand simply due to the emotions of these religious individuals. This has the chance of making these people subject to exploitation from ill-intentioned corporations or even individuals, abusing the inelasticity of demand.

For instance, a paper by Jeffrey A Smith regarding the commodification of religion in twentieth century films[9] states that religion does indeed sell. The purpose of the paper was to highlight the profits made from films that involve religion as its central theme(s). This further proves that there is indeed a profitable market for religion which can very well be subject to exploitation. In this case, it was shown that regardless of religious inclination, simply using a prevalent social theme such as religion can draw large audiences.

Moreover, the paper also suggests that the followers of religion and religious organisations may not be fond of the way religion is often depicted in these films and thus commodification of religion can also have adverse effects on how a religion is perceived. Similarly, in the case of Thai amulets, several monks seemed to feel that the Thai amulets (and hence the commodification of Buddhism) represented Buddhism in a materialistic and negative light, hence proving that the ramifications of the commodification of religion extend beyond exploitation by firms.

Conclusion

Due to the broad nature of this agenda, there haven't been many studies conducted regarding the inelasticity of demand for religion as a commodity. However, I believe the examples outlined above can be taken as indicators for the potential of this possibility. Though it could be likely, more studies need to be conducted, that too across several forms of religion (Hinduism, for example, which does involve the sale of trinkets around religious locations) perhaps with more controls, and also connected to a variety of reasons for the demand for religion. Ultimately, there may not ever be an answer to this question due to the myriad of religions, reasons for religious demand and examples of commodification of religion.

Works Cited

Hackett, Conrad, and Brian J. Grim. "The Global Religious Landscape." *Pew Research Center's Religion & Public Life Project*, 14 Apr. 2022, www.pewresearch.org/religion/2012/12/18/global-religious-landscape-exec/. Accessed 2 Apr. 2024.

Hackett, Conrad, and Marcin Stonawski. "The Changing Global Religious Landscape." *Pew Research Center's Religion & Public Life Project*, 14 Apr. 2022, www.pewresearch.org/religion/2017/04/05/the-changing-global-religious-landscape/. Accessed 2 Apr. 2024.

Nath, Shanjendu. "Religion and Its Role in Society." *IOSR Journal of Humanities and Social Science*, vol. 20, no. 11, Nov. 2015, pp. 82-85.

Anderson, Gary M. "Mr. Smith and the Preachers: The Economics of Religion in the Wealth of Nations." *Journal of Political Economy*, vol. 96, no. 5, 1988, pp. 1066–88. *JSTOR*, http://www.jstor.org/stable/1837247. Accessed 2 Apr. 2024.

Thornton, Stephen. "Sigmund Freud: Religion." *Internet Encyclopedia of Philosophy | An Encyclopedia of Philosophy Articles Written by Professional Philosophers*, iep.utm.edu/freud-r/. Accessed 7 Apr. 2024.

Somasundram, Sotheeswari, and Muzafar S. Habibullah. "Motives for Demand for Religion: A Confirmatory Factor Analysis." *International Conference on Contemporary Economic Issues*, 2nd-3rd November 2016, Ramada Bintang Bali Resort Bali, Indonesia, 2016, pp. 64-71.

Lyytikäinen, Teemu, and Torsten Santavirta. "The Effect of Church Tax on Church Membership." *Journal of Population Economics*, vol. 26, no. 3, 2013, pp. 1175–93. *JSTOR*, http://www.jstor.org/stable/43738187. Accessed 13 Apr. 2024.

Bunluesilp, Noppawan. "Thai amulet craze "unacceptable face of Buddhism"." *Reuters.com*, 10 Aug. 2007, www.reuters.com/article/feature-thai-amulet/thai-amulet-craze-unacceptable-face-of-buddhism-idUKNOA22955920070712/. Accessed 14 Apr. 2024.

Smith, Jeffery A. "Hollywood Theology: The Commodification of Religion in Twentieth-Century Films." *Religion and American Culture: A Journal of Interpretation*, vol. 11, no. 2, 2001, pp. 191–231. *JSTOR*, https://doi.org/10.1525/rac.2001.11.2.191. Accessed 25 Apr. 2024.

Using Mathematical Ways to Analyze Economic Problems By Li Xiangyu

This manuscript talks about how to use mathematical methods to analyze economic problems. Economists can conduct experiments and develop frameworks to predict future growth using these models. Mathematical equations and techniques provide a rigorous foundation for modeling, analyzing, and solving economic issues, as well as understanding economic behavior and making predictions because of doing calculations based on known general mathematical economic models about future economic changes, etc., and these specific methods will be proved in the upcoming manuscript that you are going to read soon. This manuscript includes reasons, examples and solutions between math and economic problems, from economics definitions to using mathematical formulas calculation, even new guesses based on academic assumptions.

Brief Introduction

Mathematical economics refers to the use of mathematical principles and tools to create economic theories and solve economic problems. This definition highlights the close relationship between math and economics. By analyzing economic graphs, we can see that mathematical methods can be used to predict the future direction of the economy. The 2007–2008 financial crisis and other significant economic events in history serve as evidence of the critical role math plays in economic success and failure – huge number of calculations, predictions, etc.

The Federal government observed that financial institutions and credit rating agencies relied heavily on mathematical models as predictors of risk before the 2007–2008 financial crisis, at the expense of human judgment. However, models can be unreliable if they omit important variables, leading to poor decisions and even bankruptcy for firms.

For example, consider the use of mathematical models to analyze the impact of government policies on the economy. Economists may use mathematical models to estimate the effects of changes in tax rates or interest rates on the economy. Similarly, economic models can be used to analyze the relationship between supply and demand and predict the impact of changes in market conditions on prices. Mathematical methods play a vital role in economics, and they are used extensively to create economic theories, solve economic problems, and make informed decisions. However, it is essential to use caution when relying on mathematical models and to ensure that they reflect the complexity of the economic systems they are intended to analyze.

What is the economy?

According to the Cambridge Dictionary (https://dictionary.cambridge.org/us/dictionary/english/economy), an economy is a system of trade and industry by which the wealth of a country is made and used. Economics intersects with a broad range of disciplines, including business and physics, but its most fundamental connection is to mathematics. In economic thinking, concepts and calculations are inseparable from math, as illustrated by examples such as stock forecasting, data analysis, and marketing strategies.

Another way to explain the economy is as a dynamic system that encompasses the

production, circulation, distribution, and consumption of material and spiritual goods. Production serves as the foundation, while consumption represents the ultimate destination. This underscores the vital connection between the economy and everyday people. Indeed, the economy is ubiquitous in daily life. Even simple tasks like calculating work profits or paying at the supermarket involve mathematical calculations that illustrate the deep and inextricable link between mathematics and economics.

In summary, the economy is a multifaceted and complex system that shapes our lives and determines how resources are allocated. Mathematics plays a crucial role in economic thinking and is essential to our understanding of key concepts and calculations. Whether we are predicting stock prices, analyzing data, or calculating simple transactions, math is an essential tool that helps us navigate and understand the intricacies of the economy.

History reasons

The Great Depression of 1929 and the 2019 COVID-19 economic crisis share a common characteristic: both were caused by external factors that disrupted the economy. For instance, the Great Depression was triggered by the economic collapse following World War One, which was exacerbated by the Treaty of Versailles and its negative impact on inflation. John Maynard Keynes argued that the reparations demanded by the treaty were economically harmful, leading to severe economic hardship in countries like Germany, which ultimately contributed to the outbreak of World War Two.

Similarly, the 2008 financial crisis was the result of predatory lending that targeted low-income homebuyers, excessive risk-taking by global financial institutions, and the bursting of the United States housing bubble, which created a "perfect storm" in the global financial system. The root causes of the crisis were mathematical errors in risk models, which led to overconfidence and poor decision-making by financial institutions. During solving this unprecedented tragedy, many methods, formulas and calculations concerning mathematics are used. (http://www.zsjjgw.com/news/63.html). For example, Mathematical models and algorithms have helped many financial institutions conduct risk management and pricing of financial derivatives to reduce risk exposure and effectively control the situation. Also, mathematical models, help economists and policymakers assess the impact of different policy options and provide advice on how to respond to crises. The blessing of various mathematical methods was a big reason for the end of the financial crisis.

By examining these events, it becomes clear that economics and mathematics are deeply interconnected. By analyzing data, making predictions, and exploring economic models, we can gain a deeper understanding of the critical role that mathematics plays in the economics, and how external factors can have a profound impact on economic outcomes.

Mathematical ways

The most common mathematical tools used in economics are calculus, exchange equations, and national accounts equations.

Calculus, as one of the most fundamental parts of mathematics, includes numerous formulas and concepts that are essential for analyzing economic graphs and data. By focusing heavily on functions and derivatives, calculus enables economists to efficiently analyze complex economic phenomena. For instance, a calculus model can be used to understand the impact of government spending and borrowing on the economy. Government spending requires the government to borrow, then raise taxes to repay debt. Calculus allows us to determine the optimal labor and savings rates of individuals as a function of the tax rates. As tax rates increase, the reward to working and saving falls, so people work and save less. The reduction in work and saving causes output to decrease.

We may go over another example: The Americans personal saving function, from 1950–2020. Only looking at the graph may draw conclusions on the trend of economic change, but may not analyze the detailed information in this graph. However, by only using a simply equation in calculus, , it is obvious and easy to calculate the changes in data between years.
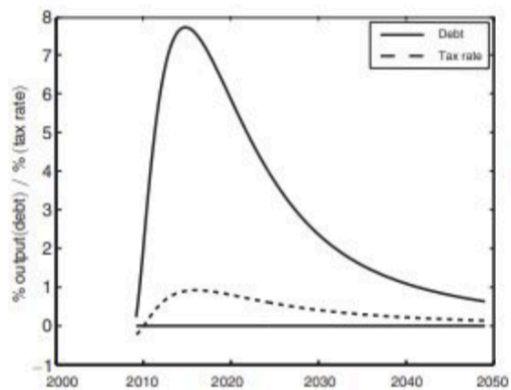
FIGURE 4. DEBT AND TAXES: 40 YEARS   FIGURE 5. OUTPUT AND GOVERNMENT SPENDING: 40 YEARS
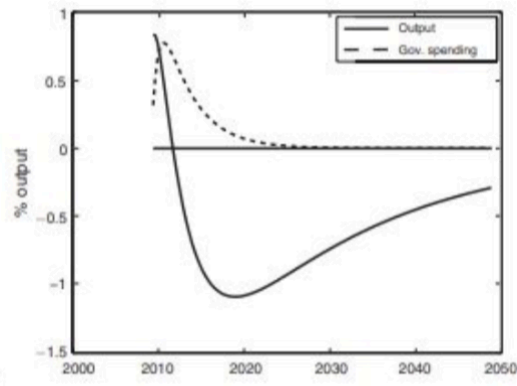
1950–1955, the slope is 0.414
2015–2020, the slope is 76489

It is simple to see that these two slopes have great difference, and from 2015–2020, the data increased rapidly and quickly, in stark contrast to the previous data.

Figure 2. Personal saving function of Americans from 1950 to 2022

Optimization is a crucial aspect of the application of mathematics in the field of economics. One specific example of optimization is linear programming, which is used to maximize or minimize a linear function subject to a set of linear constraints. For instance, in agriculture, farmers might use linear programming to optimize their crop yields by balancing their use of resources such as water, fertilizers, and labor. Another example is inventory management, where businesses use mathematical models to minimize their costs of storing and stocking inventory while maintaining enough stock to meet customer demand.

Another example is portfolio optimization, which is a strategy that investors use to maximize their returns while minimizing their risks. By using mathematical models to analyze past market trends, investors can identify the ideal portfolio mix of assets such as stocks, bonds, and commodities, to achieve their desired returns while minimizing the risks of potential losses. Additionally, game theory is another example of optimization in economics, where mathematical models are used to study strategic decision-making in situations where the outcomes depend on the choices of multiple parties.

In summary, optimization is an important application of mathematics in economics that helps companies and individuals make informed decisions to maximize their profits and benefits. By using mathematical models to identify objective functions and constraints, individuals and companies can make informed decisions that lead to a better future.

Statistics is also an essential part of mathematical economics and a powerful tool for analyzing large amounts of data. For instance, companies can use statistics to identify patterns and trends in consumer behavior, predict market demand, and optimize pricing strategies. In addition, statistics can help firms make informed decisions by calculating the behavior and decisions of their competitors. By knowing what their rivals are likely to do, companies can gain a competitive advantage and increase their chances of success.

For example, let's consider the case of Netflix, a streaming giant that relies heavily on data analytics and statistical modeling to drive its business decisions. By analyzing viewers' viewing habits, ratings, and preferences, Netflix can recommend personalized content and create hit shows like "Stranger Things" that appeal to its target audience. Moreover, Netflix can use statistics to analyze its competitors' strengths and weaknesses and develop strategies to outperform them. For instance, when Amazon Prime Video entered the market, Netflix quickly responded by ramping up its investment in original content and expanding its global reach.

In conclusion, statistics is a crucial tool for making informed decisions and gaining a competitive advantage in today's data-driven economy. However, it is important to use statistical methods appropriately and interpret the results carefully to ensure that the conclusions drawn are reasonable and meaningful.

"Base" theory?

Nowadays, the international number system is based on base 10, which consists of the digits 0 to 9. However, most technology, such as computers and phones, use base 2, which only has two digits, 0 and 1. This is because computers use binary code to represent data and instructions. For example, a QR code or bar code is made up of a series of black and white lines that are read by a computer as a sequence of 0s and 1s. Despite the fact that base 2 is not widely used in the world, it allows computers to perform calculations much faster than humans can. Therefore, if humans adopt the same analytical methods as technology, could we analyze data faster and more efficiently?

For instance, in finance, binary options are a type of financial contract that pays a fixed

amount or nothing at all depending on whether a certain condition is met or not. The use of binary options simplifies the financial decision-making process and reduces the risk of ambiguity. Another example is the use of binary search algorithms in computer science, which is a search algorithm that works by repeatedly dividing the search interval in half until the target value is found. After all, while the world currently uses base 10 for most purposes, the use of base 2 in technology has proven to be more efficient and faster in many cases.

Conclusion

In conclusion, using mathematical methods to analyze economic problems is a valuable and efficient approach. The benefits of employing mathematical equations to solve problems are evident and can be observed in various fields. Moreover, as the world becomes more complex and unpredictable, mathematics remains the only language that humans can use consistently over time and throughout history. Mathematics provides a common language that transcends cultural and linguistic barriers and enables people to communicate and solve problems across borders. For some time to come, mankind will continue to depend on mathematics and economics to make sense of the world and develop solutions to pressing problems. As new challenges arise and technology advances, the role of mathematics in driving innovation and progress will only continue to grow.

Works Cited

[1]. Kenton, Will. "Mathematical Economics: Definition, Uses, and Criticisms." *Investopedia*, 30 Aug. 2021, www.investopedia.com/terms/m/mathematical-economics.asp.

[2]. The Financial Crisis Inquiry Commission, Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States, Pursuant to Public Law 111-21, https://www.govinfo.gov/content/pkg/GPO-FCIC/pdf/GPO-FCIC.pdf, January 2021.

[3]. Freedman, David H. "A Formula for Economic Calamity." *Scientific American*, 20 Feb. 2024, www.scientificamerican.com/article/a-formula-for-economic-calamity.

[4]. Klein, Christopher, and Christopher Klein. "How Economic Turmoil After WWI Led to the Great Depression." *HISTORY*, 28 Mar. 2023, www.history.com/news/world-war-i-cause-great-depression.

[5]. "How Is Calculus Used in Economics?" *Sciencing*, 31 May 2019, sciencing.com/how-is-calculus-used-in-economics-13593453.html.

[6]. *Sticky Price Consumer Price Index Less Food and Energy*. 10 Apr. 2024, fred.stlouisfed.org/series/CORESTICKM159SFRBATL.

[7]. *Personal Saving*. 25 Apr. 2024, fred.stlouisfed.org/series/PSAVE.
.

The Role of Music Therapy in Fostering Long-Term Engagement with Cardiac treatment in Adolescents By Sanjay Sreedhar

Abstract

This research project reviews the possibility of utilizing music therapy for encouraging a long- term involvement in the therapeutic process among adolescent patients with cardiac conditions who do not tend to follow the regime of secondary preventive procedures. Previous work focused on showing the body and psychological influence of music therapy but there still is no detailed research on its role in maintaining patient engagement. The magnitude of the gap indicates a deficiency in the systematic use of novel strategies to stimulate continued participation in other therapeutic regimens, which is one of the main pillars in effective management and secondary prevention in cardiac care. A mixed research methods approach was deployed, and both quantitative and qualitative methods were used (heart rate assessments prior, during and after sessions, and emotional well-being check ups via questionnaires, assessing present and future stress levels as well as the patients' willpower to continue sessions). Thirty-minute music listening sessions plus 5 minutes of low-frequency acoustic simulation were experienced by 6-teen aged participants over a period of six weeks. With comprehensive research review on applied techniques into consideration, the resulting design intended to provide a full picture regarding the outcome of therapy. The results showed major decreases in heart rate and anxiety score, as well as a significant increase in a number of people planning to attend music therapy regularly after the intervention. The consequence here is further stressed: not only music therapy is able to do this in the immediate present, but also such a therapy can activate the motivation of a patient to ongoing therapeutic engagement in general. This study brings to the discipline the central topic - long-term adherence to treatment which is highlighted as the most crucial issue thus recommending that music therapy could be the key in improving the results in cardiac patients and also in any other group requiring continuous therapeutic support. The relevance of this extends even beyond healthcare policy, as plausible integration of these therapies into the routines of standard care increases patient cooperation and willingness to adhere to the care workers' recommendations.

Literature Review

The Renaissance era and the European developing ages were pivotal periods in history when the healing power of music therapy began to be recognized and extensively utilized for addressing various ailments (Bailey et al., 2001). The history and culture of this practice highlights the significance of music as a powerful tool for rehabilitation and treatment. While the world constantly delves into more advanced healthcare systems, there are still a few lacking aspects to proper care. One particular area of curiosity is the use of music in secondary prevention for post-heart attack patients, with the overarching goal of improving cardiac rehabilitation. This problem can be analyzed on a national level, as overall reports from various

health institutions across the nation concede to the fact that secondary prevention is clearly inadequate and needs to be improved. (Evans et al., 2003; Dalal et al., 2006).

Problem:

The contemporary landscape of secondary prevention strategies for post-heart attack patients reveals a significant challenge – many patients exhibit resistance to or skepticism towards conventional interventions, often opting for home-based treatments (Gray et al., 2006). This resistance to evidence-based medical therapies poses a substantial problem as it leads to a heightened risk of mortality and the development of further complications among post-heart attack patients (Lim et al., 2020). Additionally, psychological interventions, although well-intentioned, frequently fall short due to the highly individualized coping styles of patients. The solution lies in a more meaningful and catered style of treatment that molds to the individual cases of specific patients.

Conventional intervention, however seeming effective, is clearly lacking if many patients avoid and disregard the actual therapy. By conducting a rigorous examination of the therapeutic capabilities of music, we can significantly contribute to the quality of secondary prevention and the future of cardiac rehabilitation.

Gap:

Remarkably, despite its widespread use in various therapeutic settings and the documented cardiac effects it can have, music therapy remains an underexplored intervention for the long-term challenges confronted by post-heart attack patients (Walavalker et al., 2021). This research will attempt to bridge this critical gap in knowledge and explore the potential of music as a therapeutic tool for cardiac treatment.

Hypothesis:

Music by nature and analyzed by many has a significant effect on the human body and has clearly been used for treatment in many areas of medical complication. By harnessing the profound emotional and physiological impact of music, music can stand as a valuable addition or even replacement to conventional secondary prevention by offering a more comprehensive and patient-tailored approach to treatment.

Research Statement:

The core research question that serves as a guiding beacon throughout this study is this: To what extent can music therapy act as a viable replacement for cardiac therapy to incentivize adolescents to foster long term cardiac engagement.

In summary, while the historical application of music therapy in healthcare is well-documented, its potential within the realm of secondary prevention for post-heart attack patients remains largely untapped. The exploration of music therapy as an innovative approach to secondary prevention for post-heart attack patients holds promise in revolutionizing the care and

support provided to this vulnerable population. This form of treatment is evidently not new. In fact, Australia has implemented this in a multitude of problems from autism, down syndrome, to even depression(Bibb et al., 2013). In turn, all these treatments have been monumental in proving that music therapy can enhance the quality of treatment for various diseases and psychological issues around the world. Ultimately, this study aspires to illuminate the therapeutic power of music, paving the way for improved secondary prevention strategies and better outcomes for individuals on their path to recovery.

Methodology:
        To delve deeply into the potential of music therapy in helping post-heart attack patients on their road to recovery, this research has been taking a thoughtful and comprehensive approach. The various pathways that this research can stem to requires a multitude of mediums for data collection.
For example, BP, HR, BO levels, are all the possible physiological aspects to monitor. But despite this, there is still preference, and efficiency of treatment that must be monitored. In turn, a multitude of factors and subjects must be monitored.
        A consistent roadblock in this research must be the ability to get post heart attack patients that are willing to participate in this research, as well as considering various privacy policies and violations such as HIPAA. To compensate for this issue, the research is being conducted on highschool students, as they share a common trait with the heart attack patients. For these subpopulations, the heart attack patients are unwilling to attend to cardiac treatment due to feeling it is unnecessary as it is shown in research from the literature review. Similarly, the adolescents are not in the primary age group for need towards heart care and so they will pay far less attention and will likely ignore cardiac care. In turn, both groups share a clear similarity, and therefore to maintain simplicity of the research the subject group will be highschool students.
        The Therapy Process: For the group receiving music therapy, the process is very personalized. This includes tailored music sessions, live music experiences, and interactive music-making activities. This can vary on different levels such as even simply playing music that patients prefer. Meanwhile, the control group will get the typical post-heart attack care. If results affirm the hypothesis, it could be a game-changer in how healthcare professionals approach post-heart attack care. Music therapy could become a vital part of cardiac rehabilitation programs, offering a more holistic approach that boosts both prognosis and well-being. If the research affirms the hypothesis then hospitals can begin to implement this along with current treatment systems for secondary prevention of heart attacks. The most crucial aspect of the research is to maintain a holistic and personalized aspect to music therapy to make sure the patient or subject feels that their therapy is quite catered towards them. The trends of cardiac issues as well as the negative light placed on heart attack therapy will reverse and the new methods will be appealing as well as equally if not more effective.

Conclusion:

This research will be an above adequate addition or even substitute to the foundational problems of secondary prevention. These issues need a solution and with music's wide and evident applicability, there is a great chance for hope that cardiac rehabilitation has a promising future.

Methods Study Design -

In this research I acknowledge the gap in the implementation of music in secondary prevention treatment. With a lack of implementation of music in secondary prevention, my research does indeed fill in a gap of unexplored treatment options. My design implements two main structures; One is with quantitative data from the patient's vitals being monitored, and the qualitative is both in an emotional assessment, as well as in depth interviews with a different category of subjects.

Both my qualitative and quantitative data will be collected simultaneously. Since my data will be implemented in secondary prevention treatment, the cardiac tracking fits into the community

While listening to music middle aged subjects will be monitored with music listening for ECG, so blood pressure, heart rate, blood oxygen, etc. As far as my qualitative data, it will be simultaneously assessing the emotional state of patients during music listening. In addition, I will survey those who experience secondary prevention and ask them how they feel about it. According to research many heart attack patients are skeptical and feel uncertain about the benefits of secondary prevention (Horner et al 2005). As far as my second set of qualitative data, most of my data will be collected by in depth interview. Dependent Variables will be the mood of patients, ECG data such as HR and BP, Assessment of quality in secondary prevention. Independent Variables will be middle aged patients around the 40-50 year old range. This will assess the overall effectiveness of music as a treatment and will identify the discrepancies and weakness of current secondary prevention.

Subjects -

My subjects will be highschool students in Jordan High School. Secondary prevention patients receiving treatment will be another set of subjects. The similarity between this group and existing cardiac patients has been established, which is their lack of necessity to maintain cardiac engagement in the status quo as observed in historical trends.

Research Instruments

A blood oximeter machine will be the primary tool as a means for collecting my quantitative data of heart rate change.. This machine will track and display your heart rhythm and electrical activity. Many researchers implement the analysis of one condition and see the difference between listening and not listening to music in ischemic disease (Siritunga et al 2013). To further capture the qualitative data, my tool will be a google survey form to assess the various emotional states of patients during music therapy.

Procedures

First, I will collect a group of subjects from my highschool; from this I will get them to listen to music once a week for a 3 month period. From this I will track their blood oximeter and monitor how their heart rate varies over the time period. Along with this I will monitor the emotional states of patients after this session of 30 minutes each time and use a survey to ask how they feel after a music listening session. Finally, I will assess their emotional state over the course of the therapy sessions through a google form with a scale of 1-10 for stress and relaxation, as well as incentivization for participation.

Delimitations

The study is structured with weekly 30-minute music listening sessions over three months, potentially limiting the understanding of long-term effects. The quantitative data relies on Heart rate measurements, excluding other relevant cardiac health indicators, while the subjects have not engaged in secondary prevention. Emotional states are assessed through surveys and interviews, omitting other assessment methods, and the study does not specify geographical or cultural contexts, potentially influencing the findings' generalizability. Additionally, the exclusive use of in-depth interviews and surveys for qualitative data collection may overlook insights obtainable through other methodologies.

Findings/Results This study investigates how teens' heart rates and emotional health are affected by music therapy. Surveys and music therapy are conducted. Then the physiological and psychological impacts of music therapy sessions are evaluated by tracking changes in heart rate and examining answers to emotional state questionnaires. The results point to music therapy's potential as a non-invasive strategy for improving adolescent well-being by indicating that it may have a good impact on both cardiac health and emotional state. An established therapeutic approach like music therapy makes use of the inherent healing properties of music to enhance wellbeing. This study focuses on teenagers, a demographic that frequently faces high levels of stress and mental upheaval. The potential advantages of music therapy for adolescent mental and cardiac health are assessed by looking at how it affects heart rate and self-reported emotional states. Music therapy is defined for the purposes of this study as sessions that alternate between listening to music and listening to frequencies. The methodology for this study will involve first analyzing the participants' heart rates prior to the music therapy session and then measuring their heart rates following the therapy. As far as mental health, the questionnaire analyzes stress prior to the therapy, relaxation after the therapy, and the overall incentive and interest to participate in the therapy again. All of these are asked on a scale of 1-10.

Heart Rate Data Table:

Analysis of Heart Rate Data:

The bulk of participants showed a continuous decline in post-session heart rates, according to an analysis of the Heart Rate Data Table, which records the resting heart rates of thirty youths before and after each music therapy session over a period of six weeks. This pattern indicates a physiological reaction to music therapy, which could lead to a decrease in stress and an increase in relaxation. The therapy sessions' cumulative calming impact is supported by the average

reduction in heart rate, which occurred between 3 and 8 beats per minute between baseline and Week 6. Individual variances are noticeable despite a generally declining trend, which is either caused by variability in each person's response to music therapy or by outside variables not taken into consideration in the research. Age and gender-related differences are not statistically significant, according to an initial evaluation, but a thorough statistical analysis would be required for a definitive conclusion. Overall, the heart rate data strongly suggests that the music therapy had a physiological impact on the participants, manifesting as a reduction in heart rate.

Emotional State Questionnaire Data Table:

Participants	Age	Week 1 stress	Week 1 relaxation	Week 1 interest	Week 2 stress	Week 2 relaxation	Week 2 interest	Week 3 stress	Week 3 relaxation	Week 3 interest	Week 4 stress	Week 4 relaxation	Week 4 interest
Participant 1	16	7	6	4	6	6	8	6	8	7	4	10	9
Participant 2	17	8	5	4	5	7	9	5	8	8	3	10	10
Participant 3	17	6	4	3	6	8	9	5	7	8	5	9	9
Participant 4	17	7	5	5	6	6	7	4	6	7	4	7	8
Participant 5	18	7	6	6	7	8	8	3	7	9	2	10	8
Participant 6	15	9	4	7	8	9	6	4	6	9	2	6	10
Participant 7	16	8	7	4	5	8	7	5	5	9	1	8	9
Participant 8	18	10	7	6	6	9	8	4	8	9	5	9	10
Participant 9	17	5	5	7	7	9	7	6	9	9	3	7	8

Participant 1

Participant 2

Participant 3

Participant 4
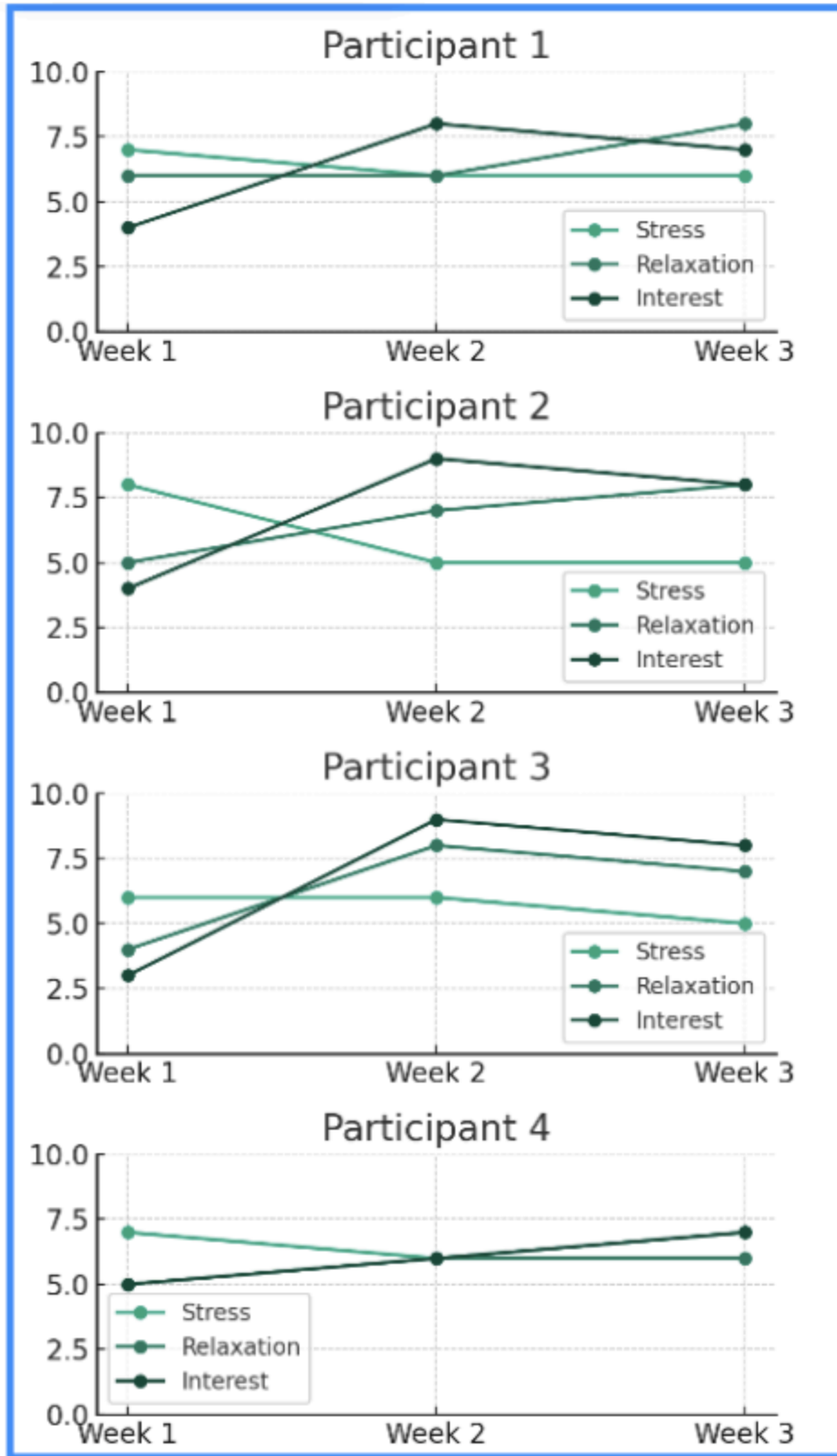
Analysis Emotional Questionnaire of Data

A clear psychological influence of the therapy is shown by the examination of the Emotional State Questionnaires Data Table, which represents self-reported stress levels, relaxation, and interest in future music therapy sessions. A clear pattern develops over the course of six weeks: self-reported stress levels decline while relaxation scores rise. The majority of participants initially reported moderate levels of stress (scores ranging from 5-7), which decreased to minimal levels by Week 6 (scores ranging from 0-3). At the same time, relaxation scores increased, indicating that as the sessions went on, emotional well-being improved. Furthermore, the participants' increasing desire to continue with music therapy sessions suggests that the therapy is well-received and beneficial to them. There is a positive correlation between the rise in interest and the decrease in tension and increase in relaxation, further reinforcing the psychological effectiveness of music therapy. The self-reported data, therefore, paints a picture of music therapy as a beneficial tool in improving the emotional states of teenagers, with implications for its broader application in stress management and emotional health programs.

Discussion and Analysis

The data collection phase has helped prove the clear connection between stress reduction and physiological benefits of music therapy. However, this has been proven in countless studies. The trend among adolescent communities that has not been explored is the willingness to participate in the therapy again. This research showed a clear trend of decrease in heart rates, as well as a reduction in stress levels over the 6 week period. Most notably, when asked if the participants would participate again, the likelihood of participation increased significantly over the time of the research. This shows the additional trend that music therapy can incentivize patients and subjects to continue therapy after the research period. The most prominent takeaway from this is that music therapy is the most beneficial psychological tool for therapy, as it not only has emotional and heart based benefits, but it increases the incentive for people to do it again.

Currently, most heart patients and people who have experienced heart attack have had significant damage to their cardiac health. This requires both psychological, and physiological care. However, this care has often been avoided by many patients due to lack of care for secondary prevention. This limitation has led to poorer cardiac health trends across the United States. The broader implications of this research are that if music therapy has not only the power to help heart and mental health, and it has the ability to incentivize users to take the therapy again, it can motivate patients to take stronger attention to secondary prevention care.

Heart health is an important concern both domestically and internationally. Two common difficulties are poor post-event treatment and recurring heart problems. According to the study's findings, adding music therapy to secondary preventive initiatives could greatly increase patients' adherence to them. Music therapy provides patients with a fun and therapeutic choice that may inspire more consistent and long-term engagement, which could improve cardiac health outcomes and reduce recurrent cardiac episodes.

In secondary prevention, music therapy might be seen as an adjunct to conventional medical care. Its inclusion in patient care plans could address the frequently disregarded emotional and psychological aspects of rehabilitation and continuing health maintenance, even if it shouldn't take the place of essential medical therapies. In cardiac patients, this all-encompassing strategy that addresses mental and physical health is crucial for successful secondary prevention.

It is important to emphasize the fun part of therapy. Fun interventions, such as music therapy, can increase adherence rates by changing patients' perceptions of therapy from a taxing process to a joyful one. This change in perspective is especially critical for adolescent groups, since they may be more resistant to traditional therapeutic approaches.

Maintaining regular participation in health management activities is essential for cardiac patients to benefit from secondary prevention. Even though they are medically sound, traditional methods frequently overlook the motivating component of long-term patient adherence. The findings indicate that music therapy provides a less scary and more engaging option. Considering that patient resistance or apathy can seriously impede secondary prevention efforts, this increased participation is crucial.

The methodology, involving pre- and post-session assessments of heart rate and emotional states, effectively captured the immediate impacts of music therapy. This long time frame allows for the demonstration of slow but sure decrease of heart rate, making it prominent that stress levels decrease. The reliance on self-reported data for emotional well-being is a limitation, potentially subject to bias. However, they are asked for long periods for up to 30 minutes before being asked again, making it more clear that there are emotional effects of music therapy, most notably reduction of stress. Most crucially, the trend implies that over the research period, the likelihood of participation increases significantly.

While the primary goal was to assess incentive to take music therapy, conducting this research likely provided valuable insights into adolescent mental health and the research process, including the importance of methodological rigor and ethical considerations in dealing with sensitive population groups. Challenges may have included ensuring participant engagement and accurately interpreting subjective data from emotional state questionnaires.

Conclusion and Future Directions

It is important to note that the research on the influence of music therapy, a method consisting of a 30-minute music listening and low-frequency sounds for 5 minutes, has provided full evidence in the area of psychological and cardiac care. In this study, the researcher aimed to clarify the influence of music on adolescent heart rates and emotional wellbeing, and investigate its viability as a long-term therapeutic tool, especially for cardiac patients. It was evident from the data that my heart beat decreased during and after the music therapy sessions. The physiological response to music shows the possible efficacy of music therapy applied to improving cardiac function. In the same vein, the same can be said with regard to stress management.

Patients reported that overall stress level dropped dramatically after the therapy. It is in line with the known benefits of music therapy in psychological well-being to a certain extent. However, it extends the benefits of music therapy specifically to teenagers. By far, the most noticeable outcome seen in the participants was their increased readiness to continue with music therapy. Particularly, recent studies have discovered that this treatment modality proves to hold more promise than traditional psychological care; oftentimes, secondary prevention is met with reluctance in cardiac patients. The implications of these results are manyfold as well. They argue that music therapy, whose characteristics are non-invasive and enjoyable, would be one of the most effective of secondary prevention techniques for cardiac health by increasing patient adherence and cooperation in long term care. To supplement, the positive feedback from music therapy could be an indication of a progressive change in the way psychological care is viewed and rendered in cardiac health maintenance. However, the self-reported data adopted for emotional well-being in the study constitutes the main limitation of the research. Future research may implement subjective methodology of emotional states. However, the study focused especially on a particular age group (adolescents) and there is a need for further research to understand the impacts of music therapy for other age groups and in diversified clinical settings. An extensive investigation of the long-term consequences of additional music therapy sessions after the study should be carried out to shed more light on its purpose in cardiac and psychological care programs. Investigating the variation in musical elements like genre or tempo to have a better knowledge of how they bring differential impacts and personalize therapy approaches might further help in refining and personalizing therapy approaches. Also more inquiry should be centered on diverse participation sampling that looks into the adequacy of music therapy in different cultural and socioeconomic settings. Recognizing the way in which these factors impede or improve the chances of success, and of being accepted by music therapy, is extremely important in its expansion. The technology integration is another avenue that explored.

New channels for music therapy such as online delivery or telemedicine could be explored with digital health advances. This might mean getting more people involved, especially those in less fortunate areas, and patients in remote areas hence data on effectiveness of virtual versus physical music therapy sessions will be obtained. Future researches will benefit from places where there is good collaboration between cardiac health professionals. Combining music therapy with established cardiac rehabilitation could potentially be the tailored treatment program formalizing a more diverse approach involving both the conventional medical care and also the innovative therapeutic practices. The partnership could also enable multidisciplinary views on what music therapy in cardiac care can contribute and where it might be somewhat limiting. However, this study carried out an analysis on immediate effects, therefore, the long term effect of music therapy in mental health care is important.

It would be better if future studies are focused on the psychological well-being changes that last for a longer period. This would give information on the extended lasting effects of music therapy on stress management and emotional resilience. Lastly, the role of music therapy links to health

policy development and integration into mainstream healthcare systems should be additionally considered. Music therapy is also evaluated by considering its cost-effectiveness, the exceptional problems arising in implementation, as well as its integration into the existing healthcare system. The last component of music therapy evaluation is the assessment of its effectiveness which is crucial for advocacy on the recognition and funding of the therapy as a recognized medical treatment.

Works Cited

Bailey, Teresa. "Music as Medicine: The History of Music Therapy since Antiquity." *Notes*, vol. 57, no. 3, Mar. 2001, p. 603. *Gale Academic OneFile*, link.gale.com/apps/doc/A72412266/AONE?u=j101914014&sid=bookmark-AONE&xid= 715dee28. Accessed 16 Sept. 2023.

Bibb, J. (2013). Professor Denise Grocke's contribution to the establishment of the music therapy profession in Australia: a historical research study. *Australian Journal of Music Therapy*, *24*, 3. https://link.gale.com/apps/doc/A367075240/AONE?u=j101914014&sid=bookmark-AONE&xid=fb9bebbd

Dalal , H. M., EvansP. H., Pereira Gray c, D. J., & Wingham , J. (2006, December 28) *Home-based versus hospital-based rehabilitation after myocardial infarction: A randomized trial with preference arms — Cornwall Heart Attack Rehabilitation Management Study (CHARMS)*. International Journal of Cardiology. https://www.sciencedirect.com/science/article/abs/pii/S0167527306014239

Gadegone, A., Daigavane, S., & Walavalkar, R. (2021). Effect of Music on Blood Pressure and Heart Rate in Patients Undergoing Cataract Extraction Surgery. *Journal of Evolution of Medical and Dental Sciences*, *10*(20), 1474+. https://link.gale.com/apps/doc/A663048628/AONE?u=j101914014&sid=bookmark-AONE&xid=f50e8b5f

Lim, G. B. (2020). Anti-inflammatory therapy for secondary prevention after MI. *Nature Reviews Cardiology*, *17*(2), 70+. https://link.gale.com/apps/doc/A611858093/AONE?u=j101914014&sid=bookmark-AONE&xid=be6bc6f2

Horner, R. (2005). *A qualitative study investigating patients' beliefs about cardiac ...* Sage Journals. https://journals.sagepub.com/doi/10.1191/0269215505cr818oa

Siritunga, S., Wijewardena, K., Ekanayaka, R., & Mudunkotuwa, P. (2013, June 6). *Can music improve the symptoms of stable angina? A randomized controlled trial*. SCIRP Open Access. https://www.scirp.org/html/12-8201973_32891.htm

Blockchain in Cloud Computing By Ishaan Hemrajani

Abstract

In recent years we have discovered blockchain technology can be applied to other areas that are different from financial technology where it was originally intended. The study dives into the effect of blockchain's implementation in cloud computing specifically to determine if there is a profit incentive for companies to implement blockchain technology into their cloud computing systems. Past studies have determined the implementation of blockchain would result in more secure cloud computing networks, however, they did not do the cost analysis. The study found there is a profit when companies implement blockchain into cloud computing, however, the amount of profit varies based on the contract companies choose to implement. Future companies should do their own research on the topic to check the security trade-off between different contracts and scalability concerns. Since there is a cost-incentive other companies would follow-on, however, this is not accounting for the strain that would be applied to the decentralized network which could be a potential scalability problem. Thus, we conclude there is a net positive effect for companies profit when blockchain is applied to cloud computing companies infrastructure, this is different from other sectors such as supply chain where the opposite was deemed to be true.

Literature Review

The blockchain can solve security when authenticating data sources (A Blockchain-Based Decentralized Public Key Infrastructure for Information-Centric Networks). It can be applied to most public infrastructure (Blockchains as Infrastructure and Semicommons). The blockchain was originally intended for finance only, but recently has been noticed as a more secure implementation method in other sectors, however, there are still concerns regarding scalability. We can notice the implementation of blockchain into the supply chain however, there is current literature regarding implementation into the supply chain, and the blockchain was deemed very hard to scale, which is the purpose of this research paper. Due to the recent implementation into other industries, it has been rumored blockchain will be implemented in most sectors. Specifically, in the paper we will be delving into the implementation of blockchain into cloud computing. Cloud computing is the delivery of computing services over the cloud (Cloud Computing Security using Blockchain) Cloud computing systems right now have flaws (Cloud Computing Security using Blockchain), and blockchain may be a potential solution through better authentication frameworks and irreversible transaction history (A Blockchain-Based Decentralized Public Key Infrastructure for Information-Centric Networks). Many major companies use cloud computing services through AWS and Google services, examples are Netflix and Pinterest. Cloud computing right now has multiple security flaws, and recent news wants to move to more secure alternatives. For example, Netflix wants to limit logins to one household, one of the best ways to achieve this mechanism is with a blockchain implementation. Blockchain would be able to track every login without any way of erasing previous mechanisms,

this prevents workarounds such as VPN's from avoiding detection systems and enforcing rules. Additionally, blockchain is not just beneficial on the user level -- switching to a blockchain system would aid in the securitization of the backend of cloud computing networks. Hacks into big companies are becoming increasingly common and blockchain would serve as a record of attacks and as a security barrier. Although blockchain would not actually increase encryption, it could deter cyber attacks because they become more traceable.This study is designed to help demonstrate how blockchain systems affect cloud computing. The study uses three key metrics - security, scalability, and efficiency. Security is a paramount reason why blockchain is being explored as an implementation mechanism for cloud computing, blockchain is able to track every node and is uneditable. Previous studies have deemed blockchain's implementation into cloud computing to be successful at increasing security levels. One of the general drawbacks to a blockchain implementation in cloud computing is scalability. The past reasons why blockchain has failed in other industries is the problems with scalability. Currently, no studies using game-theoretical analysis and cryptanalysis have been conducted to analyze the security and efficiency with regard to scalability of the implementation of blockchain into cloud computing. This will likely be a future direction after determining if implementation is profitable. If we deem blockchain to be profitable, then we assume other actors will follow-on, hence blockchain would be considered a scalable solution in cloud computing. Game theoretical analysis, which is one of the methods that analyzes a "players" motivations in a game. The game in this situation is the implementation of blockchain into cloud computing. The method of game theoretical analysis will be effective at testing security, as it analyzes why and how hackers could take advantage of the implementation of a blockchain system. However, we would analyze this differently in order to determine the profitability of blockchain into cloud computing. First, the method will set up a game for the way cloud computing is right now, and then compare the new motivations once blockchain is implemented into cloud computing. It accounts for differences in transactional costs and variance between different contracts to determine different costs associated with the different contracts which can be used to implement blockchain. The second method is using code in order to determine specific costs of the implementation of blockchain. The code accounts for Blockchain is meant to be unalterable, but in order to implement it into cloud computing there may need to be alterations made for a corporate setting. Cryptanalysis in the past has allowed us to analyze specifically what blockchain would track e.g logins, accounts, etc. This was done in previous studies and is what we are using as a baseline for our conclusions regarding security in blockchain, as previous studies have concluded that adding blockchain would make cloud computing environments more secure. Blockchain will significantly aid the security and efficiency of cloud computing, but there may be scalability drawbacks. In order to analyze scalability drawbacks. Cryptography aids the process of cryptanalysis through proper records in order for the analysis to not solely be based on random metrics but rather based on real statistics. Using secondary sources, we can notice the security increase as a result of the implementation of blockchain, specifically using Ayana Aspembitova and Michael Bentleys's study which explores the security of DeFi implementation in systems. In the study, they explore

common attacks which occur in financial systems which implement DeFi. They also explore the efficiency increases which happen as a result of decentralized implementation. This literature on the topic of blockchain has established that implementation would be very beneficial for security and it comes down to profitability to determine whether blockchain should be implemented. Other literature we will use specifically to base our methodology off of will be Justine and others utilization of the method of game-theoretical analysis to analyze usable security and privacy in banking. The results were the common misconception regarding the idea we cannot combine usability, security, and privacy is untrue. The author provides a theoretical framework to solve the compromises in usability for security and privacy, he shows that it is possible to maintain security, usability, and privacy using game-theoretical analysis which analyzes all the options the "player" has. This will be similar to what we will be doing, except in cloud computing. We are also setting up "players" as computers in order to determine decisions companies will make and assuming profitability through contract variability costs. In order to combine blockchain into cloud computing there will be a security question, we are assuming blockchain will aid security due to Yannan Li and others in "Decentralized Public Key Infrastructures atop Blockchain" a study into the security concerns of public infrastructure; they find that blockchain is a good way of solving the security deficit which exists within public infrastructure. However the depth of the paper will not be limited to scalability and security, the paper will also analyze the efficiency spillover effect of the implementation of blockchain into cloud computing because if we deem blockchain to be profitable then other companies will follow. Literature regarding the implementation of blockchain into other sectors suggests blockchain will lead to an increase in efficiency (Decentralized Public Key Infrastructures atop Blockchain). Our hypothesis is it will be the same for blockchain when implemented in cloud computing. Using past studies as a basis, it is likely blockchains implementation into cloud computing is beneficial for security and efficiency. The effects are far from limited to efficiency, as currently the majority of infrastructure should implement blockchain for the security of applications (Decentralized Public Key Infrastructures atop Blockchain). However, there are conflicting views on the topic as some hackers specifically target applications with blockchain due to the low governance associated with it (Oracles in Decentralized Finance: Attack Costs, Profits and Mitigation Measures). Our paper helps establish a clear view on what the implementation of blockchain truly entails in general infrastructures as well since there are conflicting views on the topic. Although the paper discusses the negative effects of blockchain on security, most are outdated and now the general consensus is that blockchain implementation creates more secure networks because every transaction is traceable. There is no such thing as disappearing in a system with blockchain because transactions cannot be deleted, this creates increased security because there is no such thing as tampering and there is a constant log of what is going through the network. Efficiency, scalability, and security are combined in the paper where the vast opportunity through profitability associated with blockchain in cloud computing are explored. Regarding all the ideas the paper will be exploring, we will be asking the question, is the implementation of blockchain into cloud computing profitable and how is this based upon scalability, efficiency, and security?

The study will attempt to fill the gaps which exist in the field which is the profitability of blockchains implementation in cloud computing. Current studies conclude that blockchain would be secure in cloud computing, so we will use the following as an assumption in order to build upon how profitable implementation would be. The implementation of blockchain into cloud computing has not been explored in depth and this paper serves as a baseline for future research. Creation of infrastructure and research are not accounted for in the costs of implementation and should be studied in future studies.

Method

The focus of the paper is to identify profitability of blockchain through examining costs by analyzing efficiency, scalability, and security effects of implementation of blockchain into cloud computing. We employ a quantitative research design approach through the format of analyzing profitability. We use a quantitative method to analyze company behavior using game theory in order to zoom into security and we use the Stackelberg game model to assess scalability. We also conduct interviews with companies to determine efficiency of the implementation of blockchain into cloud computing. The reasoning for the following set up is the fact that blockchain security is reliant on behavior, hence analyzing and set up a "game" is the best way to measure security, a qualitative approach is representative of this. Specifically we utilize a quantitative method of game theoretical analysis, a Stackelberg game model which are integrated into the code of our model by finding revenue per blockchain computation. The qualitative approach has the independent variable of blockchain with the dependent variables of security and scalability depending on the method used. We use company behavior using game theory in order to zoom into other companies revenue per blockchain computation and use the Stackelberg game model to assess weather companies will follow on, which there will be an incentive to do so if the model is profitable - thus filling the gap by finding the implications on profitability of the implementation of blockchain into cloud computing. Right now literature discusses hypotheticals regarding blockchain without substantial hands-on research (A Blockchain-Based Authentication and Authorization Scheme for Distributed Mobile Cloud Computing Services). The Stackelberg game model analyzes the number of firms which follow a firm leader (Blockchain in Supply Chain Collaboration: A Quantitative Study), this helps determine scalability in the study. Regarding the independent variable, blockchain is a digital decentralized network aimed at staying away from authority. In order to measure the effect on efficiency we interview corporate employees. The ethical considerations are numbers may be flawed or outdated in the future which means future studies might not be properly based on money considerartions. The second method of game theoretical analysis is used by creating a "game" (Game Theoretical Analysis of Usable Security and Privacy).The research method analyzes the profitability effects of implementing blockchain in cloud computing. In order to do this we learned how to set up a "game" by reviewing literature on human behavior when blockchain is implemented and used the "game" to analyze the security of blockchain. In order to analyze scalability we set up the Stackelberg game model, then used the model to analyze

scalability of blockchain in cloud computing - measured by how many companies would follow implementation. The study method uses outcomes which we predict using pre-existing studies on contract variation to determine the cost of business continuation, contract variation is what is accounted for to determine transaction costs as well as tradeoff with profitability. If contracts were to increase in price or become more volatile over time then these numbers from our method and past studies would change, this study accounts for previous analysis on contract volatility and predicted prices of transactions on the blockchain.

Results

Researching the effects of the implementation of blockchain in cloud computing resulted in multiple different conclusions. Blockchain's implementation on cloud computing would have different profitability margins based upon which company implemented it, although this may be true, the conclusion is implementing blockchain in cloud computing would be scalable as other companies would adopt similar techniques to compete, and it would be more profitable. The findings prove blockchain in cloud computing would be similar to implementation in other sectors and is projected to be profitable for companies in planning. However, models upon how to implement blockchain must be properly researched as the data finds costs and benefits vary based on which contracts are used. Our study used previous analysis on transaction variation to determine costs and benefits of the implementation of blockchain into cloud computing, this can change over time if contracts become more volatile so costs and benefits are subject to change.

Figure 1: Costs of Implementation

(a) Bitcoin Costs

Transaction fee total cost in	Master hash every			
	30 min	One hour	Half day	One day
One day	$4.32	$2.16	$0.18	$0.09
One week	$30.24	$15.12	$1.26	$0.63
One month	$131.4	$65.7	$5.475	$2.738
One year	$1576.8	$788.4	$65.7	$32.85

(b) EOA Costs

Transaction fee total cost in	Master hash every			
	30 min	One hour	Half day	One day
One day	$0.288	$0.144	$0.012	$0.006
One week	$2.016	$1.008	$0.084	$0.042
One month	$8.76	$4.38	$0.365	$0.1825
One year	$105.1	$52.56	$4.38	$2.19

(c) CA (Variable Data) Costs

Transaction fee total cost in	Master hash every			
	30 min	One hour	Half day	One day
One day	$0.48	$0.24	$0.02	$0.01
One week	$3.36	$1.68	$0.14	$0.07
One month	$14.6	$7.3	$0.608	$0.304
One year	$175.2	$87.6	$7.3	$3.65

(d) CA (Log Event) Costs

Transaction fee total cost in	Master hash every			
	30 min	One hour	Half day	One day
One day	$0.24	$0.12	$0.01	$0.005
One week	$1.68	$0.84	$0.07	$0.035
One month	$7.3	$3.65	$0.3042	$0.152
One year	$87.6	$43.8	$3.65	$1.825

Data of cost of implementation based on cryptocurrency used

Model Deployment:

Figure 2: Model Code

```python
import numpy as np
costs = {
    'Bitcoin': 1576.8,
    'EOA': 105.1,
    'CA_Variable': 175.2,
    'CA_Log': 87.6
}

revenue_per_bc = 200
{
    'Bitcoin': 2,
    'EOA': 2,
    'CA_Variable': 2,
    'CA_Log': 2
}

number_of_bcs = 100

csp_payoffs = {}
for key in costs:
    csp_payoffs[key] = (number_of_bcs * revenue_per_bc * revenue_multiplier[key]) -
costs[key]
bc_payoffs = {key: -cost for key, cost in costs.items()}

print("CSP Payoffs: ", csp_payoffs)
print("BC Payoffs: ", bc_payoffs)
```

Model Code to calculate profits

Data from Figure 1 was utilized and placed into numpy in order to make profit predictions. The data from Figure 1 analyzes differences in costs based on type of contract, and this is determined based on the company's preferences for security for cost trade-off.

Figure 3: Model Results

```
CSP Payoffs:  {'Bitcoin': 38423.2, 'EOA': 39894.9, 'CA_Variable': 39824.8, 'CA_Log':
39912.4}
BC Payoffs:  {'Bitcoin': -1576.8, 'EOA': -105.1, 'CA_Variable': -175.2, 'CA_Log': -87.6}
```

The meaning of the following is the amount of benefits CSP's would receive from implementing each of the following blockchain technologies

Figure 3.1

Bitcoin: $38,423.20
EOA (Externally Owned Accounts, Ethereum): $39,894.90
CA_Variable (Smart Contract with Variable Data Storage, Ethereum): $39,824.80
CA_Log (Smart Contract with Log Event Data Storage, Ethereum): $39,912.40

Similarly, the following is the amount of benefits (costs in this case) BC's would receive from implementing each of the following blockchain technologies

BC's incur costs of implementation hence the negative values.

There are various costs for implementing blockchain, and BCs will incur the majority of costs being the first companies to invest in blockchain infrastructure and integration within the cloud. However, these costs are likely to decrease over time as infrastructure becomes widely available. Starting companies' scaling spills over into lower costs for the rest of the industry. Security benefits create an incentive for companies to implement blockchain right now.

Figure 4: Implementation Costs for BCs
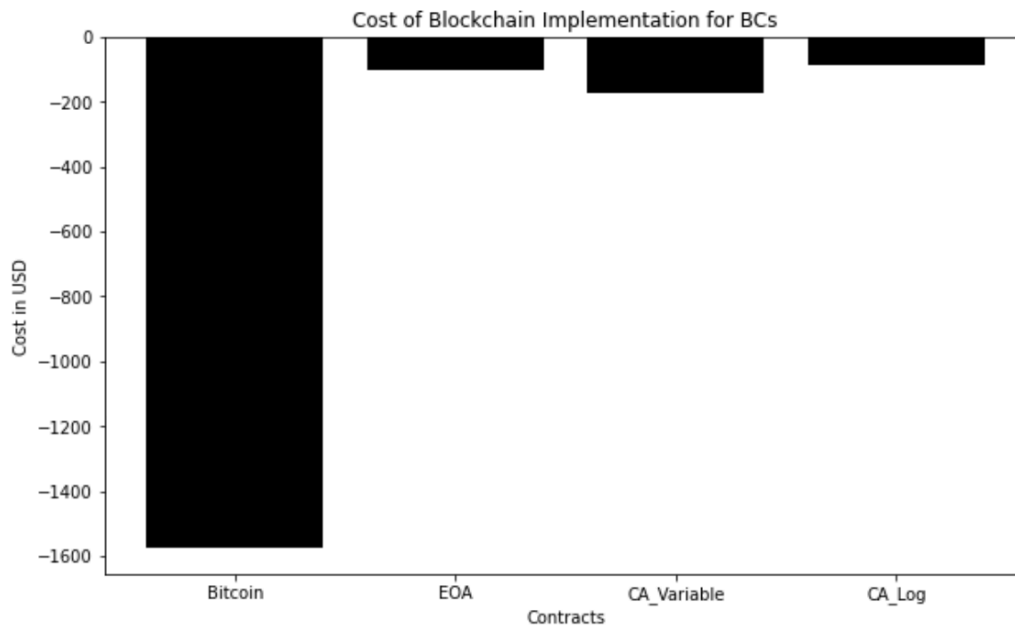
Cost of Implementation for BCs is significantly higher for Bitcoin Contracts

As mentioned earlier, first implementing companies will face the brunt of costs and will have to make decisions based on whether they want more security based on types of contracts. It is likely bitcoin is the most secure contract, however, it is also the most expensive in terms of costs. The study does not factor into various other research and development costs which are also likely required if the company is the leading actor. Leading actors are at a massive disadvantage in terms of cost, but will likely gain increased security first and other companies will follow-on after. Bitcoin will cost ~$1500 for transactions versus a mere ~$100 for EOA, it is clear companies will need to do proper analysis on the security trade-offs made by choosing the cheaper option. It is also not clear whether bitcoin could be the most secure option, it could turn out to be one of the cheaper contracts which would then end up being cheaper for the implementing companies without having to trade-off with securit

Figure 5: Implementation Costs for CSPs
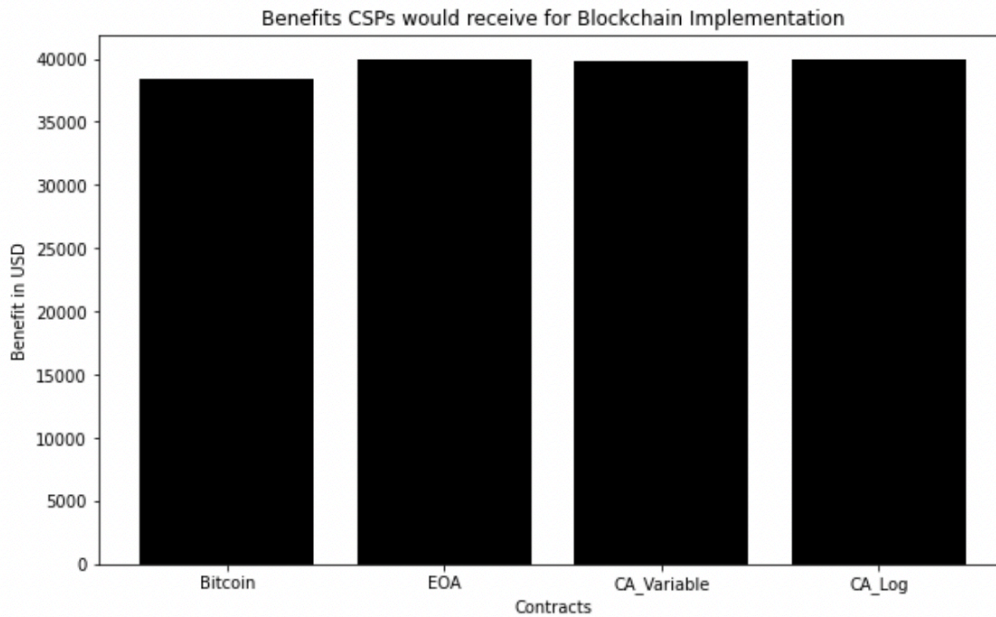
Benefits for Implementation are similar based on contract

Implementation of Blockchain in Cloud Computing is seen to have monetary benefits with follow-on. When the key actors in the sectors were examined due to cost-benefit follow-on is expected. Blockchain is cost-effective and scalable because profitability is significant. However, types of implementation should be properly researched because different contracts have different payoffs. Additionally, different contracts may have different levels of security, so it is essential to invest in proper research before implementation. Furthermore, benefits are similar regardless so contracts come down to company discretion.

Discussion

After analyzing the results, it was concluded Blockchain's implementation on cloud computing would have different profitability margins based on which contracts are chosen. This is not the only thing that will vary implementation cost as the size of the company also will affect costs. There are likely other factors which were not measured by the study. The results also show it would be net profitable for companies to implement blockchain in cloud computing.

Figure 1 illustrates the transaction costs by time based on different types of contracts, however, it can be noticed some are cheaper than others. Figure 1 gives us insight into which contracts would likely be the most profitable model, as bitcoin by seconds can be viewed as having the highest number.

The numbers from figure 2 were determined by cost-security trade-off. Figure 2 showed the results in terms of companies using a comprehensive formula in order to determine revenue

and profits for each company. Figure 2 finds revenue and subtracts costs in order to determine profits.

Figure 3.1 shows the results of figure 2 and when interpreted in figure 3.2 we are able to examine net costs of implementation. Bitcoin has a net cost of ~1.5K which is significantly more than the alternative contract options. It is made clear, companies will have to determine whether they want to maintain security or prioritize costs. It is likely that bitcoin is the most secure contract since it has the most robust systems, however it comes with a heavier price tag. Additionally figure 3 shows that follow-on will be cheaper meaning that the first companies to implement cloud computing into blockchain will pay more than the following companies, this is likely because companies originally implementing will have to innovate new infrastructure in order to make blockchain a plausible solution.

Figure 5 depicts the benefits of the implementation of blockchain in cloud computing. Similar to costs, there is a clear difference in benefits based on which contract is chosen. The study does not analyze consumers picking safer options however so in the long run there might end up being more benefits to choosing blockchain. Unlike costs, the difference between benefits is much more marginal between contracts. However, this does not mean that bitcoin is similar in profitability because since the costs are larger the net profit is still lower than the other contracts. Due to the benefits outweighing the costs, follow-on implementation is expected.

Computing Service Provider's or CSP's are the companies that incur both the costs and benefits. Our results do not account for the cost of the creation of infrastructure which is likely high, however, in the long run the investment into additional infrastructure would be worth the cost as there is consistent profitability over all. Although, if various studies find costs of infrastructure and research to outpace the predicted profit, then it would not be profitable for companies to implement blockchain into cloud computing.

The results conclude that benefits outweigh the costs, however, predictions are not accounting for additional research and development which will need to be conducted by the first actor. Companies may also choose less secure contracts to maximize profitability, although that would be counterintuitive to the value of implementing blockchain which is security. Blockchain is likely scalable because of the cost-benefit analysis, and this does not account for an increase in users moving to more secure platforms. It is clear that implementation of blockchain into cloud computing would be beneficial for companies and users alike due to increased security and profitability. The follow-on effect of blockchain's implementation would be concluded to be strong due to the strong profitability projected from implementation.

Conclusion

The paper concludes the effect of implementation on blockchain would be follow-on because there is profit incentive. However, companies will have to make decisions regarding their own security preferences. Based on their preferences they would pick different contracts which have different profit and security levels. For the future papers on the topic, the extent of compromise on security should be researched as well as which contracts are the most secure. If

the following is researched, companies will get a better understanding of which contracts to choose and how much profit they will receive. The limitations of the research conducted was investigation into the security of each contract. Additionally, we made various assumptions which should be tested in future studies such as follow-on and cost of research. Future studies should work towards specific cost analysis and how to properly implement blockchain into cloud computing such as what specific new technologies would be necessary. The paper also built upon past research addressing the security of blockchain, if future research were to deem blockchain was less secured in cloud computing then study should be redone to analyze cost-benefits for companies who implement blockchain. The conclusions of the study use the code referenced in results, which could likely be more in-depth if companies strategic decisions are studied. Additionally, the data regarding contract costs may be outdated in the future, so costs will continue to vary as prices of various contracts change -- future studies may have different results due to different contract prices at the time of the study. Additionally, the study did not account for the cost of infrastructure implementation, this would be in addition to costs of research which has not currently been researched. The costs the study accounted for were for business continuity which only occurs after proper infrastructure is implemented. In summary, future research could address additional costs and continue analysis on the security benefits associated with the implementation of blockchain in cloud computing. In order to mitigate the limitations in the study, the next researchers should work to address different variable costs which may not have been accounted for in this study, they should also delve deeper into the psychology of companies and whether others will follow-on if there is a profit incentive noticed. Future research should also look into which companies would be poised to take the first step in the development of technology for the implementation of blockchain into cloud computing.

Works Cited

Abramowicz, Michael. "The Very Brief History of Decentralized Blockchain Governance."
Vanderbilt Journal of Entertainment & Technology Law, vol. 22, no. 2, Winter 2020, pp.
273–98. EBSCOhost,
search.ebscohost.com/login.aspx?direct=true&db=asn&AN=142877357&site=ehost-live.

Aspembitova, Ayana T., and Michael A. Bentley. "Oracles in Decentralized Finance: Attack
Costs, Profits and Mitigation Measures." Entropy, vol. 25, no. 1, Jan. 2023, p. 60.
EBSCOhost, https://doi.org/10.3390/e25010060.

Justine, Cynara, et al. "Game Theoretical Analysis of Usable Security and Privacy." Security &
Privacy, vol. 4, no. 5, Sept. 2021, pp. 1–14. EBSCOhost, https://doi.org/10.1002/spy2.55.

K. Gai, J. Guo, L. Zhu and S. Yu, "Blockchain Meets Cloud Computing: A Survey," in IEEE
Communications Surveys & Tutorials, vol. 22, no. 3, pp. 2009-2030, thirdquarter 2020,
doi: 10.1109/COMST.2020.2989392.

Li, Yannan, et al. "Decentralized Public Key Infrastructures atop Blockchain." IEEE Network,
vol. 34, no. 6, Nov. 2020, pp. 133–39. EBSCOhost,
https://doi.org/10.1109/MNET.011.2000085.

Park JH, Park JH. Blockchain Security in Cloud Computing: Use Cases, Challenges, and
Solutions. Symmetry. 2017; 9(8):164. https://doi.org/10.3390/sym9080164

Shi, Jia, et al. "A Blockchain-Based Decentralized Public Key Infrastructure for
Information-Centric Networks." Information (2078-2489), vol. 13, no. 5, May 2022, p.
264. EBSCOhost, https://doi.org/10.3390/info13050264.

Walker, G. A. "Money and Financial Technology (FinTech) History." International Lawyer, vol.
56, no. 2, July 2023, pp. 227–331. EBSCOhost,
search.ebscohost.com/login.aspx?direct=true&db=asn&AN=164443984&site=ehost-live.

Economically Sustainable Urban Development in Metropolitan Cities By Sophia Zheng

Introduction

Ever since the dawn of humanity, cities have been the major hubs of economics, politics, and culture. With the industrial revolution, and more recently, the technological boom, urbanization has rapidly accelerated, greatly shifting the demographics of many metropolitan cities such as New York, Tokyo, Shanghai, London, etc ("The History of Cities"). According to the world bank, over 50% of the world's current population lives in cities, with that number being projected to increase to 70% in 2050. Being responsible for 80% of global GDP, cities are undeniably crucial hubs of economic activity and growth. Despite the rapid growth of cities, issues such as growing slum populations, excess energy usage, urban sprawl, and inflated prices pose many challenges for urban planners, local governments, businesses, and the citizens themselves (World Bank). Since the future only points toward growing urbanization, how can large cities be designed to promote economic prosperity amongst its inhabitants?

The Social Mobility Dilemma in Detroit, Michigan

Social mobility is one of the defining characteristics of livable cities, as it attracts investment, rising entrepreneurs, and potential citizens. It can be interpreted as the movement of individuals and families to and from varying socioeconomic situations. Factors such as employment opportunities, education, and family can impact one's future position in the socioeconomic ladder. Ultimately, children who have grown up in mixed-income and mixed-race communities were found to be more likely to break the poverty cycle (Chetty et al.). A lack of social mobility is present in many cities around the world, especially those that have undergone deindustrialization. For example, Detroit has lost over 1.2 million residents to the nearby suburbs since the 1950s, coupled with continuous economic decline (Hustwit). According to the Social Capital Atlas, pioneered by economist Raj Chetty, Wayne County, where Detroit is located, has the lowest level of economic connectedness compared to its adjacent counties at 30.8% of people's acquaintances being high income. Furthermore, it lacks cohesion and clustering as only 8.3% of friends are friends with each other. Ewing, an American urban planner and prominent professor at the University of Utah also posits that urban sprawl can inhibit upward mobility. As Detroit kept on expanding, businesses and centers of employment migrated to the suburbs, where poor black workers had trouble accessing (Ewing et al.). However, Micheal LaFaive, an author and Public Policy expert views Detroit's inability to attract capital as its major issue, not its demographics and infrastructure. This is due to Detroit's high taxes and poor services, repelling companies to the suburbs instead (Beyer). Consequently, this racial segregation posed an obstacle toward establishing economically diverse communities, dashing the chances of poor African Americans to move up the social ladder. As a result, many experts argue that cities should strive to minimize excessive growth toward suburbs, and instead focus on promoting mixed-income neighborhoods to encourage upward social mobility.

Subsidized Housing in Europe

In order to counter the effect urban sprawl has on social mobility, Chetty suggests changing zoning laws to promote economic diversity and implementing affordable housing projects (Chetty et al.). Although Detroit still has a long way to go, Vienna has been experimenting with subsidized and affordable housing called Gemeindebau. Such complexes come with shared social spaces that can be utilized in a multitude of ways, promoting economic connectedness and cohesion within the community. Niedermuhlbichler, a member of Vienna's city parliament supports high income limits in subsidized housing because it creates economic diversification and prevents the development of ghettos. Eda Steixner, a resident of one of Vienna's many Gemeindebau enjoys the sense of community, greenery, and inexpensive cost of living (Revell and Yeldham). This development can also be seen with Nordhavn, a neighborhood in Copenhagen where the CPH City & Port Development is tasked with constructing homes and workplaces to offset levels of displacement from urban sprawl. Just like the Gemeidebau of Vienna, Nordhavn's new housing also strives to accommodate low-income residents and encourage economic diversity by subsidizing social housing companies through the national and local government (Azria et al.). While subsidized housing requires investment from both private companies and the government, it works wonders in breaking down upward mobility obstacles for low-income citizens.

The Proven Benefits of Cycling in the US and Denmark

Another way urban planners can improve their cities' economies could be through promoting bike infrastructure and making areas more pedestrian friendly. According to urban studies associate professor Jenny Liu, the sales, wages, and employment of the local food service industry in American cities such as Indianapolis, Memphis, Seattle, San Francisco, Portland, and Minneapolis greatly improved when bike lanes were added to replace street parking and motor vehicle lanes (Liu and Shi). This is expected, since bikers are more likely to "window shop" due to having easier access to retail stores and restaurants along the streets. The Cycling Embassy of Denmark affirms this conclusion, claiming that for every Euro a driver spends on fuel, only 4% stays in the local economy. However, for every Euro a cyclist spends, 32% remains in the local economy ("Cost Benefit of …"). This way, money is more likely to be circulated within local businesses, increasing the chances of business owners and employees to move up the socioeconomic ladder.

Bicycle infrastructure is also more economical to build compared to car infrastructure, and creates economic benefits that extend beyond privately owned businesses. A common phrase used in the urban planning community is "induced demand", referring to the consequences of building more highways and adding more lanes. Although extra lanes and roads are built to combat congestion, they have the adverse effect, leading to more and more traffic congestion as people are given an incentive to drive. Furthermore, this leads to demand for parking space, negatively impacting small businesses by taking away space that can be used for economic development (Ewing et al.). However, a report authored by Darren Flusche shows a glimpse of

hope in the North American urban planning scene. In order to keep up with transportation around the city, urban planners should increase bike lanes since paving them can cost as low as $5,000 per mile, while 3 miles of highway repair in Los Angeles can cost $75 million. Bike lanes also last longer, since bikes cause less wear on the pavement. The economic importance of the bike industry can also be observed in Portland, where investment into bike infrastructure and prudent urban design led to over 90 million dollars involved in bicylic-related endeavors such as rentals, repair, retail, and classes. Moreover, by encouraging density and discouraging car dependency, many Portland residents report saving significant amounts of time and money on transportation, thus being able to focus on their interests (Flusche).

Limitations

Bike infrastructure and subsidized housing have economical costs that cannot be overlooked by city, state, and even federal governments. In order to successfully combat the detrimental effects of urban sprawl on a larger level, urban planners must be able to convince people in power, who generally take a top-down approach to urban design. The top-down perspective advocates for urban renewal, typically involving the clearing of slums. This displaces many people and contributes to urban sprawl, at the expense of minorities and low-income groups (Hustwit). Public initiatives such as protesting, petitioning, and spreading awareness of sustainable urban development are key to ensuring the successful implementation of subsidized housing and quality bike infrastructure (Emanuel). In order to implement practices such as bike and pedestrian friendly infrastructure and subsidized housing, urban planners need to account for the preexisting regulations and practices adopted by previous generations of urban planners.

Conclusion

In this modern age of urbanization, more and more businesses are shifting toward cities, creating more economic opportunities for the local population. However, as seen with urban sprawl, the opposite effect is possible. Businesses and residents can move out of city centers, creating areas that lack economic prosperity and areas that are economic strongholds. Urban sprawl can not only dash the economic hopes of residents, but also contribute to social isolation, greenhouse gas emissions, and psychological distress. As perspectives in urban planning start to shift away from the top-down approach, additional bike lanes and subsidized housing are among one of the many ways planners are attempting to build economically prosperous cities.

Works Cited

Azria, Maria Camila, et al. *Integrated Urban Development: Copenhagen and Its Nordhavn Case*.
    14 June 2019,
        blogs.iadb.org/ciudades-sostenibles/en/integrated-urban-development-copenhagen-and-its
        -nordhavn-case/. Accessed 28 Feb. 2023.

Beyer, Scott. "Why Has Detroit Continued to Decline?" *Forbes*, 31 July 2018,
        www.forbes.com/sites/scottbeyer/2018/07/31/why-has-detroit-continued-to-decline/?sh=5
        767106f3fbe. Accessed 1 May 2023.

Chetty, Raj, et al. "Social Capital and Economic Mobility." *Opportunity Insights | Policy
    Solutions to the American Dream*, Aug. 2022, opportunityinsights.org/. Accessed 4 Mar.
    2023.

"Cycling Infrastructure Is an Economic Asset for Society as a Whole." *Cycling Embassy of
    Denmark*, 17 June 2019, cyclingsolutions.info/cost-benefit-of-cycling-infrastructure/.
    Accessed 14 Feb. 2023.

Emanuel, Martin. "Making a Bicycle City: Infrastructure and Cycling in Copenhagen Since
    1880." *Urban History*, vol. 46, no. 3, Nov. 2018, pp. 493–517,
        https://doi.org/10.1017/s0963926818000573. Accessed 25 Jan. 2023.

Ewing, Reid, et al. "Does Urban Sprawl Hold Down Upward Mobility?" *Landscape and Urban
    Planning*, vol. 148, Apr. 2016, pp. 80–88,
        https://doi.org/10.1016/j.landurbplan.2015.11.012.

Flusche, Darren. "LEAGUE of AMERICAN BICYCLISTS the Economic Benefits of Bicycle
    Infrastructure Investments." *Economic Benefits of Bicycle Infrastructure Improvements*,
    2009,
        www.aarp.org/content/dam/aarp/livable-communities/old-learn/transportation/economic-
        benefits-bicycle-infrastructure-report.pdf. Accessed 25 Mar. 2023.

Gössling, Stefan, and Andy S. Choi. "Transport Transitions in Copenhagen: Comparing the Cost
    of Cars and Bicycles." *Ecological Economics*, vol. 113, May 2015, pp. 106–13,
        https://doi.org/10.1016/j.ecolecon.2015.03.006.

Liu, Jenny, and Wei Shi. *Understanding Economic and Business Impacts of Street Improvements
    for Bicycle and Pedestrian Mobility: A Multi-City, Multi-Approach Exploration*. 2020,
        https://doi.org/10.15760/trec.248. Accessed 24 Feb. 2023.

Revell, Megan, and Duncan Yeldham. "Design Tours: The World's Best Public Housing? -
    Film." *Monocle*, 14 Dec. 2022,
        monocle.com/film/culture-and-design/design-tours-the-worlds-best-public-housing/.
        Accessed 1 May 2023.

"The History of Cities | National Geographic Society." *Education.nationalgeographic.org*,
        education.nationalgeographic.org/resource/history-cities/. Accessed 21 Feb. 2023.

World Bank. "Urban Development." *World Bank*, 6 Oct. 2022,
        www.worldbank.org/en/topic/urbandevelopment/overview. Accessed 5 Mar. 2023.

Yellow Peril: The Rise of Anti-Chinese Sentiment in the 19th Century and the Chinese Exclusion Act By Christopher Voon

On January 24th, 1848, while building a water-powered sawmill along the American River in Coloma, California, James W. Marshall discovered gold. His finding marked the start of the California Gold Rush, as news of his discovery spread around the world. California's population immediately underwent immense changes and growth. By the end of 1853, its non-indigenous population increased to almost 300,000, compared to just 14,000 five years earlier (Mountford and Tuffnell). Immigrants streamed in from the Eastern United States, Europe, Latin America, and Asia, with 67,000 arrivals in 1852 alone. Of these, 20,000, or almost 30%, came from China ("From Gold Rush"). Like all prospectors, these Chinese immigrants were lured by dreams of finding abundant gold and the promise of quick wealth, but gold mining was grueling work, and very few would strike it rich. This concentration of adventurers competing over a limited resource of gold created a volatile environment where White miners began to target Chinese immigrants with violence and regulations to drive them out of mining (Hoexter 35). As time passed and Chinese immigrants moved into other occupations, their treatment progressed from being physically victimized to being systematically discriminated against by the legislative system. In California from the 1850s to 1880s, anti-Chinese sentiment, in the form of violence and discriminatory and exclusionary laws, intensified due to the complex interplay between the perceived economic threat that the Chinese posed to White workers, the belief by White Californians that the Chinese were an inferior and unassimilable people, and the rise of well-organized labor unions and political parties, all of which laid the groundwork for anti-Chinese legislation, culminating in the Chinese Exclusion Act.

Chinese immigrants began to arrive in America in the late 1840s and early 1850s, primarily through California, and were generally welcomed. Businesses, manufacturers, the agricultural industry, and those interested in fostering trade supported Chinese immigration, which provided an abundant source of cheap labor and a step towards building stronger relations with China. In his 1852 State of the State Address, California Governor John McDougal promoted the immigration and settlement of the Chinese, whom he called "one of the most worthy classes of our new adopted citizens" (McDougal). Despite this, as the number of Chinese immigrants soared, White miners and laborers began to view the Chinese as an economic threat, leading to the rapid rise of anti-Chinese sentiment.

Some of the first views of the Chinese as economic threats and the subsequent responses came from the highly competitive California gold fields. Initially, most miners worked independently or in groups, competing for the limited amount of easily accessible surface-level gold. Competition intensified in the early 1850s when most of this easy gold had been mined, and the number of miners in the area increased, including a large influx of Chinese immigrants ("California Gold Rush"). As a result, the amount of money individual miners could make steadily declined (see Table 1).

Table 1: Miners' Income and Chinese Immigration: 1848-1856

Date	Miners' Daily Income	# of Chinese Immigrant Arrivals into the US
1848	$20	NA
1849	16	325
1850	10	450
1851	8	2,716
1852	6	20,026
1853	5	4,270
1854	NA	16,084
1855	NA	3,329
1856	3	4,807

Source: Chiu, Ping. *Chinese Labor in California, 1850-1880: An Economic Study*. Edwards Brothers, Inc., 1963, pp.20, 142.

Increasing competition combined with prospectors' failure to "strike it rich" led many to use force against those they felt were trespassers. "The Yankees regarded every man but a native American as an interloper, who had no right to come to California to pick up the gold of the free and enlightened citizens," wrote one miner (Kelly 25). Across California, White miners drove Chinese miners off their claims or attempted to exclude them from mining in entire areas (Hoexter 36-9). For example, the Chinese were prohibited from mining in the Columbia District in Tuolumne County and purchasing mining claims in districts like Dutch Flat, Centreville, and Helltown. Locals in at least 12 other mining districts also attempted to exclude Chinese miners (Kanazawa 783). These actions marked some of the first organized discrimination against the Chinese and foreshadowed more to come.

At the state level, in response to increased competition from non-White miners, California imposed a $20 monthly tax on all foreign-born miners in 1850. Due to enforcement difficulties and lower-than-expected revenue from it, the tax was repealed after a year and replaced with a modified version of $3 per month. While these taxes were aimed at all foreign-born miners, an additional tax specifically targeting the Chinese was levied in 1855. Further pushes in 1858 from mining districts led the California legislature to pass a law that banned Chinese immigration entirely, though the Supreme Court of California later declared it to be unconstitutional (Kanazawa 784-7). The passage of these racist laws and taxes revealed the presence of an active and widespread anti-Chinese movement in the gold mining industry.

As the easily reachable gold deposits were gradually depleted in the late 1850s and large numbers of White miners left the industry from 1859-1860, the competition between White and

Chinese miners declined, and anti-Chinese sentiment in the mining industry cooled (Peng 17-8). The number of Chinese miners increased as White miners exited, and Chinese miners did not start to leave the gold fields until 1864 (Chiu 28). Many returned to China, but those who remained were employed in other areas, such as the building of the Central Pacific Railroad, agricultural labor, and land reclamation– occupations most Whites considered undesirable. With the reduced direct competition between White and Chinese labor, legislative and physical attacks against the Chinese diminished (Peng 18-9). Yet, after the completion of the Transcontinental Railroad in 1869, thousands of Chinese laborers sought employment in the San Francisco area, where they were once again seen as threats to White labor.

The Chinese were often willing to work the same jobs as Whites for lower pay. In the late 1870s and early 1880s, they were paid significantly less for doing the same job in several industries (see Table 2).

Table 2: Comparisons of Wages Between Chinese and White Labor in the Late 1870s and Early 1880s

Type of Work	Chinese Wage	White Wage
Boot and Shoe Manufacturing	$0.75-$1.25/day	$2.00-$4.00/day
Cigar Manufacturing	$6.00/week	$11.00/week

Source: Chiu, Ping. *Chinese Labor in California, 1850-1880: An Economic Study*, Edwards Brothers, Inc., 1963, pp. 114; Coolidge, Mary R. *Chinese Immigration*, Henry Holt and Company, 1909, pp 366.

Due to the differences in wages, businesses were eager to hire Chinese labor, and by the early 1880s, the Chinese made up 52% of workers in the boot and shoe industry, 84% in the cigar industry, and 33% in woolen mills despite being a minority of the overall population (Chiu 65). As direct competition for jobs increased, so did anti-Chinese sentiment among the working class.

Their willingness to work for lower wages gave rise to the myth that all Chinese immigrants were coolies, unskilled and indentured laborers from Asia who were willing to work for little pay and endure horrid conditions (Pfaelzer 26). Although the large majority of Chinese immigrants came to the United States of their own free will, many politicians, anti-Chinese groups, and newspapers sought to portray them as a race of semi-human slaves with no free will who threatened to drive down free White Americans' wages and standards of living (Hoexter 34-5; Ngai 89; Pfaelzer 26-7). The coolie myth was a racist trope repeated to dehumanize the Chinese immigrants, create fear, and fan anti-Chinese sentiment.

One of the first politicians to weaponize the coolie myth was California Governor John Bigler, who issued a special message in April 1852 to proclaim that California must "check this tide of Asiatic immigration" and warned of an invasion of coolies "ignorant of the solemn character of the oath or affirmation in the form prescribed by the Constitution" and "indifferent to the solemn obligation…to speak the truth" that could "endanger the public tranquility and

injuriously affect the interests of our people" (Bigler 2). The next year, the *Daily Alta California*, an influential newspaper at the time, published a letter warning that "most of them in the mines are not free… they are coolies, brought here by rich mandarins or merchants to work for little more than a bare subsistence" and that "the degradation and reduction of the price of labor" was at stake (Pilgrim 1). Even though only a small minority of the Chinese who came to America were actually indentured laborers, Americans began to characterize all Chinese laborers as such due to the myth being perpetuated by anti-Chinese politicians and newspapers (Pfaelzer 25-7).

In addition to portraying the Chinese immigrants as a race of soul-less slaves, the anti-Chinese movement denounced their customs and cultural practices as uncivilized and immoral and created the narrative that the immigrants were unassimilable and dangerous to the integrity of White-American society (Sandmeyer and Daniels 34). An editorial in the *Marin County Journal* in 1876 described Chinese immigrants in a manner that reflected common sentiment at the time, stating, "he herds in scores, in small dens, where a white man and wife could hardly breathe, and has none of the wants of a civilized white man…his sister is a prostitute…wherever they are numerous, as in San Francisco, by a secret machinery of their own, they defy the law, keep up the manners and customs of China, and utterly disregard all the laws of health, decency and morality" ("The Chinaman in America" 2). Another striking example is the political cartoon "A Picture for Employers" by J. Keppler, which compared the "superior" White-American culture to the "inferior" culture of the Chinese immigrants by showing a White man returning to his private home and being greeted by his wife and children, contrasted with a tiny room overflowing with tens of Chinese men smoking opium and eating rats (see fig. 1).

Figure 1. J. Keppler, "A Picture for Employers" *Puck*, 21 August 1878

Such dehumanizing representations of the Chinese helped to stoke widespread contempt and persecution of the Chinese.

The view that the Chinese were inferior and unassimilable was commonplace and not limited to working-class Whites in economic competition with the immigrants. Even the educated and elite class often viewed the Chinese as inferior. In 1854, in the California Supreme Court case *People v. Hall,* the court ruled that in addition to Black and Native American people, Chinese people did not have the right to testify in cases against White defendants. The court wrote that the Chinese are a "distinct people, living in our community… in which they indulge in open violation of law; whose mendacity is proverbial; a race of people whom nature has marked as inferior, and who are incapable of progress or intellectual development beyond a certain point… differing in language, opinions, color, and physical conformation; between whom and ourselves nature has placed an impassable difference" (*People v. Hall* 405). The belief that the Chinese immigrants were unassimilable was a key argument that the anti-Chinese movement would later use to restrict Chinese immigration.

Not only did White Americans view many aspects of Chinese culture with contempt, but they also believed the Chinese people were inferior for the simple fact that they were non-White. The initial waves of Chinese immigration happened not long after the idea of Manifest Destiny became popular. First used in 1845, the phrase refers to the belief in the God-given right of White settlers to conquer North America. Under the justification of Manifest Destiny, the United States gained large swaths of new territory, including California, at the expense of the Hispanic and Native American people they displaced (History.com Editors). Proponents of Manifest Destiny also believed that Americans and only Americans had the right to the land's natural resources and other opportunities on American territory. In California, Manifest Destiny was largely a racial, not a nationalistic issue, as White immigrants were included in the people who they believed deserved the right to mine or compete for other jobs (Hoexter 34). As a result of the cultural differences that the Chinese maintained and the American belief in both Manifest Destiny and the superiority of the White race, many firmly believed that the Chinese did not share these same rights. In a report to the California State Senate, the Senate Committee on Federal Relations described Chinese immigrants as a "class of semi-barbarians" and proclaimed "that California is peculiarly the country for the white man, and that we should exclude the inferior races" (Senate Committee on Federal Relations Report 602). Although their presence increased the supply of available workers and thus lowered wages in a manner not unlike the Irish, Germans, or other Europeans, the Chinese were scapegoated as the root cause for the economic struggles of the working class in a way that other ethnicities weren't, largely due to widespread bias against non-Whites.

The rise of well-organized groups, including anti-coolie clubs and labor unions in the late 1860s and early 1870s, reignited the anti-Chinese movement. Anti-coolie groups led large anti-Chinese demonstrations and promoted boycotts of Chinese-made goods, such as cigars, boots, and shoes, and urged customers to buy White-made goods that had labels stating that they were "made by white labor." These groups also led violent attacks on the Chinese and their

property (Ngai 144). Most notably, in 1871, a mob of five hundred people descended upon the Chinese quarter in Los Angeles, killed 19 Chinese immigrants, 17 of whom by hanging, and looted several buildings. All of those in the mob who were accused were released (Pfaelzer 47-53). Hundreds of brutal attacks and purges like these would occur across California, terrorizing the Chinese ("Mapping Anti-Chinese Violence"). The anti-Chinese movement gained momentum in the mid-1870s as the United States went through an economic depression that resulted in high unemployment rates; the Chinese were a convenient scapegoat. By 1876, almost one-quarter of the workforce in San Francisco was unemployed. In response, in 1877, the trade unions and anti-coolie clubs formed a political party, the Workingmen's Party, which adopted an anti-monopolist, anti-Chinese platform (Ngai 147). Led by Irish immigrant Denis Kearney, the party blamed the working man's situation on the rich and politically powerful, though they focused their efforts on attacking a less powerful group– the Chinese. In one of Kearney's speeches, he states, "to add to our misery and despair, a bloated aristocracy has sent to China… for a cheap working slave. It rakes the slums of Asia to find the meanest slave on earth – the Chinese coolie – and imports him here to… degrade white Labor" (Kearney and Knight). Kearney, like many anti-Chinese agitators before and after him, invokes the myth of the coolie. Such political fearmongering was successful– on an 1879 ballot, a staggering 99 percent of California voters voted against Chinese immigration (Sandmeyer 62).

A large part of the Workingmen's Party's ultimate goal was to expel the Chinese, as made clear in their statement that "we have made no secret of our intentions…the Chinaman must leave our shores…women, and boys, and girls, cannot live as the people of the great republic should and compete with the single Chinese coolie in the labor market…death is preferable to life on a par with the Chinaman" (Kearney 2). The Workingmen's inflammatory and hateful messages scapegoating the Chinese found considerable support. Within a year of its founding, the party gained significant political power, winning one-third of the total seats at the state constitutional convention. At the convention, a new state constitution was written that included sections restricting Chinese employment and calling the presence of the Chinese "dangerous to the well-being of the State," and that to deal with this threat, "the Legislature shall discourage their immigration by all the means within its power" ("Constitution of the State of California" 1519).

The Workingmen's Party ended up collapsing almost as quickly as it rose, but the Democratic and Republican parties continued pursuing anti-Chinese legislation for their political gain. In an 1880 editorial, *The Daily Alta California* wrote, "The Senate and the Assembly apparently intend to sacrifice themselves to almost every measure which has for its object anti-Chinese legislation…Some of the bills…are merely "molasses to catch [Sand-lot][73] flies" ("The 'Moon-Eyed Leaper'" 1).

The greatest obstacle for those who favored restricting Chinese immigration lay at the federal level. Any state or municipal legislation restricting immigration would conflict with the

---

[73] Sandlot refers to the pro-labor, anti-Chinese rallies held on sandlots in San Francisco in the 1870s

U.S. Constitution and the Burlingame Treaty, a bilateral treaty between the United States and China that included articles dealing with immigration. At the national level, there had historically been little support for the restriction of immigration. However, the influence of organized labor continued to grow across the country, as did the political importance of California, especially with respect to the state's six electoral votes. The 1876 U.S. presidential election had been decided by a single electoral vote, with Republican Rutherford B. Hayes winning 185 votes versus Democrat Samuel Tilden's 184. California played a pivotal role, with the state's six electoral votes going to Hayes after he narrowly edged out Tilden, receiving 50.9% of the state's popular votes compared to 49.1% for Tilden ("1876"). After years of intense lobbying by Californian politicians and expectations for another close presidential election in 1880, the anti-Chinese movement gained national attention and momentum. Various congressional committees launched investigations into the effect of Chinese immigration. In 1879, a House Education and Labor Committee report declared, "The evils of Chinese Immigration have been fully recognized upon the Pacific slope for many years. Welcomed at first as a unique addition to the society and a valuable ally in the development of the material resources in their new home, the Chinese by their sordid, selfish, immoral, and non-amalgamating habits, within a very short time reversed the judgment in their favor and came to be regarded as a standing menace to the social and political institution of the country" (House Committee on Education and Labor report 793). In 1880, both political parties adopted platforms calling for restrictions on Chinese immigration. The stage was set, and in 1882, Congress passed the Chinese Exclusion Act that banned the immigration of Chinese laborers for 10 years. It was the first federal law restricting the immigration of a specific race. Eventually, the Chinese Exclusion Act was renewed for another 10 years, and then, in 1902, Congress passed another act extending the Chinese Exclusion Act indefinitely.

The Chinese Exclusion Act was repealed in 1943, though an immigration quota was set, which allowed only 105 visas for immigrants of Chinese ethnicity per year. The repeal happened during World War II when the US was allied with China against Japan. The Chinese Exclusion Act had been a source of contention between China and the US, and its repeal allowed the US to claim that Chinese were welcome, though in reality, the strict quota ensured very limited immigration. In a message to Congress regarding the repeal of the Chinese Exclusion Act, President Franklin D. Roosevelt sought to assure the American people that while Chinese immigration would be allowed, with the quota, "there can be no reasonable apprehension that any such number of immigrants will cause unemployment or provide competition in the search for jobs" (Roosevelt). Even after 60 years of exclusion, the threat of the coolie undercutting wages and taking jobs from Whites loomed. It was not until 1965, after the civil rights movement led to the Immigration and Nationality Act that abolished quotas based on race and national origin, that Chinese immigrants had the freedom to migrate to America again.

In 2011, the United States officially admitted that the treatment of the Chinese in the 19th century had been a mistake. The U.S. Senate passed Senate Resolution 201, formally acknowledging and expressing regret for the legislature's past actions that contributed to

discrimination against Chinese in America, including the passage of the Chinese Exclusion Act ("S. Res 201").

Although the basis of the anti-Chinese movement in the 1850s to 1880s was rooted in economic competition, it is important to understand that the discrimination and attacks on the Chinese, both physical and legislative, came from the racist belief that the Chinese people were culturally and racially inferior to White-Americans. These beliefs were engineered and spread by a vocal and politically powerful constituent.

Chinese immigrants were initially welcomed as valued labor, but when they were seen as economic competition, first by White miners for limited amounts of gold during the gold rush from the late 1840s to the late 1850s and then by White laborers for manufacturing jobs starting in the 1870s, they were subjected to violence, mistreatment, and discriminatory legislation. While immigrants had come from all over the world in search of gold and jobs, the Chinese were singled out for this discrimination. This was partly due to the prevalent view of the time that Whites were a superior race but was also the result of the rise of well-organized anti-Chinese agitators. The early injustices the Chinese miners faced came from White miners, who were loosely organized at the local level. At the state level, politicians seeking the miners' votes implemented taxes specifically aimed at Chinese miners. As the Chinese moved into manufacturing jobs in competition with White workers, they were confronted by well-organized and politically influential labor unions and anti-coolie clubs. These groups intensified the abuses against the Chinese, forming their own political party to advance their agenda and lobbying the state government to restrict Chinese immigration. In turn, state representatives took advantage of the political landscape and were able to successfully ban Chinese immigration with the passing of the Chinese Exclusion Act.

The Act was symbolically repealed during World War II as a political move to strengthen the United States' relationship with China as an ally against Japan, but it would take until 1965 before the Chinese would be allowed to immigrate to the United States in meaningful numbers.

The treatment of the Chinese in the late 19th century and the legacy of the Chinese Exclusion Act serve as reminders of the importance of ensuring that rights, opportunities, and fair treatment are extended to all people, regardless of race or ethnicity.

Works Cited

"1876." *The American Presidency Project,* UC Santa Barbara,
        www.presidency.ucsb.edu/statistics/elections/1876.

Bigler, John. "Governor's Special Message." *Daily Alta California*, 25 Apr. 1852, pp. 2–2,
        Courtesy of the California Digital Newspaper Collection, Center for Bibliographic
        Studies and Research, University of California, Riverside,
        https://cdnc.ucr.edu/?a=d&d=DAC18520425.2.7. Accessed 14 Apr. 2024.

"The California Gold Rush." *American Experience.* PBS,
        www.pbs.org/wgbh/americanexperience/features/goldrush-california/#:~:text=Part%20of
        %20the%20difficulty%20for,the%20mines%20with%20violent%20tactics. Accessed 21
        Jan. 2024.

"The Chinaman in America." *Marin County Journal*, 30 Mar. 1876, pp. 2–2. *Courtesy of the*
        California Digital Newspaper Collection, Center for Bibliographic Studies and Research,
        University of California, Riverside, https://cdnc.ucr.edu/?a=d&d=MJ18760330.2.10

"Chinese Immigration and the Chinese Exclusion Acts." *Office of the Historian, United States*
        Department of State,
        history.state.gov/milestones/1866-1898/chinese-immigration#:~:text=In%20the%201850
        s%2C%20Chinese,especially%20in%20the%20garment%20industry. Accessed 28 Jan.
        2024.

Chiu, Ping. *Chinese Labor in California, 1850-1880: An Economic Study*. Edwards Brothers,
        Inc., 1963.

Constitution of the State of California. Article XIX. Chinese, 3 Mar 1879. *Debates and*
        Proceedings of the Constitutional Convention of the State of California. Vol. 3, pp.
        1510-1521, J.D. Young, 1881. Pdf. *The Internet Archive*,
        https://archive.org/details/debatesandproce02stocgoog/page/n4/mode/2up

Coolidge, Mary R. *Chinese Immigration*, Henry Holt and Company, 1909

"From Gold Rush to Golden State." *Early California History: An Overview*. Library of
        Congress,
        www.loc.gov/collections/california-first-person-narratives/articles-and-essays/early-califo
        rnia-history/from-gold-rush-to-golden-state/. Accessed 17 Jan. 2024.

History.com Editors. "Manifest Destiny." *HISTORY*, 15 Nov. 2019,
        www.history.com/topics/19th-century/manifest-destiny.

Hoexter, Corinne K. *From Canton to California: The Epic of Chinese Immigration*. Four Winds
        Press, 1976.

House Committee on Education and Labor report, 28 Jan 1879. *Congressional Record.*
        Proceedings and Debates of the Forty-Fifth Congress. Third Session. Vol. 8, Part 1*, pp.*
        793-793, 1879. Pdf. *Congress.gov*, Library of Congress,
        https://www.congress.gov/bound-congressional-record/1879/01/28/house-section.

Kanazawa, Mark. "Immigration, Exclusion, and Taxation: Anti-Chinese Legislation in Gold
        Rush California." *The Journal of Economic History*, vol. 65, no. 03, 26 Aug. 2005, pp.

779–805, *Carleton Digital Commons,*
https://digitalcommons.carleton.edu/econ_faculty/2/.

Kearney, Denis, and H. L. Knight. "Appeal from California. The Chinese Invasion.
Workingmen's Address." *Indianapolis Times*, 28 Feb. 1878, *History Matters: The U.S.
Survey Course on the Web*, https://historymatters.gmu.edu/d/5046/

Kearney, Denis. "The Workingmen: A Manifesto from the Officials of the Organization." *San
Francisco Chronicle*, 16 Oct. 1877, pp. 2–2. *San Francisco Chronicle Archives,*
https://sfchronicle.newsbank.com/

Kelly, William. *An excursion to California over the prairie, Rocky mountains, and great Sierra
Nevada. With a stroll through the diggings and ranches of that country.* London,
Chapman and Hall, 1851. Pdf. *Library of Congress*, www.loc.gov/item/rc01000799/

Keppler, Joseph. "A Picture for Employers." *Puck*, 21 Aug. 1878, pp. 16–16, *Library of
Congress*, www.loc.gov/pictures/item/2002720432/.

"Mapping Anti-Chinese Violence." *The Tacoma Method*,
www.tacomamethod.com/mapping-antichinese-violence. Accessed 7 Feb. 2024.

McDougal, John. "State of the State Address." 7 Jan. 1852. *The Governors' Gallery,* California
State Library, 2019, https://governors.library.ca.gov/addresses/s_02-McDougall.html.
Accessed 14 Apr. 2024.

"The 'Moon-Eyed Leaper' Catching it Hot and Heavy." *Daily Alta California*, 14 Feb 1880, pp
1-1. *Courtesy of the California Digital Newspaper Collection, Center for Bibliographic
Studies and Research, University of California, Riverside*,
https://cdnc.ucr.edu/?a=d&d=DAC18800214.2.14

Mountford, Benjamin Wilson, and Stephen Tuffnell. "How Gold Rushes Helped Make the
Modern World." *Faculty of History,* University of Oxford, 4 Apr. 2018,
www.history.ox.ac.uk/article/how-gold-rushes-helped-make-modern-world. Accessed 17
Jan. 2024.

Ngai, Mae. *The Chinese Question: The Gold Rushes and Global Politics*. W. W. Norton &
Company, 2021.

Peng, Linan. "The Political Economy of the Anti-Chinese Movement in California in the 19th
Century." *SSRN*, 27 July 2020, https://doi.org/10.2139/ssrn.3688598.

THE PEOPLE, Respondent, v. GEORGE W. HALL, Appellant. 4 Cal. 399, 1 Oct. 1854, *Casetext*,
https://casetext.com/case/people-v-hall-2243.

Pfaelzer, Jean. *Driven Out: The Forgotten War against Chinese Americans*. University of
California Press, 2008.

Pilgrim, Peregrim. "The Chinese in California." *Daily Alta California*, 29 July 1853, pp. 1–1,
*Courtesy of the California Digital Newspaper Collection, Center for Bibliographic
Studies and Research, University of California, Riverside*,
https://cdnc.ucr.edu/?a=d&d=DAC18530729.2.2

Roosevelt, Franklin D. "Message to Congress on Repeal of the Chinese Exclusion Laws." 11
Oct. 1943. *The American Presidency Project,* UC Santa Barbara,

https://www.presidency.ucsb.edu/documents/message-congress-repeal-the-chinese-exclusion-laws.

Sandmeyer, Elmer Clarence, and Roger Daniels. *The Anti-Chinese Movement in California*. University of Illinois Press, 1991.

"S. Res. 201 – 112th Congress (2011-2012): A resolution expressing the regret of the Senate for the passage of discriminatory laws against the Chinese in America, including the Chinese Exclusion Act." *Congress.gov*, Library of Congress, 6 Oct. 2011, www.congress.gov/bill/112th-congress/senate-resolution/201/text.

Senate Committee on Federal Relations report, 19 Apr. 1858. *Journal of the Ninth Session of the Senate of the State of California*, pp. 601-602, John O'Meara, 1858. Pdf. *The Internet Archive*, https://archive.org/details/journ1858cali/page/600/mode/2up

Navigating School-Based Mental Health Services for Student Well-being and Success By Chris Chun

Abstract

Improving school-based mental health services (SMHs) is a critical area of research and practice that aims to promote the well-being and academic success of students. However, SMHs face many challenges in terms of access, quality, and effectiveness of services. This paper reviews the literature on the barriers and strengths of SMHs, as well as the evidence-based treatment programs that can be adapted to the school context. The paper argues that the student population is a unique population that requires special considerations and adaptations to increase the reach and impact of SMHs interventions. The paper identifies access barriers to mental health care at the student and institutional levels, highlights the unique features of SMHs that can enhance their potential, and the treatment programs that are effective in SMHs settings. The paper concludes with implications and recommendations for future research and practice in SMHs.

Introduction

In school settings, the availability and accessibility of mental health services for students are severely lacking. Earlier assessments suggest that nearly 20% to 38% of young individuals require assistance for their mental health (Goodman et al., 1997; Marsh, 2004; Paternite, 2005). According to the 2021 report from the Centers for Disease Control and Prevention, more than 42% of US high school students reported persistent levels of depressed mood and approximately 29% of students reported experiencing mental health issues (Mental Health, 2023). This lack of support is a matter of great concern, considering the pressing need for adequate mental health care for students. Research indicates that students have significant treatment needs that must be addressed to ensure their overall well-being and academic success (Greenberg et al., 2003; Paternite, 2005). The prevalence of mental health issues among students, such as anxiety, depression, and stress, is rising and underscores the urgency to provide them with appropriate services.

However, many students do not receive timely and appropriate treatment due to significant barriers at the student- and institutional-level. As a result, students who are unable to access care are negatively influenced in ways such as a decrease in attendance, cognitive abilities, and rates of absenteeism (Swick & Powers, 2018). Though these barriers often interact with SMHs in negative ways that perpetuate impediments for students accessing care, several exemplary programs exist that capitalize on their unique features for beneficial outcomes for students.

Thus, it is imperative to examine the current state of mental health care in school settings, the barriers and gaps that prevent effective delivery of care, and model treatment programs that effectively leverage their strengths to navigate and increase access and the quality of care for students (Carnegie Corporation of New York, 1989; Elias, Zins, Graczyk, &

Weissberg, 2003). This paper's culminating aim is to provide an overview of how currently implemented treatment programs at schools are successfully addressing individual and institutional barriers to mental health care.

Treatment Utilization Barriers in School Settings

It is important to first understand what barriers may impact students' engagement in school-based mental health services. These barriers are often categorized on two levels: student-level barriers and institutional-level barriers. Student-level barriers refer to a myriad of idiographic and individual-centered factors that concern the student such as increased stigma regarding mental health and treatment, low mental health literacy, student time and schedule conflicts, and limited financial resources. Institutional-level barriers investigates the broader field of mental health services and the problems that surround this environment such as counseling confidentiality concerns, insufficient funding, mental health education, and use of non-evidence-based practices, leading to inconsistencies and inefficiencies in the treatment outcomes. Close examination of these barriers may elucidate the unique considerations necessary for effective delivery and implementation of treatment programs in SMHs.

Student-Level Barriers

It is important to consider both the student (internal) and institutional (external) barriers that may prevent students from seeking and receiving mental health care. Student barriers are those that are perpetuated by the patients themselves, such as stigma, personal factors, and mental health literacy. These barriers illustrate the factors to take into consideration when providing treatment to both students and mental health care administrators.

One of the most pervasive student-level barriers is stigma, which refers to the negative attitudes and stereotypes that people have toward mental illness and those who suffer from it. (American Psychiatric Association, 2020). Stigma can affect students' willingness to seek help, their expectations of treatment, and their adherence to treatment plans. Stigma can also come from different sources, such as self-stigma, which is the internalization of negative beliefs about oneself; public stigma, which is the perception of how others view mental illness; and perceived stigma, which is the anticipation of discrimination or rejection from others (Corrigan & Watson, 2002). A cross-sectional study examined the stigma in mental illnesses and help-seeking intentions and reported that students who reported higher levels of perceived public stigma were less likely to report an intention to seek help (Lally et al., 2013). The results indicate that stigma can deter students from seeking professional help for their mental health problems, even if they are aware of their need for treatment. The review also found that students who had higher levels of stigma were less likely to recognize their need for help, to have positive attitudes toward treatment, and to use formal sources of care. This is especially pertinent as demonstrated by a study by Gaddis and colleagues where students were less likely to admit to suicidal thoughts or self-harm if they attended school in high-stigma environments (Gaddis et al., 2018).

Another student-level barrier is the personal, peer, and environmental factors that may influence students' decision to seek help or not. These factors include idiographic aspects such as students' personality traits, social support, and perceived stress (Linnenbrink & Pintrich, 2003; Skinner & Pitzer, 2012; Finn & Zimmer, 2012). For example, some students may have a preference for self-reliance or a fear of losing control, which may make them reluctant to seek professional help. Some students may also have low self-esteem or low self-confidence, which may affect their ability to cope with mental health problems. Pulling from Goldberg's Five Factor Model of personality, which outlines five personality traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness), Jennings' study of the role of personality traits in mental health treatments found that neuroticism was the only attribute of a student that increased the probability of seeking treatment, while the other traits had no significant effect (Jennings et al., 2017). Furthermore, environmental barriers, such as lack of time or transportation may make it difficult for students to access mental health services. A survey of college students in the United States found that the most common barriers to mental health services were financial reasons, lack of time, and preference for other sources of support (Statista, 2023).

A third student-level barrier is the mental health literacy among the students themselves, which refers to their knowledge and understanding of mental health problems and their treatment options. Mental health literacy can affect students' ability to recognize the signs and symptoms of mental illness, to seek appropriate help, and to adhere to treatment recommendations. Mental health literacy can also affect students' attitudes and beliefs about mental health issues and their causes, consequences, and treatments, indirectly driving and perpetuating stigma (Miles et al., 2020). A study by DeBate and colleagues found that students who had taken at least one course related to clinical psychology had higher mental health literacy scores than those who had not (DeBate et al., 2022). The study also found that higher mental health literacy was associated with having a personal, family, or peer history of mental illness, having been diagnosed or treated for a mental illness, and having a family that was open to discussing mental health issues. Generally, the more a student was exposed to mental health issues through ways like conversation or personal experience, the more likely the student was to gain a clearer and fuller understanding of how to treat these issues.

Institutional-Level Barriers

In addition to the internal factors that may impact a student at an individual level, it is necessary to include external factors that operate at the institutional level. These include the availability and quality of the services offered by the schools, the policies and procedures that regulate the referral and delivery of the services, and the funding and support that the schools receive from the government and other sources. These factors may create barriers and challenges for both the students and the providers of mental health services in schools, and they may limit the accessibility and suitability of the services for the student's needs.

One of the main barriers is the lack of funding from the government and school budgeting.

According to a report by the National Association of School Psychologists, the average ratio of students to school psychologists in the U.S. was 1,127:1 during the 2021-2022 school year, far exceeding the recommended ratio of 500:1 (*State Shortages Data Dashboard*, n.d.). It would take another 60,000 school psychologists to meet the amount recommended by experts. Moreover, only one state, Utah, meets the National Association of School Psychologists standard while the other 49 states fall way behind. These numbers indicate that many schools do not have enough mental health professionals to meet the needs of their students and that they may face difficulties in hiring and retaining qualified staff. Additionally, schools may not have sufficient funds to invest in school-based mental health programs and practices that address the prevention and treatment of common concerns even as students are increasingly seeking out these services. According to the National Center for Education Statistics, 87% of all public schools in the US strongly disagreed that they could effectively provide mental health services to all of their students and 47% of these schools reported that inadequate funding was the main limitation to supplying their programs (National Center for Education Statistics, 2022).

Furthermore, a study found that despite many schools' commitment to promoting mental health and supporting students in need, commonly reported barriers to delivering mental health provision include a lack of national policy, guidance, funding, and limited staff capacity (U.S. Department of Education, 2021). This suggests that even if students have some level of mental health literacy, they may not be able to access adequate and appropriate services due to systemic and institutional limitations.

Environmental factors may also influence the availability and accessibility of mental health services in schools. These factors include the physical location and layout of the school, the school climate and culture, and the policies and procedures that regulate the referral and delivery of services (Lenox, 2021). Some schools may not have a designated space for providing confidential and comfortable counseling sessions, or they may have a long waiting list for appointments. Others may have a negative or indifferent attitude toward mental health, or they may ineffectively encourage students from seeking help and produce fear of academic consequences or social repercussions. Schools may also not have a clear and consistent protocol for identifying and referring students who need mental health support, or they may not communicate effectively with parents, community providers, and other stakeholders about the services available and the outcomes achieved. According to a study by Langley and colleagues, they found the four primary implementation barriers were competing responsibilities, logistics, parent involvement, and support from staff (teachers and administrators), three out of the four involving problems involved with the school (Langley et al., 2010).

Another barrier is the confidentiality concerns that students may have when accessing mental health services in schools. Confidentiality is the ethical and legal term that protects the information shared within the counseling relationship, essential for building trust and rapport between the counselor and the client. However, confidentiality is not absolute, and some exceptions and limitations may require the counselor to disclose information to others, such as when the student poses a danger to self or others, when there is a court-ordered disclosure,

or when the student participates in group counseling (Rix, 2022). Furthermore, confidentiality may not be granted by state laws and local guidelines, especially when the counselor is not a licensed mental health professional. Therefore, students may have questions and concerns about who will have access to their personal and sensitive information, and how it will be used and stored. They may also fear that if they approach school-based mental health services, their teachers and surrounding faculty will treat them differently or judge them negatively (Harmon et al., 2021).

Unique Features and Strengths of School-Based Mental Health Services

School-based mental health services are an important source of support for students who may experience mental health problems that affect their well-being and academic success. Specifically SMHs differ from community-based mental health services, which are typically provided by private or public agencies outside of the school setting, in that they are able to provide services to students on-site. In this section, the paper will discuss some of the key differences between SMHs and community-based mental health services, such as the population they serve, the goals they pursue, the structure they follow, the treatments they offer, and the referral and identification process they use. These contrasts can be seen as the strengths of SMHs as they are employed to reduce and overcome the barriers previously discussed. Understanding these differences can help us understand the unique challenges and opportunities that SMHs face in delivering effective and accessible mental health care to students.

One unique feature of SMHs is the method by which students are identified and referred to services. Unlike in community settings, where students or their families may seek help on their own or be referred by a primary care provider, students in schools are usually identified and referred by school staff, such as teachers, counselors, or administrators (Romer et al., 2011). School staff may notice student academic performance, behavior, or attendance changes that indicate a possible mental health concern. However, some students may also request services themselves or be referred by their peers or parents (Guttman-Lapin et al., 2015). The referral process may vary depending on the school's policies and procedures but typically involves a student intervention team that coordinates and monitors the delivery of mental health services within the school and with community partners.

Another distinctive feature of SMHs is the increased coordination in supporting academic outcomes as part of the goals of treatment. While academic outcomes may not be the primary target for some SMHs, SMHs can closely monitor academic functioning and progress while providing care as they are integrated directly into school systems (Greenberg et al., 2003). Though community-based mental health services may also address academic issues, they tend to prioritize other outcomes, such as symptom reduction, functioning, or quality of life (Castillo et al., 2019), and face additional barriers in monitoring or coordinating care with school staff (e.g., teachers). Community-based or private services' patient populations are general and they tailor their treatments with broad and general approaches that target the masses. SMHs, on the other hand, can aim to improve students' mental health to enhance their learning and achievement in

school settings. SMHs' proximity and integration into educational institutions such as their ability to readily coordinate with teachers and school administration provide advantages over other forms of care. Studies have shown that effective SMHs can contribute to greater academic success, reduced absenteeism, decreased behavioral problems, and improved school climate (Ohio Department of Education and Workforce, n.d.). However, this does not mean that SMHs
11

neglect other aspects of students' well-being, as they also provide intervention strategies that target social and emotional skills, resilience, and coping strategies that could play a role in improving a student's quality of life.

A third feature differentiating SMHs from other settings is the structure of treatment delivery. SMHs typically operate within a multi-tiered system of support (MTSS), which provides a continuum of services at three levels: universal, selective, and indicated (Harlacher et al., 2013; Eagle et al., 2014). Universal services are preventive and promotive interventions that reach all students, such as mental health education and screening. Selective services are targeted interventions for students who are at risk for developing mental health problems, such as group counseling or skill-building programs. Indicated services are intensive interventions for students who already have mental health problems, such as individual therapy or case management. The MTSS framework allows SMHs to match the type and intensity of services to the level of need and to monitor the progress and outcomes of students.

Case Studies of Exemplar School-Based Treatment Programs

One of the unique challenges that SMHs face is choosing the most appropriate and effective treatment programs for their students. While community-based or other forms of healthcare may target vast populations, SMHs treat specifically students. There is a vast variety of treatment programs available, and they can vary in their goals, methods, outcomes, and evidence base. Therefore, it is important for school staff, parents, and students to understand the characteristics and benefits of different treatment programs, and to make informed decisions about the quality and suitability of care for students. In this section, the paper will review three examples of treatment programs that are commonly used or recommended in SMHs: Collaborative for Academic, Social, and Emotional Learning (CASEL), Positive Behavioral Interventions and Supports (PBIS), and Cognitive Behavioral Therapy (CBT) (Mendez, 2016). The paper will also describe the unique strengths and benefits of each program, and summarize the research evidence on their effectiveness in improving students' mental health and academic performance. Nevertheless, it is crucial to acknowledge that these three intervention programs
are just a subset of popular available strategies, and there may be others that either address similar or distinct needs of students with varying levels of success.

SMHs, designed to address mental health issues within schools, exhibit variations in their scope, quality, and availability across regions and populations. Consequently, the

effectiveness of these programs can differ significantly. Among the most commonly utilized and proven effective SMHs frameworks are the Collaborative for Academic, Social, and Emotional Learning
(CASEL), which emphasizes the development of core competencies; Positive Behavioral Interventions and Supports (PBIS), a framework promoting positive behavior through clear expectations; and the Mindfulness-Based Stress Reduction for Teens program (MBSR-T), an adaptation that integrates mindfulness practices to support adolescents.

CASEL is a framework that promotes integrating social and emotional learning (SEL) into school curricula and culture. It identifies the five core competencies of SEL: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making. Beyond presenting data, the model also provides guidance and resources for implementing SEL in schools, such as the CASEL Guide to Schoolwide SEL, which outlines four focus areas: build foundational support and plan, strengthen adult SEL competencies and capacity, promote SEL for students, and practice continuous improvement (Zins et al., 2000; Ross & Tolan, 2017). According to a meta-analysis of 213 studies involving more than 270,000 students, SEL programs can improve students' academic performance, social skills, behavior, and mental health
outcomes (Durlak et al., 2011). The authors of the meta-analysis state that the SEL programs yielded multiple benefits in each review and were effective in both school and after-school settings and for students with and without behavioral and emotional problems. They also report that the benefits of SEL programs lasted up to 18 years after the intervention and that the economic return of SEL programs was 11 times the cost.

PBIS is a framework that aims to prevent and reduce problem behaviors and enhance school climate and student well-being. PBIS involves defining, teaching, and reinforcing positive expectations for student behavior, as well as providing data-based decision-making and continuous monitoring of student progress. The model is implemented at three levels of support: universal (for all students), targeted (for students at risk of developing problem behaviors), and intensive (for students with chronic and severe problem behaviors) (Gage et al., 2020). PBIS also involves collaboration among school staff, families, and community partners to create a positive and supportive learning environment. According to a systematic review of 12 studies, PBIS can have positive effects on student behavior, academic achievement, and mental health outcomes; reduce disciplinary referrals, suspensions, and expulsions; and increase attendance, engagement, and graduation rates (Estrapala et al., 2020).

CBT is a branch of psychotherapy that helps students identify and challenge negative thoughts and emotions, as well as learn coping skills and problem-solving strategies. CBT can be delivered individually or in groups, and it can target specific mental health issues, such as anxiety, depression, or trauma. Based on the assumption that thoughts, feelings, and behaviors are interrelated, the treatment changes one of these components as a means to affect the others. CBT typically involves setting goals, identifying and testing cognitive distortions, developing alternative and balanced thoughts, practicing relaxation and exposure techniques, and reinforcing

positive behaviors (Nakao et al., 2021). According to a meta-analysis of 61 studies involving more than 6,000 students, CBT has proved to significantly reduce symptoms of anxiety and depression, and improve self-esteem and academic performance (Hofmann et al., 2012). The study also reported that CBT can be delivered by trained school staff, such as teachers or counselors, with similar outcomes as those delivered by mental health professionals. Another study using CBT conducted on forty children in a school setting yielded positive results, 95% on the Clinical Global Impressions-Improvement scale, compared to 16.7% when CBT was not used on waitlisted participants (Chiu et al., 2013).

Discussion

The previous sections have established the need, motivation, and unique features of SMHs for students, as well as the student-level and institutional barriers that hinder their access and effectiveness. The highlighted case examples of widely used treatment programs (CASEL, PBIS, and CBT) showcase effective techniques that can both leverage the unique features of SMHs and address the prevalent student- and institutional-level barriers.

The mental health treatment program CASEL, incorporating SEL, consists of three components: a universal curriculum that teaches the five core competencies of SEL, a targeted intervention that provides individual and group counseling for students with mental health needs, and a professional development program that trains teachers and school leaders on how to foster a positive and supportive school climate. The program aims to improve the mental health and well-being of students, as well as their academic and social outcomes. One of the main strengths of this program is that it addresses the barrier of stigma. First, by implementing a universal curriculum that teaches all students the skills and knowledge of SEL, the program normalizes the discussion of emotions and mental health in the classroom and reduces the sense of shame and

fear that students may have about their own or others' mental health issues. Second, by providing a targeted intervention that offers counseling to students who need it, the program creates a safe and confidential space for students to express their feelings and concerns, and receive support and guidance from trained professionals. Third, by training teachers and school leaders on how to create a positive and supportive school climate, the program fosters a culture of respect and empathy among staff and students and encourages them to challenge the myths that fuel stigma. By addressing stigma at multiple levels, the program increases the likelihood that students will benefit from mental health care in schools.

The PBIS framework aims to reduce problem behaviors and enhance school climate and student well-being by integrating mental health services into the three levels of support that PBIS provides: universal, targeted, and intensive. The program also involves collaboration among school staff, families, and community partners to create a positive and supportive learning environment. One of the major strengths of this framework is that it tackles the barrier of lack of funding. First, by integrating mental health services into the PBIS framework, the program leverages the existing infrastructure and resources that schools already have for behavior

support, such as data systems, teams, and practices. This reduces the need for additional funding and staff and increases the efficiency and effectiveness of service delivery. Second, by collaborating with families and community partners, the program expands the pool of resources and supports that are available for students and staff, such as referrals, consultations, and interventions. This enhances the coordination and continuity of care and reduces the duplication and fragmentation of services. Third, by demonstrating positive impacts, the program builds a strong case for the importance of mental health care in schools and attracts the attention of stakeholders, such as policymakers, administrators, and funders. This increases the likelihood that the program will receive stable funding, and be sustained and scaled up in other schools. The program also has a high economic return, as it saves costs associated with mental health problems, such as absenteeism, dropout, and health care.

The CBT program helps students identify and challenge negative thoughts and emotions, and learn coping skills and problem-solving strategies. At both an individual and collective level, the program can be delivered to treat specific mental health issues based on the assumption that individual emotions and thinking are dependent on each other. The key strength of this program is that it targets the barriers of confidentiality concerns and mental health literacy. First, by teaching students the strategies of CBT, the program empowers them to take an active role in their mental health care and to apply the learned techniques to their daily lives. This increases their self-awareness, self-confidence, and self-efficacy, and reduces their dependence on external sources of help. Second, by providing students with relevant information about mental health issues, the program educates them about the nature, causes, and treatments of their problems, and dispels the myths that may hinder their help-seeking behavior. This increases their awareness and acceptance of their own and others' mental health needs and reduces the stigma that they may experience or perceive. Third, by ensuring that the program is delivered confidentially and respectfully, the program protects the security of students' personal information with mental health providers and builds their trust and comfort in seeking help. This involves obtaining informed consent from students and parents, following ethical and legal guidelines, and using secure and encrypted platforms and tools.

While the aforementioned treatment programs offer a myriad of strategies to navigate current barriers for students, several gaps in care for this population exist.

One of the major gaps in mental health care for students is the mismatch between the current treatment programs/frameworks and the needs of students. As noted in the introduction, SMHs have some distinctive characteristics compared to other settings, such as the referral process, the treatment goals, and the structure of service delivery. However, these characteristics may not always align with the preferences and expectations of students who seek mental health care. According to an overview of behavioral health screening in schools by Siceloff, approximately less than 15% of schools in a South Carolina school district implement screenings to evaluate students' mental health needs (Siceloff et al., 2017). Screenings are crucial components of an effective implementation of mental health programs as they assess the tailored needs of a school student population. With only a small percentage of educational

institutions effectively utilizing screenings as part of their treatment plans, the programs end up overlooking the critical requests of students in need of mental support. Even more, screenings help develop data-driven perspectives on the delivery of school services; an absence of these tests indicates an unfocused and unsubstantiated approach. Treatment strategies like CASEL that aim to incorporate multiple components as part of their care package are ideal programs that can effectively navigate the above problems.

The lack of communication between mental health care providers and other sectors in a school also manifests itself as a gap in mental health care for students. This gap exists because many educators do not see mental health as part of their responsibility, and may not have the knowledge, skills, or confidence to address mental health issues in their classrooms. As a result, school mental health programs face challenges in gaining teacher and administrator buy-in, and may not be able to collaborate effectively with other school-based services. To address this gap, some best practices and action steps have been suggested by the U.S. Department of Education,

such as establishing regular meetings, creating shared goals and expectations, providing feedback and recognition, and resolving conflicts. These strategies aim to improve communication and collaboration among school mental health staff, school administrators, teachers, and other school personnel, and to enhance the quality and effectiveness of school mental health services. Furthermore, treatment programs such as PBIS offer opportunities for close collaboration between mental health providers and school staff, effectively increasing outcomes for students.

Despite the barriers and challenges that students face in accessing and receiving appropriate mental health care, there are still endeavors being made today to address the gap in mental health care for students in the USA. One such endeavor is a policy strategy that aims to connect children to coverage through Medicaid and the Children's Health Insurance Program (CHIP), which provide robust coverage for those seeking mental health services, including programs provided at school. The Biden-Harris Administration has taken several steps to expand and improve Medicaid and CHIP, such as increasing the federal matching rate, extending postpartum coverage, and creating a new special enrollment period for the ACA Marketplace (The White House, 2021). These actions can help reduce the financial barriers for students and families to access mental health care. Another strategy is to promote school-based mental health education, support, and services. One example is the Department of Education released new resources such as the "Supporting Child and Student Social, Emotional, Behavioral, and Mental Health" that outlines key challenges and provides evidence-based recommendations for educators, staff, and providers to create a system of supports for students with behavioral health needs and their families (U.S. Department of Education, 2021). The resource emphasizes the importance of universal screening, early identification, prevention, intervention, and referral to appropriate services. It also highlights the need for coordination among school personnel, community providers, and families.

Conclusion

The articles and studies reviewed and examined in this paper have demonstrated the need, motivation, and unique features of SMHs for high school and university students. They have illustrated the various barriers and challenges that students and providers face when seeking and delivering mental health care in schools, such as stigma, time and resources, mental health literacy, lack of funding, environmental factors, confidentiality concerns, and therapist use of evidence. Moreover, the review has highlighted the unique strengths of the current treatment programs and frameworks in SMHs, and how they match the specific needs and preferences of the students. Based on the literature review and the analysis, the paper has attempted to answer the research questions and provide some implications and recommendations for future research and practice.

Rooted in the main findings of the paper, some implications for future research and practice include an exploration of the effectiveness and feasibility of different types of interventions and delivery methods in SMHs; the adoption of a more comprehensive and student-centric approach to therapy; and an acknowledgment of the dual-faceted nature of barriers in accessing mental health care. SMHs are a valuable and promising setting for providing mental health services to high school and university students in the USA, but they also face many challenges and limitations that prevent them from meeting the needs and preferences of the students. Therefore, more research and practice are needed to overcome these barriers and to improve the accessibility and suitability of the services offered. By doing so, SMHs can enhance the mental health and well-being of the students, as well as their academic and social outcomes.

Works Cited

American Psychiatric Association. (2020, August). Stigma, prejudice and discrimination against people with mental illness. https://www.psychiatry.org/patients-families/stigma-and-discrimination Bowers, H., Manion, I., Papadopoulos, D., & Gauvreau, E. (2012). Stigma in school‑based mental health: perceptions of young people and service providers. *Child and Adolescent Mental Health*, **18**(3), 165–170. https://doi.org/10.1111/j.1475-3588.2012.00673.x

Carnegie Corporation of New York. (1989). Turning points: preparing American youth for the 21st century. https://www.carnegie.org/publications/turning-points-preparing-american-youth-for-the-2 1st-century/

CASEL. (n.d.). What is the CASEL framework? https://casel.org/fundamentals-of-sel/what-is-the-casel-framework/

Castillo, E. G., Ijadi-Maghsoodi, R., Shadravan, S., Moore, E., Mensah, M. O., Docherty, M., Nunez, M. G. A., Barceló, N. E., Goodsmith, N., Halpin, L. E., Morton, I., Mango, J., Montero, A. E., Koushkaki, S. R., Bromley, E., Chung, B., Jones, F., Gabrielian, S., Gelberg, L., . . . Wells, K. B. (2019). Community interventions to promote mental health and social equity. *Current Psychiatry Reports*, **21**(5). https://doi.org/10.1007/s11920-019-1017-0

Chiu, A. W., Langer, D. A., McLeod, B. D., Har, K., Drahota, A., Galla, B. M., Jacobs, J. W., Ifekwunigwe, M., & Wood, J. J. (2013). Effectiveness of modular CBT for child anxiety in elementary schools. *School Psychology Quarterly*, **28**(2), 141–153. https://doi.org/10.1037/spq0000017

Corrigan, P. W., & Watson, A. C. (2002). The paradox of self-stigma and mental illness. *Clinical Psychology-science and Practice*, **9**(1), 35–53. https://doi.org/10.1093/clipsy.9.1.35

DeBate, R., Gatto, A., Rafal, G., & Bleck, J. (2022). A qualitative assessment of mental health literacy and help-seeking behaviors among male college students. *Discover Mental Health*, **2**(1). https://doi.org/10.1007/s44192-022-00028-9

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: a meta‑analysis of school-based universal interventions. *Child Development*, **82**(1), 405–432. https://doi.org/10.1111/j.1467-8624.2010.01564.x

Eagle, J. W., Dowd-Eagle, S., Snyder, A., & Holtzman, E. G. (2014). Implementing a multi-tiered system of support (MTSS): collaboration between school psychologists and administrators to promote systems-level change. *Journal of Educational and Psychological Consultation*, **25**(2–3), 160–177. https://doi.org/10.1080/10474412.2014.929960

Elias, M. J., Zins, J. E., Graczyk, P. A., & Weissberg, R. P. (2003). Implementation,

sustainability, and scaling up of social-emotional and academic innovations in public schools. *School Psychology Review*, **32**, 303–319.

Estrapala, S., Rila, A., & Bruhn, A. L. (2020). A Systematic review of tier 1 PBIS implementation in high schools. *Journal of Positive Behavior Interventions*, **23**(4), 288–302. https://doi.org/10.1177/1098300720929684

Finn, J. D., & Zimmer, K. S. (2012). Student engagement: what is it? why does it matter? In *Springer eBooks* (pp. 97–131). https://doi.org/10.1007/978-1-4614-2018-7_5 Gaddis, S. M., Ramirez, D., & Hernandez, E. L. (2018). Contextualizing public stigma: endorsed mental health treatment stigma on college and university campuses. *Social Science & Medicine*, **197**, 183–191. https://doi.org/10.1016/j.socscimed.2017.11.029 Gage, N. A., Beahm, L. A., Kaplan, R., MacSuga-Gage, A. S., & Lee, A. (2020). Using positive behavioral interventions and supports to reduce school suspensions. *Beyond Behavior*, **29**(3), 132–140. https://doi.org/10.1177/1074295620950611 Goodman, S. H., Lahey, B. B., Fielding, B., Dulcan, M., Narrow, W., & Regier, D. (1997). Representativeness of clinical samples of youths with mental disorders: a preliminary population-based study. *Journal of abnormal psychology*, **106**(1), 3–14. https://doi.org/10.1037//0021-843x.106.1.3

Greenberg, M. T., Weissberg, R. P., O'Brien, M. U., Zins, J. E., Fredericks, L., Resnik, H., & Elias, M. (2003). Enhancing school based prevention and youth development through coordinated social, emotional, and academic learning. *American Psychologist*, **58**, 466–474.

Guttman-Lapin, D., Nickerson, A., O'Malley, M., Renshaw, T., Silva, K., & Sockalingam, S. (2015). School mental health referral pathways (SMHRP) toolkit. In U.S. Substance Abuse And Mental Health Services Administration.

Harlacher, J. E., Sakelaris, T. L., & Kattelman, N. M. (2013). Multi-Tiered system of support. In *Springer eBooks* (pp. 23–45). https://doi.org/10.1007/978-1-4614-9360-0_3 Harmon, S. L., Price, M., Corteselli, K. A., Lee, E. H., Metz, K., Bonadio, F. T., Hersh, J., Marchette, L. K., Rodríguez, G. M., Raftery‑Helmer, J. N., Thomassin, K., Bearman, S. K., Jensen‑Doss, A., Evans, S. C., & Weisz, J. R. (2021). Evaluating a modular approach to therapy for children with anxiety, depression, trauma, or conduct problems (MATCH) in school-based mental health care: study protocol for a randomized controlled trial. *Frontiers in Psychology*, **12**. https://doi.org/10.3389/fpsyg.2021.639493 Hofmann, S., Asnaani, A., Vonk, I. J. J., Sawyer, A. T., & Fang, A. (2012). The Efficacy of cognitive behavioral therapy: a review of meta-analyses. *Cognitive Therapy and Research*, **36**(5), 427–440. https://doi.org/10.1007/s10608-012-9476-1 Jennings, K. S., Goguen, K. N., Britt, T. W., Jeffirs, S. M., Wilkes, J. R., Brady, A. R., Pittman, R. A., & DiMuzio, D. J. (2017). The role of personality traits and barriers to mental health treatment seeking among college students. *Psychological Services*, **14**(4), 513–523. https://doi.org/10.1037/ser0000157

Lally, J., Conghaile, A. Ó., Quigley, S., Bainbridge, E., & McDonald, C. (2013). Stigma of mental illness and help-seeking intention in university students. *The Psychiatrist*, **37**(8), 253–260. https://doi.org/10.1192/pb.bp.112.041483

Langley, A. K., Nadeem, E., Kataoka, S. H., Stein, B. D., & Jaycox, L. H. (2010). Evidence-based mental health programs in schools: barriers and facilitators of successful implementation. *School Mental Health*, **2**(3), 105–113.
https://doi.org/10.1007/s12310-010-9038-1

Lenox, K. (2021, March). Environment and mental health — Intimately connected, much to learn. National Institute of Environmental Health Sciences.
https://factor.niehs.nih.gov/2021/3/feature/3-feature-mental-health

Linnenbrink, E. A., & Pintrich, P. R. (2003). The role of self-efficacy beliefs in student engagement and learning in the classroom. *Reading & Writing Quarterly*, **19**(2), 119–137. https://doi.org/10.1080/10573560308223

Marsh, D. (2004). Serious emotional disturbance in children and adolescents: opportunities and challenges for psychologists. *Professional Psychology: Research and Practice*, **35**, 443–448.

Mendez, L. M. R. (2016). Cognitive behavioral therapy in schools. In *Routledge eBooks*. https://doi.org/10.4324/9781315694399

Mental health. (2023). DASH | CDC.
https://www.cdc.gov/healthyyouth/mental-health/index.htm

Miles, R., Rabin, L. A., Krishnan, A., Grandoit, E., & Kloskowski, K. (2020). Mental health literacy in a diverse sample of undergraduate students: demographic, psychological, and academic correlates. *BMC Public Health*, **20**(1).
https://doi.org/10.1186/s12889-020-09696-0

Nakao, M., Shirotsuki, K., & Sugaya, N. (2021). Cognitive–behavioral therapy for management of mental health and stress-related disorders: recent advances in techniques and technologies. *BioPsychoSocial Medicine*, **15**(1).
https://doi.org/10.1186/s13030-021-00219-w

National Center for Education Statistics. (2022). Press release - roughly half of public schools report that they can effectively provide mental health services to all students in need - may 31, 2022. https://nces.ed.gov/whatsnew/press_releases/05_31_2022_2.asp National Center on Safe Supportive Learning Environments. (n.d.). Implementing school mental health supports: best practices in action.

Paternite, C. E. (2005). School-based mental health programs and services: overview and introduction to the special issue. *Journal of Abnormal Child Psychology*, **33**(6), 657–663. https://doi.org/10.1007/s10802-005-7645-3

Rix, K. (2022, April 22). Understanding school-based mental health services. US News & World Report.
https://www.usnews.com/education/k12/articles/understanding-school-based-mental-health-services

Romer, N., Valdez, A., Alcalá, L., Diaz, J., Gurrola, E., Mcclellan, P., & Mccullough, S. (2011). Improving coordination and access to comprehensive school-based mental health services in california: a preliminary landscape analysis. In WestEd.

Ross, K. M., & Tolan, P. H. (2017). Social and emotional learning in adolescence: testing the CASEL model in a normative sample. *The Journal of Early Adolescence*, **38**(8), 1170–1199. https://doi.org/10.1177/0272431617725198

Ohio Department of Education and Workforce. (n.d.). School-based mental health https://education.ohio.gov/Topics/Student-Supports/School-Wellness/School-based-Ment al-Health

Siceloff, E. R., Bradley, W. J., & Flory, K. (2017). Universal behavioral/emotional health screening in schools: overview and feasibility. *National Library of Medicine*, 32–38. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6350819/

Skinner, E. A., & Pitzer, J. R. (2012). Developmental dynamics of student engagement, coping, and everyday resilience. In *Springer eBooks* (pp. 21–44). https://doi.org/10.1007/978-1-4614-2018-7_2

State Shortages Data Dashboard. (n.d.). National Association of School Psychologists (NASP). https://www.nasponline.org/about-school-psychology/state-shortages-data-dashboard Statista. (2023, August 15). Barriers to mental health services for U.S. college students in 2022-2023. https://www.statista.com/statistics/1126750/barriers-to-mental-health-services-college-stu dents-us/

American Psychiatric Association. (2020, August). Stigma, prejudice and discrimination against people with mental illness. https://www.psychiatry.org/patients-families/stigma-and-discrimination Swick, D. C., & Powers, J. D. (2018). Increasing access to care by delivering mental health services in schools: the School-Based Support Program. *School Community Journal*, **28**(1), 129–144. http://files.eric.ed.gov/fulltext/EJ1184769.pdf The White House. (2021, October 19). Fact sheet: improving access and care for youth mental health and substance use conditions. https://www.whitehouse.gov/briefing-room/statements-releases/2021/10/19/fact-sheet-im proving-access-and-care-for-youth-mental-health-and-substance-use-conditions/ U.S. Department of Education. (2021). Supporting child and student social, emotional, behavioral, and mental health needs. https://www2.ed.gov/documents/students/supporting-child-student-social-emotional-beha vioral-mental-health.pdf

Zins, J. E., Elias, M. J., Greenberg, M. T., & Pruett, M. K. (2000). Implementation of prevention programs: a special issue of the journal of educational and psychological consultation (1st ed.) *Routledge*. https://doi.org/10.4324/9781315046266

The Hidden Multi-Billion Industry: A Comparative Study of the Chinese and Japanese Videogame Industries By Joyce You

0. Abstract

This paper aims to investigate the disparity in international influence between the Chinese and Japanese video game industries as the Japanese video game industry consistently receives greater international revenue and recognition despite China's significantly greater local market size. By employing a comparative analysis approach, the research explores various aspects of the two industries, including their historical development, market dynamics, and relevant policies. The study reveals that, in addition to disparities in experience, the Chinese video game industry places a significant emphasis on mobile gaming. This focus on mobile games, while catering to a massive user base, has resulted in limited opportunities for the development of large-scale projects. Furthermore, current government policies in China have created an environment that discourages competition and large investments in a single project. Understanding these dynamics can aid policymakers, industry professionals, and investors in formulating strategies to enhance the competitiveness and influence of their respective video game industries. By aiding talent training and encouraging ambitious ventures, the Chinese government can aid the Chinese video game industry in expanding its international revenue and influence. Finally, the dynamic nature of the video game industry necessitates continuous monitoring and exploration of emerging trends and developments. Further research that studies the Chinese video game industry from other perspectives would offer valuable insights.

1. Introduction

Video games have emerged as a dominant form of entertainment in the modern era. With their interactive nature and immersive experiences, video games have captivated people of all ages and backgrounds, overcoming geographical boundaries. They provide a unique blend of art, technology, and storytelling, allowing individuals to explore virtual worlds, assume different roles, and embark on epic quests.

In recent years, the global video game industry has experienced remarkable growth, captivating 2.7 billion players worldwide as of 2020 (Newzoo 17). Two countries that have played a significant role in shaping this industry are China and Japan. While both nations carry rich cultural heritage and have made a significant presence in the world of video games, a notable disparity exists in the international influence demonstrated by their respective gaming industries, as the Japanese video game industry consistently receives greater international revenue and recognition. This research paper aims to explore and compare the Chinese and Japanese video game industries, analyzing the factors that have contributed to the disparity in influence.

The Japanese video game industry has long been recognized as a creative powerhouse, captivating players with iconic franchises like Super Mario, Pokémon, and Street Fighter. Japanese video games have not only achieved commercial success but have also left a lasting

impact on global gaming culture. On the other hand, the Chinese video game industry, despite its rapid expansion in the past decade, has demonstrated significantly less influence on the global video game industry. While China has a massive population and big video game companies like Tencent and NetEase, its video games have struggled to achieve the same level of recognition and impact as their Japanese counterparts. This research paper will analyze the factors that have contributed to this difference, such as the supply of talent, investments, and governmental policies. By examining these factors, we can gain insights into why Chinese video games have faced challenges in gaining widespread influence and recognition beyond their domestic market, and how this can be changed through industrial policy.

2. Literature Review

The topic of industrial policy has been long debated. Schwarzenberg notes that (though lacking a formal definition) industrial policy typically involves a set of government policies aimed at effectively shaping or maintaining a specific framework for production and trade within an economy[2] (Schwarzenberg 2). In the context of managing long-term goals within the U.S., Mazzucato et al. claim that when the capitalist market has proven to be incapable of reaching such goals, the government should actively step in to push the society towards the ideal vision. They also argue that this should be done through policies that steer industries towards a general direction that is both general enough for innovation to occur and specific enough so progress could be made toward the ideal. It should also involve ample use of resources, including public investment, regulation, demand-stimulating procurement, macroeconomic policy, and education and skills training (Mazzucato et al.) 3. While both provide a holistic overview of industrial policies, they may be overly generalized for the context of the Chinese video game industry.

In the works of other economists, such as Pack and Saggi, emphasis has been placed on industrial policies aimed towards "infant industries," or industries that cannot yet compete with foreign competitors due to lack of experience and higher initial production costs, much like the Chinese video game industry. In their paper, Pack and Saggi point out that while some have argued against industrial policies aimed at infant industries since there is no way to determine for sure if it would grow to be worth the investment, the investments would eventually be recompensed in the form of innovations. For this reason, they also call for the importance of policies that prompt discovery of knowledge (Pack et al. 274)[4]. In addition to Pack and Saggi's paper, Chang and Andreoni also point to the importance of innovation through industries. They argue that the production process offers significant contributions to innovation that R&D units do not cover. This is because newfound knowledge outside of an industry is not integrated into the production process directly; further innovation must be done by firms involved in production. In this process, the government can support such an industry by reducing uncertainties (Chang et al. 51)[5]. Cherif and Hasanov further this argument in their discussion of industry transformations through industrial policies. They argue that even with government investments and adaptation of existing technology, without constant innovation, industries may fail to compete and result only

in costly investment expenditures. For this reason, the authors also believe in the importance of government intervention in supporting innovation[6].

In recent years, scholars have paid more attention to the formation of video game industries. As Johns points out in her overview of the video game development, the process has developed into an international network, with every step of game development (hardware production, software development, distribution) being addressed at different geographical sites in search of cost efficiency. On the hardware side, this includes the steps of developing concept and design, manufacturing individual components (such as CPU, ROM, and peripherals), assembly of components, distributing, retailing, and eventually consumption. On the software side, this involves planning for market, genre, budget targets, designing concepts, producing components (i.e. artworks, graphics, and programs), debugging, publishing, distributing, retailing, and the eventual consumption combined with hardware (Johns 180)7.

While video game products are no longer bounded by nations due to the internationalization of publishers, Japan, the U.K., France, and the U.S. remain leaders in software development. Consalvo further points out that the successful globalization of the Japanese video game industry can be attributed partly to a network of media it has created, involving games, toys, anime, and more. The network aids in the delivery of Japanese content by diversifying possible channels and enforcing audience loyalty (Consavo 141)8. Zhao on the other hand, points to the role of console development when analyzing the success of the Japanese video game industry (Zhao 54)[9].

It is inarguable that development in electronic technology has a significant impact on the video game industry. Both Johns and Zhao point to the influence of hardware on software development and sales in their works; moreover, they also note that hardware development is dependent on breakthroughs in electronic technology. However, the video game industry has also been an active participant in innovations. In their work, Meng et al mention that in the 1980s, Nintendo (a well-known Japanese video game company) worked with Ricoh (a Japanese tech company) to minimize the production cost of a main control chip in hopes of decreasing the production cost of a video game console (Meng et al. 3)[10]. In more recent years, Young credits innovations in video game engines, such as Unity3D, GameMaker Studio, and Construct 2, for decreasing the difficulty and cost of video game development (Young et al. 193)[11]. Furthermore, Saarik credits game companies for the development of VR hardware (Saarik)[12]. Though originally aimed at providing new possibilities for gamers, VR can potentially transform storytelling across the creative industry (World Economics Forum 2018)[13]. These cases all demonstrate the video game industry's capacity for innovation.

3. History of the Japanese video game industry
The starting period (1970s-1980)

In the U.S., the launch of the Atari game *Pong* in the 1970s popularized arcade gaming before the launch of the Atari 2600 popularized console gaming. As Japan experienced continuous economic growth, people sought new forms of entertainment (Ferrer)[14]. In 1978, the launch of

the phenomenal arcade game *Space Invaders* by Taito led arcade gaming into the Japanese mainstream. Along with coffee shops and bowling alleys, arcades gained popularity. Following Taito, Namco's *Pac-Man* and many other game developers nourished this gaming platform with content.

During this period, some games were expensively imported to the more mainstream PCs in Japan at the time, such as the Apple I. However, due to technological restrictions, PC gaming was less common. Similarly, home gaming consoles were also less popular. Due to the lack of industry standards, the development of gaming hardware and software was mostly simultaneous and occurred only within the same company (Tadakazu 105)[15].

The console war (1980s-2000)

In 1983, Nintendo launched the phenomenal gaming console Nintendo Famicom (aka Nintendo NES) along with the console games dedicated to the NES. The crash of the U.S. gaming market due to Atari's failure, which occurred at around the same time, led Nintendo into the Western video game market and had huge financial success both in and outside of Japan (Szezepaniak 32)[16]. This success led Nintendo to realize the importance of video game software for consoles and allied with other video game development companies to create third-party video games for the NES.

Following Nintendo's success, Sega, and later Sony, launched a series of gaming consoles. The three companies engaged in fierce competition over the console gaming market and ended in Sega leaving the market in 1998. During this competition, gaming technology rapidly evolved; players enjoyed a series of high-quality video games, and through collaboration with the animation and film industries, famous IPs emerged (Wang)17. It was also during this period when console gaming became the majority in Japan.

The mobile age (2000s-)

As smartphone technology matured in the 21st century, the Japanese video game industry entered the age of mobile gaming. While traditional console games continued to be developed, video game development companies utilized their IPs to create mobile games as well. Through their accessible nature, the mobile game market grew exponentially and gained popularity amongst players of a wide range of genders and ages (Mäyrä)[18]. Today, it is the gaming platform with the greatest number of players and the most profit in Japan (Wezo)[19].

4. History of the Chinese video game industry

The pirating period (1980s-1990)

The history of video games in China began in the late 20th century. In the 1980s, the rapid development of personal computers across the world motivated Chinese companies to cultivate Chinese computer technology, resulting in models such as the Great Wall 100. At the same time, existing PC models, such as the Japanese Sord M5, were introduced in China. Along

with the introduction of foreign computers was the introduction of foreign PC games in the form of cassettes (Wang)[17].

These products, however, were essentially unaffordable for the majority of Chinese consumers. For this reason, the Chinese video game pirating industry began to develop alongside any emerging video game technology. In 1985, Taiwanese companies began to produce pirated videogame consoles. Through commerce between Taiwan and mainland China, pirated video game consoles also began to appear in China. Regardless, during this period, the Chinese video games market expanded quickly and attracted foreign companies to publish their games in China (Jin)[20].

The starting period (1990s-2000)

From the 1990s to the 2000s, Chinese studios consisting of mostly three to five people learned from games of more advanced regions by localizing them. In 1994, the first console game independently developed within mainland China, *Magic Eagle*, was published. Following this work, numerous Chinese console games marked with poor visual quality and primitive gameplay emerged. While they received little attention outside of China, Chinese studios gained advantages locally for tuning into the preferences of Chinese audiences (Lin 69)[21]. Financially, however, the studios suffered from pirating. *Xianjian 3* from 2003, for example, was estimated to have 3 million pirated copies sold and only half a million copies sold legally (Shi)[22].

In 2000, the "Game Machine Sales Ban", a law enacted by the Chinese government, outlawed the production and sales of all hardware dedicated to gaming. This law was largely a reflection of the mainstream Chinese society's view of video games as a "digital heroin" that leads to addictions, especially among children. While console gaming remained a majority outside of China, the Chinese console gaming market perished and never recovered even after the policy was taken out 13 years later. Since then, the majority of governmental policies regarding video games have been regulations in content aimed at "protecting the youth", while disregarding the greater video game population above the age of 18 (Ernkyist et al. 3)[23].

During the same period, as internet technology developed, online games grew in popularity.

The maturing period (2000s-)

From the 2000s onwards, Chinese video game development continued to mature. Studio sizes grew with some having more than one hundred employees. Development projects grew in scale as well and became more well-organized. The success of this period was largely correlated to the development of online video game service technologies (Nakamura 292)[24]. As the introduction of foreign online games, such as the Korean game, *Legend of Mir*, proved this strategy to be highly profitable, more Chinese games began to be charged based on monthly subscriptions rather than a one-time fee (Yao et al. 126)[25]. Through this change, video game companies were able to generate large amounts of profit from their work. However, during this

period, innovations in gameplay remained to be rare. Many Chinese video games appeared only to be imitations of existing foreign video games (Nakamura 292)[24].

At around the same time, the rapidly maturing smartphone technology opened up a new possibility for video games. Many independent game development studios emerged in China as individual game developers broke off from major companies such as NetEase and Tencent. Unlike the existing gaming platforms, mobile games are more accessible and have more potential consumers. This gave opportunity to the small game development studios (Zhang 34)[26]. Through rapid development and constant competition, the mobile gaming market quickly became the new majority of the Chinese video game market.

5. The Japanese and Chinese video game industries today

Local market sizes and structures
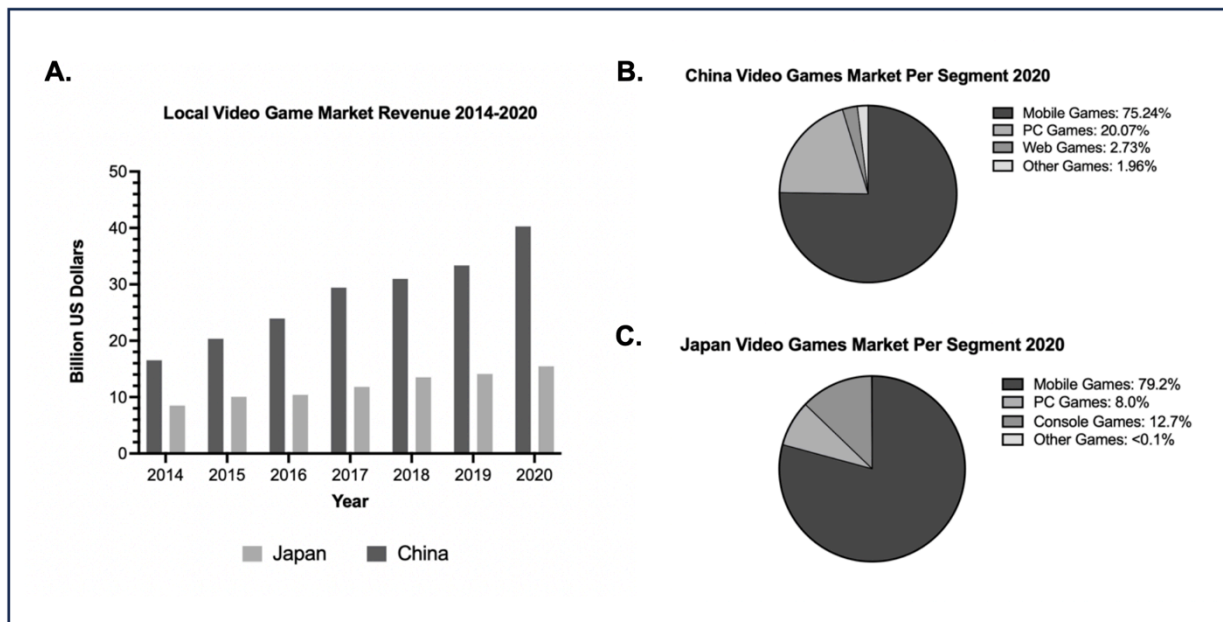
Figure 1. Japan and China video game market size and structure. Data from from Gamma Data (Gamma data 2023)[27] and Lab KADOKAW[28]. Data organized with Prism.

As shown in Figure 1A, the Chinese video game market has demonstrated remarkable growth, reaching approximately 40.3 billion dollars in revenue by 2020. In comparison, the expansion of the Japanese video game market has been less observable.

Despite these disparities, Figure 1B and Figure 1C show that both markets exhibit similar trends in terms of market structure, with mobile games dominating revenue generation. This may be due to the overwhelmingly larger number of consumers who have access to smartphones compared to those who have devices capable of running PC or console games, as well as the in-game purchase monetization strategy common in mobile games but not others.

Additionally, it is worth noting that console gaming remains a popular option in Japan, whereas the Chinese market shows nearly no support for this platform.

International sales
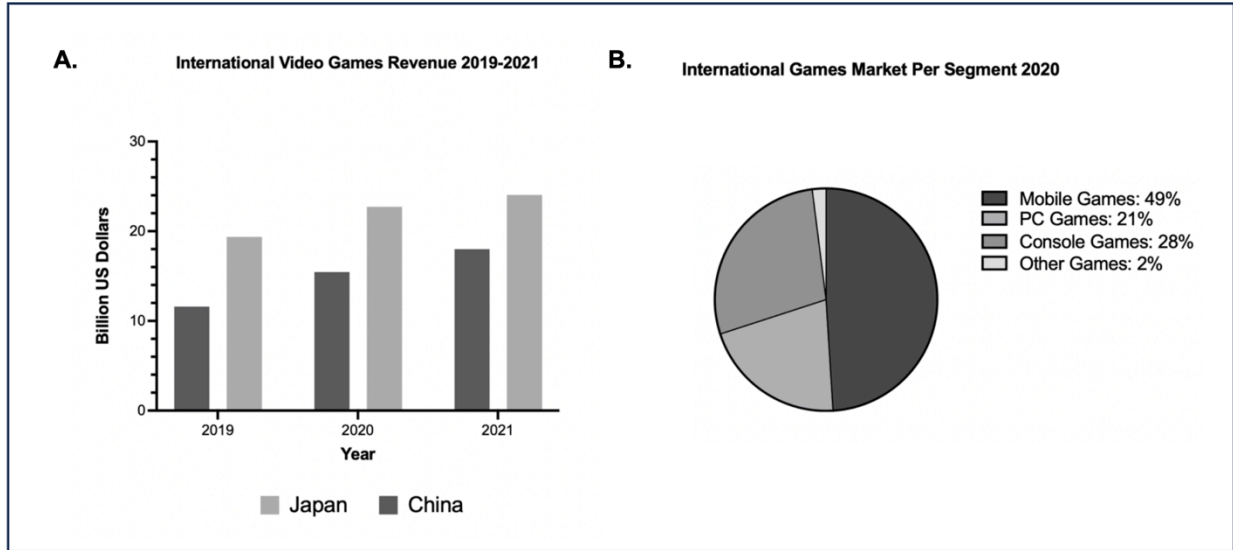
Figure 2. International video games revenue of Chinese and Japanese developed video games and international video game market structure. Data from Kinoshita and Taya (Kinoshita et al. 35)[29] and Youxi Gongwei (Gongwei 2022)[30]. Data organized with Prism.

As shown in Figure 2A, even as the local Chinese video game market has expanded to be more than twice the size of the Japanese, Japanese-developed video games have consistently received greater revenue internationally. This disparity aligns with the level of international recognition the two industries have received.

Furthermore, the majority of the international revenue for Chinese-developed video games was generated by mobile games, while for the Japanese developed video games it was by console games.

Innovations
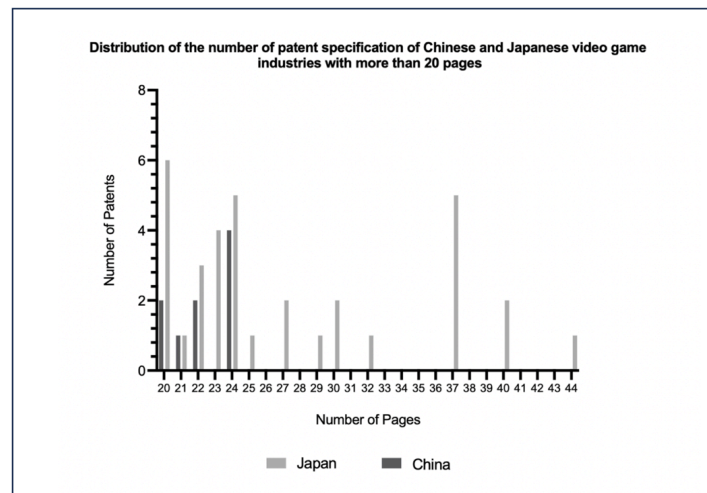
Figure 3. Distribution of page numbers of Chinese and Japanese video game patent specifications. From Nie and Luo (Nie et al. 96)[31]. Data organized with Prism.

According to Cherif and Hasonov, patents are correlated to the R&D intensity of an industry (Cherif et al. 19)[6]. In the Chang and Andreoni paper, patents are described as a type of entry barrier to an industry (Chag 51)[5]. As shown in Figure 3, Compared to the Japanese video game industry, the Chinese video game industry has produced significantly fewer patents and lacks complexity (as reflected by the length of patents). It is hypothesized that this may be due to the concentration of investments in mobile games. Facing barriers in technology and lacking sufficient investments in exploring further video game possibilities, studios lack the incentives to innovate[31].

International Awards

Figure 4. The Game Awards awards and nominations for Japanese and Chinese video games (2014-2020). From The Game Awards (The Game Awards)[32].

The Game Awards (a.k.a. TGA), founded in 2014, is an annual awards show that honors outstanding achievements in the video game industry, and it is one of the most well-recognized awards shows in the global video game industry. TGA covers a wide range of categories, including Game of the Year, Best Art Direction, Best Game Direction, Best Narrative, Best Score and Music, and many more. Winners are determined by a voting jury of international media outlets and influencers of the video game industry (The Game Awards)[32].

According to TGA, video games are judged heavily on innovation and contribution to the world video game industry. In the history of TGA, as shown by Figure 3, Japanese video games are regularly and rewarded in diverse ranges of categories, with Nintendo winning Game of the Year in 2017, and FromSoftware winning Game of the Year in 2019 and again in 2022. On the other hand, Chinese video games have made rare appearances in TGA; nominations and awards are scarce, and occur almost only in the Best Mobile Game category (shown with more details in Figure 4).

Relevant policies

Compared to the Japanese video game industry, the Chinese video game industry has received little support from governmental policies.

In Japan, while the video game industry is largely self-supporting and regulated by self-imposed guidelines, the Japanese government has seen it as an important factor in spreading Japanese cultural influence. The Cool Japan Fund, for example, is a government fund that supports the overseas growth of "cool" Japanese products, including video games (Cool Japan Strategy 2014)[33].

In contrast, Chinese video games, Since July 2016, all video games have to be approved by the National Press and Publication Administration (NPPA) to acquire a publication permit before they can be published and monetized in China (The State Administration of Press)[34]. Though intended to regulate the contents of video games, this policy has been criticized for the inefficiency it creates. From April to November of 2018, no publication permits were given to video games due to "internal adjustments in the NPPA." After 2018, an average of 100 games have been approved per month, while around 7000 games waited for approval (Wu)[35]. Countless small studios collapsed as they could not profit from their work, leaving only large corporations with sufficient funding unimpacted (Fan et al.)[36].

6. Discussions
Training and experience

According to Zhang, with more than 50 years of video game development history, Japan has matured its video game development sector with sufficient support for the training of new talents and workflows that enable the constant production of quality games. On the other hand,

Chinese video game development began 20 years later and lacks experience. In Chinese universities, the training and education for the skills required in the production of video games have only started to emerge in the past decade. Within the industry, training dedicated to the production of non-mobile games is also rare. Talents with work experience related to the production of PC games and console games are uncommon (Zhang 210)[37].

  The "Game Machine Sales Ban" also crippled the consumption and production of video game consoles in China despite its experience in console manufacturing. In comparison, Japanese video game consoles have made themselves known during the console war period. As of 2020, Sony and Nintendo together dominate 72.7% of the global gaming console market (Rolls)[38]. Due to the symbiotic relationship between consoles and console games in monetization, having no console brand of its own limits the Chinese video game industry from making itself known through this channel.

Mobile games and international influence

  Compared to the Japanese video game industry, the Chinese video game industry pays little attention to the production and distribution of non-mobile games. Despite the growth of the Chinese video game industry into a multi-billion dollar sector through the support of the local market, its emphasis on mobile game production has hindered the expansion of its international revenue and influence. In the history of TGA, no mobile game has won an award outside of the Best Mobile Game category, and this is no coincidence. With limited performance capabilities compared to gaming consoles and PCs, smartphones offer little room for innovation in graphics and gameplay to mobile games (Liang)[39]. Having produced almost only mobile games, it would be difficult for the Chinese video game industry to receive the same level of recognition as the Japanese video game industry demonstrates in Figure 4.

  The difference in business model between mobile games and non-mobile games also contributes to their difference in innovativeness. PC and console games often employ the pay-to-play (P2P) monetization strategy that charges a high initial fee for access to the full game. Further opportunities for payments exist in the form of extension packs, and are comparatively limited. This monetization strategy motivates developers and publishers to continuously create new games with more innovative graphics or gameplay that attracts players into paying the high initial fee. Mobile games often employ the free-to-play strategy. While the game itself can be accessed for free, ample opportunities for in-game purchases are offered. Oftentimes, there is no limit to how much money one can spend through in-game purchases (Newzoo 2020)[1]. This monetization strategy encourages developers and publishers to continuously update the same game with more stories, events, and in-game purchase opportunities over an extended period of time. Strapped by their sunken costs, players tend to play the same game for longer periods of time. In 2022, only 14 of the top 100 revenue-generating video games were published within the year, constituting only 7% of the generated revenue. This number has also been steadily declining since 2019 (Gamma Data 2023)[27].

One reason for the lack of attention towards developing high-profile non-mobile games would be the risk of investing in large-scale, non-mobile projects for investors. To produce a high-profile PC/console game with innovative graphics and gameplay is extremely investment intensive as it requires people, time, and R&D. While this cost is not substantially different between the Chinese and Japanese video game industries, Japanese video game developers find investment much more easily as the Japanese video game industry has consistently generated sizeable revenue from gamers around the world with its high-budget, high-profile video games (many as such shown in Figure 4). For both the Chinese and Japanese video game market, PC games and console games only constitute a relatively small portion of its revenue (as shown in Figure 1.B and Figure 1.C). The international video game market, in which PC/console games constitute nearly half of the revenue generation (as shown in Figure 2.B), is extremely important for the financial success of a high-budget PC/console game. However, the Chinese video game industry lacks experience in both production and distribution of similar games. Chinese PC/console games have little chance of competing with video games from other countries in the international video game market. Local support from Chinese players is likely, but it would not compensate for the level of risk investors must take.

The level of uncertainty for investors in creating large-scale projects in China is furthered by current governmental policies. Not only does the publication permit system regularly delay publication and revenue generation by months, but if a game does not receive approval, investors must expend more time and costs for revising the game to wait for approval again. If they are unable to cover this cost, their investments become completely sunken. The same would be true if another hiatus for permit distribution occurs as it did in 2018. Additionally, the damage this policy dealt to small production studios intensified the concentration of wealth in the video game industry, restricting competition and resulting in the domination of a few video game companies such as Tencent without them having to improve the quality of their games.

It is worth noting that although mobile games have demonstrated less room for innovation and impact, their mobile nature does not negatively impact the generation of revenue and influence. The accessibility of smartphone technology and the free-to-play strategy make mobile games accessible to an exponentially greater population around the world. As mobile technology advances, it is very possible for a new type of high-budget, high-profile mobile games that are capable of carrying quality graphics and gameplay in the same way PC/console games do to emerge. Essentially, the problem with the Chinese video game industry is rooted in the lack of experience and investment, not mobile games.

Distribution and globalization

As a result of the permission permit policy, attempts have been made by Chinese video game publishers to publish games directly in the international market.

Being one of the first participants in the international video game market, the Japanese video game industry has long secured its place in the international video game supply chain and is able to efficiently distribute its works around the world[7] (Johns 180). Due to the lack of

experience, the same is difficult for Chinese video game publishers. In the localization process, Chinese video game publishers have reported having difficulties in crossing cultural barriers, managing overseas employees, overcoming technical difficulties, and facing a lack of relevant talents (Nie et al. 96)[31].

The development of internationally recognized IPs, which is essential to the globalization of video games, is also absent in China. On the other hand, Japanese IPs have made themselves known through networks of content including games, toys, anime, movies, and more (Consalvo 141)[8].

Need for industrial policy

The Chinese video game industry holds great potential as it continuously demonstrates growth but is currently unable to compete with other countries in the international video game market. For this reason, it satisfies the definition of an infant industry in terms of international influence. To boost international revenue and influence, industrial policy is necessary.

In the case of the Chinese video game industry, instead of direct investment in projects that would not structurally transform the industry, education and skills training for video game development and localization talents is more essential. This could be done through subsidies for companies or universities to offer relevant training or courses.

Policies should support firms that initiated projects that explore high-budget, high-profile video games similar in production scale as currently internationally recognized video games. As of now, such a project is unlikely to be a mobile game, though in the future this may change. Additionally, since the Chinese video game industry is unable to profit from gaming console hardware (unlike its Japanese counterpart), PC focused games or cross platform games have more potential. This could be done through tax breaks or subsidies. Changes would also need to be made to the current restrictive policies targeting video games to support small production studios.

Policies should also further encourage the globalization of Chinese video games. One way this can be achieved is through tax breaks on overseas revenue of the video game industry. Funds that are similar to the Cool Japan Fund may also be helpful in globalization.

In doing so, the Chinese video game industry would not only generate greater international revenues but also technological spillovers as the Japanese video game industry has demonstrated.

7. Conclusion

Since Japan's entrance into the world video game industry in the 70s, the Japanese video game industry has had more time to mature, establishing a strong foundation for its success with famous IPs, experience in video game and console development, globalization of their games through networks of content, and governmental support. Today, this foundation has allowed Japanese video game developers to focus on creating innovative and complex games that continue to capture the attention of gamers worldwide.

On the other hand, the Chinese video game industry lacks a similar foundation. Education and training dedicated to video game development are rare and have only emerged recently. Within the industry, Chinese video game developers primarily have focused on profitable mobile games, leading to a relative lack of emphasis on innovative gaming experiences. Despite China's substantial local market size, the country's video game industry faces challenges in exporting non-mobile games that can compete on an international scale. These limitations have prevented Chinese video game developers from gaining the same level of international recognition as their Japanese counterparts.

The problems faced by the Chinese video game industry are furthered by the instability caused by restrictive governmental policies. Compared to the Japanese government which views the video game industry as an important "soft power", the Chinese government sees it as an industry in need of censorship and inspections. Unpredictable restrictions towards the Chinese video game industry have reduced competition between firms and discouraged investments in non-mobile games.

It is evident that multiple factors contribute to the disparity in influence between the Chinese and Japanese video game industries. While the Chinese industry has made significant progress in recent years, it still has room to mature and explore new avenues for innovation. By addressing challenges such as diversifying game development, fostering international presence, and navigating policy restrictions, the Chinese video game industry can potentially narrow the gap and establish a stronger global presence.

One significant limitation of this research paper is the limited access to original and up-to-date data. Lacking access to exclusive databases and copyrighted information that may provide a more detailed understanding of the Chinese and Japanese video game industries, the findings presented in this paper are based on publicly available information, which may not fully illustrate the industries. For example, while one may be able to reflect on the difference in innovativeness based on data related to investments spent on R&D in the Chinese and Japanese video game industries, this paper does not include such information due to a lack of access. Furthermore, the data analysis methods employed in this research were limited. Complex statistical analyses or sophisticated modeling techniques may not have been feasible due to the lack of experience and access to specialized software. Additionally, a limitation of this study is the lack of quantifiable measurement for influence and recognition. While the paper discusses the historical significance, market size, and awards of the Chinese and Japanese video game industries, it lacks a precise measurement of the influence and recognition each industry holds. Influence and recognition are relatively subjective and are difficult to illustrate based on this information only. Future research with more extensive resources and access to industry experts could employ quantitative methods to provide a more comprehensive assessment of these factors. Further studies that address these limitations could provide valuable insights that fuel the understanding of this industry.

Other approaches to this subject, such as studies that focus on individual video game development firms, analyze the Chinese video game industry from a social and cultural

perspective, or compare the Chinese video game industry with other countries may also offer valuable insight. By exploring these different perspectives, researchers can identify new opportunities for innovation and growth.

8. Methods

This research takes the form of a multi-case study. In other words, by examining two cases with essentially identical methods, this paper hopes to find meaningful contrasts that help us understand the phenomenon behind the cases (Bryman)[40]. Specifically, this paper examined the Chinese video game industry and the Japanese video game industry hoping to explain the causes of one's success through the lens of theories on industrial policy.

To better understand the factors that shaped the two video game industries, this paper examined their developmental histories and current status through the analysis of news reports, government reports, and relevant pieces of literature. In this process, the role of industrial policy would be an important focus. This examination will also be accompanied by the analysis of relevant statistics that further illustrate the past, present, and future of the video game industries. To form an explanation based on analyses, this paper will be applying theories of relevant economic publications. The findings of this paper are the results of a deductive approach, meaning that the theory guides this research through observations and toward a conclusion (Bryman)[40].

The reports and pieces of literature used in this process were located through electronic databases Google Scholar, JSTOR, and the Chinese National Knowledge Infrastructure website. This is done so through different combinations of keywords "China", "Japan", "video game", "industry", "development", and "industrial policies".

The data analyzed in this essay are secondary data collected from governmental statistic bureaus in China and Japan, company financial statements, and industry white books. In the case of this research, using secondary data allows working with high-quality data collected over a long period of time. As recommended by Bryman, this paper was careful in selecting data that is the most reflective of the reality of the Chinese and Japanese video game industries to account for the lack of familiarity with the data and the complexity of the data (Bryman)[40].

In the process of information and data collection, language barriers were common as the subject of Chinese and Japanese video game industries has been little researched by scholars outside of Asia. This was overcome mostly through the file translation function of Google Translate.

9. Acknowledgements

Works Cited

Newzoo, Global Games Market Report. 13–17 (2020).

Schwarzenberg, Industrial Policy and International Trade. *Congressional Research Service.* 1–2 (2023).

M. Mazzucato, R. Kattel, J. Ryan-Collins, Industrial Policy's Comeback. *Boston Review.* https://www.bostonreview.net/forum/industrial-policys-comeback (2021)

H. Pack, K. Saggi, Is There a Case for Industrial Policy? A Critical Survey. *The World Bank Research Observer.* **21**, 267–274 (2006).

H. Chang, A. Andreoni, Industrial Policy in the 21st Century. *Development and Change.* **51** (2020).

R. Cherif, F. Hasanov, The Return of the Policy that Shall Not Be Named: Principles of Industrial Policy. *IMF Working Papers.* **19** (2019).

J. Johns, Video games production networks: value capture, power relations and embeddedness. *Journal of Economic Geography.* **6**, 151–180 (2005).

M. Consalvo, Convergence and Globalization in the Japanese Videogame Industry. *Cinema Journal.* **48**, 135–141 (2009).

W. Zhao, Comparison of the Creative Industries Developed in China and Japan. *Shandong University.* 47-54 (2008).

P. Meng, W. B. He, K. Zhang, Riben dianzi youxi de fazhan ji wenhua xingcheng [The history of the development of Japanese video games]. *Dianying Pingjie [Movie Review].* **28**, 1–3 (2007).

C. J. Young, Game Changers: Everyday Gamemakers and the Development of the Video Game Industry. *Faculty of Information University of Toronto.* 109-193 (2018).

D. Saarik, Innovation within gaming industry. https://www.researchgate.net/publication/353368140_Innovation_within_gaming_industry (2021).

World Economic Forum Project Team, Creative Disruption: The impact of emerging technologies on the creative economy. https://www3.weforum.org/docs/39655_CREATIVE-DISRUPTION.pdf (2018).

M. L. Ferrer, The literature on the Japanese video game industry in the last ten years (2013-2022): A geographical perspective. *Proceedings of the General Meeting of the Association of Japanese Geographers* (2023).

N. Tadakazu, A study on the development of the video game industry in Japan: focusing on the 1980's production. *Cultural economics.* **6**, 97–105 (2008).

J. Szczepaniak, History of Japanese Video Games. *Kinephanos,* 28–32 (2015).

Y. Wang, *History of Chinese games.* (2018).

F. Mäyrä, Mobile Games. *The International Encyclopedia of Digital Communication and Society* (2015).

Wezo, 2023 Riben shouyou shichang dongcha baogao [2023 Report on the Japanese mobile games market]. https://www.wezonet.com/insight-report/2304-game/?source=undefined (2023).

L. G. Jin, Xiaobawang: Yige guominpingpai de huihuang yu moluo [Xiaobawang: The rise and fall of a national brand]. *Zhongguo Shangjie [Business China]*. 114–117 (2020).

L. Lin, Zhongguo youxi chanye fazhan yu qianli fenxi [Analysis of the Chinese video game industry and its potentials]. *Shichang Yanjiu [Marketing Research]*, 65–69 (2020).

Y. Shi, The Comparative Reserch of Chinese and American Single-Player Game Industry. *Huazhong University of Science & Technology* (2015).

M. Ernkvist, P. Ström, Enmeshed in Games with the Government: Governmental Policies and the Development of the Chinese Online Game Industry. *Games and Culture*. **3** (2008).

Nakamura, H. Wirman, 14. The Development of Greater China's Games Industry : From Copying to Imitation to Innovation. *Game Production Studies*. 275-292 (2021).

Y. Yao, B. P. Yu, H. Y. Sun, Hanguo wangluo youxi qiye: Cong "tiantang","chuanqi" zhong tuwei [Korean online game companies: Breaking through from "Paradise" and "Legend"]. *21 Shiji Shangye Pinglun [21st Century Business Review]*. **8**, 123–126 (2005).

G. Zhang, Zhongguo shouji youxi de fazhan yu jianyi [Development of the Chinese mobile games and related suggestions]. *Shichang Zhoukan [Market Weekly]*. **2017**, 33–34 (2017).

Gamma Data, 2022-2023 Zhongguo youxi qiye yanfa jingzhengli baogao [2022-2023 China Game Industries Competitiveness Report]. (2023).

Kadokawa Asuki- sogo kenkyujo [Lab KADOKAW], *Famiutsu gemu hakusho 2021 [Famitsu video game white paper 2021]*. (2021).

Y. Kinoshita, Y. Taya, Nihon no dejitaru kontentsu sangyo no tenbo [Outlook for Japan's digital content industry]. *Keizai torendo [Economic trends]*. **111**, 34-35 (2023).

Youxi Gongwei [Game Works Committee], 2022 Zhongguo youxi chuhai qingkuang baogao [2022 China Games Overseas Situation Report]. https://www.fxbaogao.com/view?id=3594200 (2023).

Y. Nie, X. Luo, Jiyu zhuanli de Beijing wangluo youxi xianzhuang ji duice yanjiu [Research on the Status and Countermeasures of Beijing Online Game Industry based on Patent]. *Tequ Jingji [Special Zone Economy]*. **2019**, 95–96 (2019).

The Game Awards, About | The Game Awards. https://thegameawards.com/about.

Cool Japan Strategy, Declaration of Cool Japan's Mission Japan, a Country Providing Creative Solutions to the World's Challenges. https://www.cao.go.jp/cool_japan/english/pdf/published_document4.pdf (2014).

The State Administration of Press, Publication, Radio, Film and Television of the People's Republic of China [NRTA], Guojia xinwen chuban guangdianzongju guanyu yidongyouxi chubanfuwu guanli de tongzhi[Notice from the State Administration of Press, Publication, Radio, Film and Television on the Management of Mobile Game

Publishing Services].
https://www.nppa.gov.cn/xxgk/fdzdgknr/zcfg_210/gfxwj_215/201606/t20160602_4684.h
tml (2023).

H. Wu, 7 geyue de banhao tingfa, 14000 jia youxigongsi daobi, youxihangye hequhecong?
[Publication permit suspended for 7 months, and 14,000 game companies closed down.
Where will the game industry go?]. https://zhuanlan.zhihu.com/p/470060213 (2022).

X. Fan, Banhao "chunfeng" chuibunuan youxiye "xiaohandong [The spring breeze of publication
permits unable to revive video games]. *IT Shinzo [IT Times]* (2022).

M. Zhang, ZhongRi youxi chanye fazhan bijiao yanjou [Comparison and discussion regarding
the development of the Chinese and Japanese video game industries]. *ShuZiHua YongHu
[Digitization User]*. **2019**, 210 (2019).

P. Harding-Rolls, Console market 2022 review: Hampered by lack of hardware availability.
https://ampereanalysis.com/insight/console-market-2022-review-hampered-by-lack-of-ha
rdware-availability (2023).

Q. Liang, Zhongguo shouji wangluoyouxi fazhan ji yanjiu celue [Research on development
strategies of mobile online games in China]. *Beijing University of Posts and
Telecommunications*. (2006).

Bryman, *Social Research Methods.* (2012).

Nanotechnology Used for Microplastic Remediation

Sooyoung Choi

The American School in Switzerland

Abstract

Microplastic pollution in freshwater ecosystems is a rising global issue, and given the vast amount of plastic waste present in the environment, the scale of the pollution is huge. Particles are considered microplastics when plastic materials break down sizes of 1 to 5000 micrometers. When consumed by humans or animals, microplastics can cause substantial harm as they absorb and carry considerable concentrations of substances detrimental to health such as polychlorinated biphenyls (PCB), bisphenol A (BPA), polybrominated diphenyl ethers (PBDE), and polycyclic aromatic hydrocarbons (PAH). The threat microplastics pose to both the environment and human health calls for inventive methods to solve this unprecedented issue. Recently, researchers have been testing with modern innovations in the search for potential answers to detecting and drawing microplastic particles out of water. Nanotechnology, such as carbon nanotubes (CNTs) and 3D plasmonic gold nanopockets (3D-PGNP), has been the most sought after, as they demonstrate a valid process of extraction of microplastics, as well as aiding in overcoming existing limitations in the detection and analysis of microplastics. This study discusses the fundamentals and possible future developments of each innovation.

Introduction

Plastic is one of the most used materials in the modern world, made possible by its versatility and cheap production costs. The term plastic accounts for materials such as polyethylene terephthalate (PET) used for plastic bottles; polypropylene, mostly utilized as straws and food containers; and polystyrene, more commonly known as styrofoam.

According to the OECD, the average person in the USA generates around

221 kg of plastic waste annually. In 2019, 461 million tonnes of plastic were produced, of which 353 million went to waste (OECD 2022). This is a significant surge in plastic production since 1950, when only 2 million tonnes were generated (UNEP 2022). If the trend continues as it has for the last few decades until 2050, 33 billion tonnes of plastic will have accumulated in landfills by then.

Around 70% of plastic waste has a lifetime of less than five years, and only 9% of the waste gets properly recycled. The mismanagement of plastic waste is a huge issue as the majority of the waste finds its way to freshwater sources, which are the only water sources humans are using right now. As of 2019, around 6 million tonnes of plastic waste were dumped into rivers, increasing the total number of plastic in rivers to approximately 110 million tonnes (OECD 2022).

When the plastic waste breaks down into particles with sizes ranging from 1 micrometer to 5000 micrometers, these particles are determined as microplastics. Microplastics are considered to be detrimental to the health of humans because of their ability to absorb toxic chemicals, heavy metals, and

polychlorinated biphenyls, which

they can carry easily due to their substantial surface-area-to-volume ratio (Poison Control 2022). The harmful nature of microplastics paired with their sheer abundance results in microplastic contamination being one of the major rising issues of the world.

As microplastic pollution increasingly spreads throughout the world, new innovative methods to extract the particles out of our water sources, such as nanotechnology, have emerged. More specifically, carbon nanotubes, magnetic carbon nanotubes, and 3-D plasmonic gold nano pockets give a promising outlook as solutions to the issue of microplastic contamination.

Carbon Nanotubes

Carbon nanotubes (CNTs) consist of nitrogen dopants and manganese carbide nanoparticles shaped into a helical geometry, transforming them into hydrophobic polymers. These have large surface and absorption areas owing to their abnormal aspect ratio - they have a diameter of 1 nanometer while having a length of a few hundred micrometers. Because of the aforementioned traits, CNTs exhibit an exceptionally strong

attraction and absorption capacity towards hydrophobic organic contaminants (HOC) [Apul et al.]. CNTs can only attach to nonpolar microplastics such as polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) since the attachments occur with hydrophobic interactions, and those are not present within polar microplastic particles.

The CNTs act as catalysts in the degradation process of microplastics by activating an oxidizing agent, such as peroxymonosulfate, which creates free radicals. These are highly reactive molecules due to their one or more unpaired electrons in their valence shell. Specifically, peroxymonosulfate creates sulfate and hydroxyl radicals. The radicals cause chain reactions, fragmenting the microplastics that are attached to the carbon nanotubes. The end products of the degradation reactions consist mainly of water and carbon dioxide, and may have other non-toxic substances. By catalyzing an oxidation reaction, which in turn creates radicals to break down the microplastics, carbon nanotubes are a favorable solution to remedying the microplastic pollution.

One limitation of this method for eliminating microplastics is the high manufacturing cost of the CNTs. In a laboratory setting, the nanotubes were very effective, but the excessive cost prohibits the mass production of CNTs for real-life applications. Another obstacle is the temperature required for the reactions to take place. When researchers experimented with the carbon nanotubes, a temperature of 160 degrees Celsius had to be held constant for the degradation to occur, a condition that is improbable in real life.

Magnetic Carbon Nanotubes

Magnetic carbon tubes (MCNTs) are carbon nanotubes loaded with substances exhibiting metallic and magnetic properties, such as iron oxide. With the combination of hydrophobic and magnetic attractions, M-CNTs can absorb both polar and non-polar microplastics, something that normal carbon nanotubes cannot achieve. Iron oxide is also a substance widely used for extrapolation of contaminants, therefore choosing iron oxide as the metal for M-CNT might boost its performance against microplastics. The effectiveness of these is very promising - in experiments, the magnetic carbon nanotubes were

successful 98% of the time in extracting the microplastic particles from the water samples.

Since M-CNTs can easily be retrieved from the water with magnetic force, it is easy to recycle them, and the recycling process does not heavily affect its ability to capture microplastics - even on the M-CNTs fourth usage, it retained more than 80% of its original removal capacity. After the M-CNTs absorb the contaminants, they are taken out of the water with magnetic force. Then they are put into a chamber, where they are heated in the absence of oxygen, at around 600 degrees Celsius. This is the optimal temperature as it allows for the organic waste and contaminants to be effectively removed from the nanotubes, but it is not high enough to the point where the carbon and metal nanoparticles start disintegrating. The resulting products consist of CNTs and the metal that was used for the magnetization of the tubes.

Nonetheless, the recyclability aspect of M-CNTs still requires more advancements. Outside of the thermal recovery process - the previously mentioned pyrolysis - there exist techniques involving chemical and microbiological technology that still need to be tested

more. The paramount goal for researchers is to develop a recycling method that will be more economically and environmentally efficient, as that is the major issue M-CNTs pose.

Gold Nanopockets

Unlike the CNTs and M-CNTs, the 3D Plasmonic Gold Nanopockets (3D-PGNP) do not capture microplastics for the sake of degrading them to non-toxic substances, but rather for analysis and detection with surface-enhanced Raman scattering (SERS) spectroscopy. The integration of the nanopockets with the microplastic-containing solution through a filtered syringe leads to the detection of MP without any sample preparation or treatment.

Combining 3D-PGNP with SERS spectroscopy is an effort to address the SERS's biggest challenges, such as substrates containing nanogaps between the samples, hindering the detection of larger microplastic molecules, as well as the uneven signal generation due to the way microplastics interact with the substrate.

The 3-D Plasmonic allows for micropores to form, which in turn generates multiple volumetric hotspots on the interface for effective SERS signals and increased sensitivity by capturing and surrounding the microplastics. These hotspots also translate to uniform MP signals being formed and the ability for the analysis of larger-sized microplastic particles. Through 3D-PGNP, researchers can take the steps to deal with the limitations SERS poses.

Conclusion

As microplastic pollution rises as a global threat to our ecosystems, researchers are endeavoring to find methods of efficiently removing microplastics from the water or accurately identifying the particles plaguing our environment.

They have developed carbon nanotubes, which capture the microplastic particles and act as catalysts for the creation of free radicals from oxidants such as peroxymonosulfate. These free radicals work to break down the microplastic particles into substances that are innocuous - water and carbon dioxide. A magnetized variant of carbon nanotubes, M-CNTs - exists, which can be recycled due to the facilitated process of separating the M-CNTs from the water with magnetic force. The recyclability aspect of these nanotubes increases the economic and environmental efficiency, as they perform above expectations even after being reused multiple times. 3-D Plasmonic Gold Nanopockets, 3-D PGNP for short, have proven to ease the detection of microplastics through SERS spectroscopy, by providing an increased number of volumetric hotspots, fixing the previous issues SERS technology had - uneven signal generation and the inability to analyze relatively large microplastics.

Even though CNTs, M-CNTs, and 3D-PGNPs are still in need of further development, these modern, innovative techniques involving nanotechnology give auspicious outlooks on future solutions for microplastic pollution.

References

Dirmann, Jerry. ",.", 14 June 2021,
https://www.sciencedirect.com/science/article/abs/pii/S1385894720329326.

Khan, Marzia. "The Future of Removing Microplastics from Water with Nanotubes."
AZoNano, 2 September 2021,
https://www.azonano.com/article.aspx?ArticleID=5809.

Schwertheim, Natalie. "Korean researchers create AI-based microplastic detection
kit." *Packaging Insights*, 9 October 2023,
https://www.packaginginsights.com/news/korean-researchers-create-ai-based-micropl
astic-detection-kit.html.

"Plastic pollution is growing relentlessly as waste management and recycling fall
short, says OECD." *OECD*, 22 February 2022,
https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-
ma nagement-and-recycling-fall-short.htm.

"Riverine plastic pollution." *UNEP*,
https://www.unep.org/interactives/wwqa/technical-highlights/riverine-plastic-pollution.

"Are Microplastics Harmful?" *Poison Control*,
https://www.poison.org/articles/are-microplastics-harmful.

Dedeler, Ayes Pelin. "A Novel Magnetic System with Carbon Nanotubes to Remove
Microplastics from Water." *Log In ‹ Stockholm Junior Water Prize — WordPress*,
https://watertank.siwi.org/wp-content/uploads/2023/06/sjwp2023_paper.pdf. Accessed 5
April 2024.

Comparative Study of Widely Used Microplastic Analysis Methods

Sooyoung Choi
The American School in Switzerland

Abstract

Microplastic pollution in freshwater ecosystems is becoming a huge issue around the world, given the vast amount of plastic waste present in the environment. When plastic decomposes into sizes in the range of 1 micrometer to 5000 micrometers, they are considered microplastics. These can be harmful to humans as microplastics can absorb and carry substances detrimental to human health such as high concentrations of heavy metal, polychlorinated biphenyls (PCB), and toxic chemicals. As such, correctly identifying and quantifying microplastics are essential for taking the first steps to solving microplastic pollution. There are three widespread methods used for microplastic analysis: Fourier Transform-Infrared (FT-IR) spectroscopy, Raman spectroscopy, and Pyrolysis Gas Chromatography-Mass Spectrometry (Py-GC-MS). This study goes over the fundamental principles, advantages, and disadvantages of each methodology. Understanding the strengths and limitations and using each one based on the objectives allows for better analysis and an improved comprehension of microplastics.

Introduction

Plastic is one of the most used materials in the modern world, made possible by its versatility and cheap production costs. The term plastic accounts for materials such as polyethylene terephthalate (PET) used for plastic bottles; polypropylene, utilized most as straws and food containers; and polystyrene, more commonly known as styrofoam.

According to OECD, the average person in the USA generates around 221 kg of plastic waste per year. In 2019, 461 million tonnes of plastic were produced, of which 353 million tonnes went to waste (OECD 2022). This is a significant surge in plastic production since 1950, which at that

period only 2 million tonnes were generated (UNEP 2022). If the trend continues as it has for the last few decades, 33 billion tonnes of plastic will have accumulated in the landfills by 2050.

Around 70% of the plastic waste has a lifetime of less than five years, and only 9% of the waste gets properly recycled. The mismanagement of plastic waste is a huge issue as lots of the waste find their way to freshwater sources, which are the only water source humans are using right now. As of 2019, around 6 million tonnes of plastic waste were dumped into rivers, increasing the total number of plastic in rivers to approximately 110 million tonnes (OECD 2022).

When the plastic waste breaks down into particles with sizes ranging from 1 micrometer to 5000 micrometers, these particles are determined as microplastics. Microplastics are considered to be detrimental to the health of humans because of their ability to absorb toxic chemicals, heavy metals, and polychlorinated biphenyls. Due to their substantial surface-area-to-volume ratio, they can easily carry adverse substances (Poison Control 2022). The harmful nature of microplastics paired with their sheer abundance results in microplastic contamination being one of the major rising issues of the world. As microplastic pollution increasingly spreads throughout the world, accurately identifying and measuring microplastics becomes more crucial. There are several analytical methods used for the identification of microplastics, the most widespread spectrometers being the Fourier Transform Infrared (FT-IR), Raman, and the Gas Chromatography-Mass Spectrometer (GC-MS).

FT-IR Spectroscopy

The Fourier Transform Infrared Spectroscopy is the analysis of microplastic substances based on the sample's interaction with infrared radiation, which has wavelengths ranging from 760 nm to 100,000 nm (NCBI 2017). In particular, wavelengths of 2500 nm to 25000 nm are the most used wavelengths of FT-IR spectroscopy. Upon contact with an infrared beam and a substance, specific frequencies of the radiation are absorbed by the sample, causing vibrational movements in bonds between atoms within the molecules. The absorbed frequencies are different for every bond type (LibreTexts 2022). To identify the substances in the sample, the fingerprint region of the infrared spectrum is analyzed. Like each human being has unique fingerprints, every chemical substance has a distinctive fingerprint region. This region takes

place in the 1500 to 500 cm^{-1} range of the wavenumbers on the spectrum. Absorptions in the higher wavenumbers indicate functional groups present in the molecules, such as carbonyl groups (C=O) and hydroxyl groups (O-H) (LibreTexts 2022).
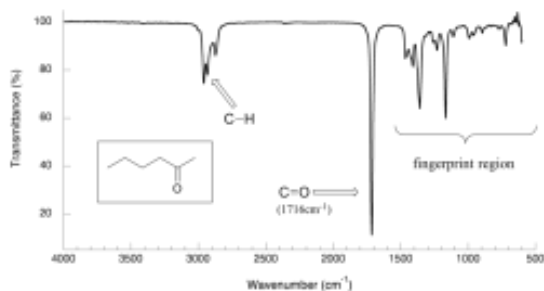
Generally, an FT-IR spectrometer has a source, interferometer, beam splitter, fixed mirror, adjustable mirror, sample compartment, and a detector (ResearchGate 2010). The Fourier Transform method of analyzing microplastics has clear advantages over other spectroscopies. FT-IR provides a non-destructive analysis – meaning that the sample's chemical properties and structure is not altered during the process (ChemLabGenius 2021). Unlike destructive methods such as GC-MS spectroscopy, FT-IR preserves the sample integrity and allows for better experimental reproducibility. The fixed and adjustable mirrors direct beams of multiple frequencies at the sample simultaneously, resulting in a reduction in the time of analysis (Measurlabs 2023).

Certainly, there are limitations to the FT-IR spectrometer. The most prominent issue is the long and meticulous process of the sample preparation. There are further problems with data collection if the sample is aqueous: as water is IR-active, water molecules also absorb infrared radiation, causing inaccuracies in the analysis. Additionally, because FT-IR measures the change in the dipole moment of the molecule, non-polar molecules will not be detected directly by infrared spectroscopy (Ruhr University 2022). With nonpolar microplastics such as polystyrene, the interactions the microplastics have with other substances are analyzed with FT-IR to identify them. Another way to detect nonpolar molecules is through different sampling methods of FT-IR such as Attenuated Total Reflectance (ATR) FT-IR, which is the most favored configuration of infrared spectroscopy for identifying microplastics. Another disadvantage of FT-IR is the size limit. For ATR FT-IR, the minimum size that a sample can have is 200 micrometers, which is large compared to other methods such as Raman spectroscopy, which can detect substances down to 2 micrometers (ResearchGate 2020).

Raman Spectroscopy

Raman spectroscopy is another method of detecting and identifying microplastics. As the name suggests, this spectroscopy is based on the Raman scattering effect. When a monochromatic beam of light, typically around the wavelengths of 500 nm to 1000 nm, is shot at a substance, the molecule absorbs a photon. This absorption puts an electron of the molecule into a higher energy state. The photon is then emitted, resulting in the electron losing the energy and falling into a lower energy state. 99% of the time, the electron will return to its original level – this is called Rayleigh scattering. However, the other 1% of the time, the electron goes to an energy level that is different from its original. This change signifies that the scattered photon has a different amount of energy than the incident photon. The change of energy in the photon is observed as the Raman shift.

In Raman spectroscopy, the Raman shift is referred to as Δv, and it is graphed against intensity. When Δv is 0, it indicates Rayleigh scattering. Where the Δv is positive, meaning that the photon gained energy, the lines are called stoke lines. Lines at a negative Δv, denoting that the photon lost energy, are named anti-stoke lines. Using these lines, the chemical structure, identity, and phase of the sample can be determined (LibreText 2022).
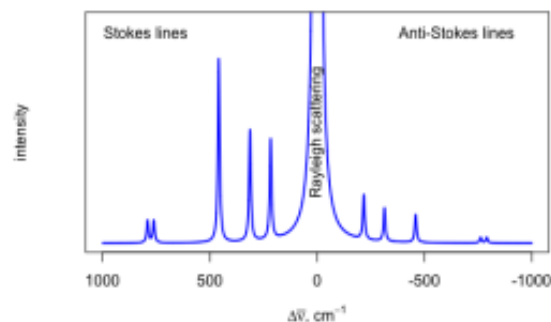
Raman spectroscopy offers advantages over other microplastic detection methods. The most eminent being the fact that it offers a 10-20x better spatial resolution in the mapping process than what the widely used FT-IR spectroscopy provides. The higher resolution translates to being able to analyze much smaller microplastics that cannot be analyzed by FT-IR, such as substances smaller than 20 micrometers. Raman spectroscopy can identify samples as small as 2 micrometers. Another advantage that Raman spectroscopy has is the fact that it has a higher sensitivity towards non-polar molecules. Non-polar substances that are IR-inactive can still be Raman-active, indicating that it can detect microplastic samples that FT-IR cannot. Additionally, a short warm-up time of around 10 minutes for the Raman spectrometer and the minimal sample preparation needed are more appealing

than FT-IR's warm up time of 20-30 minutes and the complex sample preparation (ScienceDirect 2023). However, there are limitations of Raman spectroscopy as well. The most outstanding one is the fact that it can modify the sample. As the light source is a high power laser, using Raman commonly results in the heating of the sample. This is an issue because the increase in heat might cause the substance to go through changes in phases and integrity of the substance. It also leads to difficulty in reproducing the experiment for multiple trials. Another issue is the inadequate contrast and the weak Raman signals which easily get suppressed by the fluorescence background caused by the light source (ResearchGate 2016).

Gas Chromatography-Mass Spectrometry

Gas Chromatography-Mass Spectrometry (GC-MS) is another widespread method of analyzing microplastics. As the name suggests, the spectrometer is composed of two parts: gas chromatography and mass spectrometry. For the identification of microplastics and polymers, the Pyrolysis-GC-MS (Py-GC-MS) is typically used (TechNet 2021).

The process starts with the sample being put in an analysis cup. The cup with the sample inside is then placed inside the pyrolysis chamber, where it is heated until 600-650 degrees celsius and the sample reaches thermal decomposition (Wikipedia 2023). This is the process of pyrolysis. Different products are made during the disintegration of the sample, which are then dropped to the gas chromatography chamber. Here, the products are separated based on their interactions with the stationary phase and their volatility (how easily the substance vaporizes), and polarity. Each chemical compound will react differently to the stationary phase and will reach the end of the tube at different times. After the separation, the products are then fed to the mass spectrometer. This is where a graph is produced for each compound based on their chemical structures and properties. The graph is called the pyrometer, and it is used to identify the substance that was present in the sample. The compounds in the sample are also quantified (Agilent 2022).

One great advantage over other methods of spectroscopy is that Py-GC-MS provides quantifications with mass percentages, instead of just the number of molecules each sample contains. This is a great and easy method for comparing the weight composition of the substances. There is also no size limit for Py-GC-MS. For Raman spectroscopy,

the size limit is from 2 micrometers to 100 micrometers, while for ATR FT-IR spectroscopy, it is much larger, at 500 micrometers to 5000 micrometers. Without the size limit, a wider range of samples can be analyzed with Py-GC-MS. Barely any sample preparation is needed for this analysis method because the pyrolysis breaks down the compound. Unlike FT-IR, the solid samples do not have to be a pellet to be analyzed by Py-GC-MS – it could be in the form of powder as well. There isn't a specific limit on the amount needed for the sample to be detected, meaning that the spectrometer can detect substances that are in very small quantities (Measurlabs 2023).

There are certain disadvantages that the Py-GC-MS has. The major one is the fact that it is destructive. The sample goes through decomposition, which is an irreversible change done to the sample. Due to this, the sample cannot be used again for additional tests or re-analysis, which is a problem if there is a limited amount of substances available for testing. Another issue with this method is that analysis involving heterogeneous mixtures may be inaccurate. If the products of two or more substances produced during pyrolysis overlap, the analysis will not be as accurate as other spectroscopies (EAG 2022). Another disadvantage comes from the way Py-GC-MS quantifies the substances. Because the quantification process is by a mass spectrometer, it is provided in the unit of micrograms per liter instead of the number of molecules in the sample (Measurlabs 2023).

Conclusion

As microplastic pollution rises as a global threat to freshwater environments, accurate and precise identification of microplastics becomes vital. There are various ways for the analysis, and the most commonly used ones are Fourier Transform-Infrared (FT-IR) spectroscopy, Raman spectroscopy, and Pyrolysis Gas Chromatography-Mass Spectrometry, and they all use different chemical analysis methods. FT-IR utilizes the distinct infrared absorption that every substance has to identify the microplastics; Raman spectroscopy takes advantage of Raman scattering, where every compound releases a photon at different energy levels; and Py-GC-MS identifies the microplastics by the products made after the decomposition of the sample.

There is an ongoing debate on which technique is the best out of those three. After this research for the three spectroscopies, the best method of analyzing microplastics depends on the

objectives and the information that is to be analyzed. These spectroscopes all have their respective strengths and limitations, and the user should choose the one that fits their circumstances. If there are barely any sample materials and several tests need to be run, a non-destructive method such as FT-IR and Raman spectroscopy would be a better choice than a Py-GC-MS. If finding the mass percentage composition of a sample is the priority, the Py-GC-MS would be the best choice, but for finding out the number of molecules in the sample, FT-IR or Raman spectroscopy will be preferable. If a very miniscule sample is to be analyzed - under a few hundred micrometers - the FT-IR would not be recommended; instead a Py-GC-MS or Raman would fit the requirements. Currently, there is no standardized method of analyzing microplastics, and users must choose their methodology based on the aim of their studies. In the future, establishing a standardized technique for microplastic analysis for uniform data collection procedure will be crucial.

References

"Plastic pollution is growing relentlessly as waste management and recycling fall short, says OECD." *OECD*, 22 February 2022, https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm.

"Riverine plastic pollution." *UNEP*, https://www.unep.org/interactives/wwqa/technical-highlights/riverine-plastic-pollution.

Hamblin, Michael R. "Biological effects and medical applications of infrared radiation." *NCBI*, 13 April 2017, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5505738/.

"Infrared Spectroscopy." *Chemistry LibreTexts*, 16 April 2022, https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Vibrational_Spectroscopy/Infrared_Spectroscopy.

"Advantages and Disadvantages of FTIR Spectroscopy." *chemlabgenius.com*, https://www.chemlabgenius.com/advantages-and-disadvantages-of-ftir-spectroscopy/.

"FTIR Spectroscopy." *Ruhr-Universität Bochum*, 9 May 2022,

https://www.ruhr-uni-bochum.de/pc1/methoden/ftir-spectroscopy.html.en.

"Fourier Transform Infrared (FTIR) Spectroscopy." *Measurlabs*,
https://measurlabs.com/methods/ftir-spectroscopy/.

Harvey, David. "18.1: Theory of Raman Spectroscopy." *Chemistry LibreTexts*, 24
October 2022,
https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Instrumental_Analysis_(L
ibreTexts)/18%3A_Raman_Spectroscopy/18.01%3A_Theory_of_Raman_Spectroscopy.

Claro, Paulo Ribeiro. "(PDF) Characterization of Microplastics by Raman Spectroscopy."
ResearchGate,
https://www.researchgate.net/publication/310840619_Characterization_of_Microplastics
_by_Raman_Spectroscopy.
"Gas chromatography mass spectrometry basic principles." *Agilent*,
https://www.agilent.com/en/product/gas-chromatography-mass-spectrometry-gc-ms/gcms
-fundamentals.

"Pyrolysis-GC-MS Analysis | Laboratory Services." *Measurlabs*,
https://measurlabs.com/methods/pyrolysis-gc-ms-analysis/.

"Pyrolysis–gas chromatography–mass spectrometry." *Wikipedia*,
https://en.wikipedia.org/wiki/Pyrolysis%E2%80%93gas_chromatography%E2%80%93m
ass_spectrometry.

"Pyrolysis-GC-MS: A Powerful Tool for Microplastics Analysis." *Technology Networks*,
13 October 2021,

"Pyrolysis-GC-MS | Pyrolysis Gas Chromatography." *EAG Laboratories*,
https://www.eag.com/techniques/mass-spec/pyrolysis-gc-ms/.