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Stress is a Good Thing: Understanding Stress and the Development of Resilience Through Athletes

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Abstract

Stress is experienced by all individuals throughout life to varying degrees. One of the benefits of stress, when experienced at manageable levels, is the development of resilience. Resilience is the ability to cope successfully in the face of negative situations and it has been correlated with positive mental well-being and greater satisfaction in life. Athletes are a distinct group of individuals who regularly experience stress due to the nature of competition. An athlete's ability to function in demanding circumstances increases these factors and the development of resilience, providing a framework for understanding how to build resilience. Several studies have pointed to the factors underlying the development of resilience and have shown that resilience can be strengthened in the same manner as the training of physical muscles. This paper aims to examine and evaluate the research that identifies the key factors in developing resilience, specifically high self-esteem, an internal locus of control, and strong social support. Programs that have been implemented to enhance resilience among athletes and various populations are also examined. In addition, this paper identifies the drawback and limitations of research findings to date and makes suggestions for the application of the research knowledge in the future.

Keywords: Stress, Resilience, Athletes, Self-Esteem, Self-Confidence, Internal Locus of Control, Social Support

1. Introduction

Stress is an inevitable part of life. When adversity such as financial woes, relationship issues, difficult bosses, or restrictions due to COVID-19 arises, an individual will experience psychological and/or physical stress. Although unpleasant, the right amount of stress can be beneficial for the development of resilience. Psychological resilience is defined as "the role of mental processes and behavior in promoting personal assets and protecting an individual from the potential negative effect of stressors" (Fletcher & Sarkar, 2013, p. 14). Essentially, resilience refers to one's ability to re-establish mental well-being after experiencing adversity (Stoffel & Cain, 2018). Resilience is important because it has been associated with a longer life span, lower levels of depression, and greater overall happiness in life (Harvard Health Publishing, 2017), as well as the ability to withstand future stressors. In light of this, our central objective is to provide a review of the current research literature to identify the major factors involved in developing resilience.

Within the psychological scientific community, the collective understanding of how resilience develops has evolved over the past few decades. Liu et al. (2018) note that in the 1970s, resilience was attributed to individual characteristics such as strong planning skills, positive emotions, and self-regulation

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that helped children overcome the adversity of abusive environments. By the 1990s, researchers had gone beyond the individual, to analyze how external social factors influenced resilience development (Levine, 2003; Liu et al., 2018; Ozbay et al., 2007). Over the past decade, resilience studies have incorporated biological variables as well, leading researchers to study the relationship between neural activity and neurotransmitters in the context of resilience. While resilience is dependent on a myriad of factors, research indicates that flexibility and adaptability to changing situational demands are important underlying factors in developing resilience (Bonanno & Burton, 2013; Chen & Bonanno, 2020). One distinct population that has been studied in this context is athletes. The sporting arena represents a natural setting to explore how individuals perform in demanding situations. Athletes compete in strenuous environments where they face consequences for poor performance. In addition, athletes suffer from a variety of other stressors, including recovery from injury, difficult relationships with teammates and/or coaches, and fear of failure. Even on an organizational level, stress is abundant; the best teams in professional sports may lose up to 40% of their games (Galli & Gonzalez, 2015). For example, the 2006 St. Louis Cardinals went 83-78 which is a 51% winning record (2006 Baseball Standings, n.d.). One can only surmise that their season was filled with stress. Despite this, the team was resilient and ultimately won the World Series. It is important to note, however, that resilience can be displayed in ways other than victory. In the context of sports, resilience can be operationalized as the behavior of performing better after a poor performance measured by improvements in physical testing quantities like speed, agility, and strength (Galli et al., 2015). In a study of the psychology literature, athletes were found to be more resilient than non-athletes (González-Hernández et al., 2020; Samaei et al., 2012**).** Therefore, by studying athletes' ability to remain psychologically strong in stressful situations, the findings can be applied to non-athletes to help them develop resilience to cope with everyday stresses. Researchers have identified a number of common factors among athletes that contributed to their ability to use stress as a source of strength and assist in their development of resilience. Among these factors, three are particularly noteworthy. These include: having a positive sense of self, an internal locus of control, and strong social support.

2. Positive Sense of Self

One common trait found among athletes is a positive sense of self, which can be exemplified by self-esteem or self-confidence. Self-esteem refers to how a person evaluates their worth. An individual with positive self-esteem sees themselves as good and competent while those with negative self-esteem will lack confidence and feel bad about themselves. Self-esteem and resilience have been found to be highly correlated (Cazan & Dumitrescu, 2016). A person with positive self-esteem will have greater feelings of self-confidence and self-worth. This results in greater independence and the ability to remain resilient in times of stress (Cazan & Dumitrescu, 2016). Athletes as a group tend to have high self-esteem, as success in sports requires hard work and dedication which leads them to have inner confidence to achieve their goals (Jones & Cannaughton, 2007). Participation in sports has been associated with positive development of the mind and body, leading to higher self-confidence and self-esteem. In a survey of 514 college students who completed the Rosenberg Self-esteem Scale, those who had participated in sports at an earlier age reported higher self-esteem and happiness compared to students who had not participated in sports (Collins et al., 2018). Of course, results were based on self-reported assessments and may not be generalizable beyond the college-age population. Furthermore, the authors acknowledge that other factors could also be at play for the results. Still, the results are consistent with numerous other studies. In a study of elite volleyball players, Belem et al. (2014) found a positive correlation between resilience and self-confidence. Booker et al. (2015) conducted a cross-sectional study of 4,899 adolescents and also found that high participation in sports was associated with happiness. Students who play sports consistently over time were reported to be less depressed and more satisfied with life (Collins et al., 2018). The use of positive emotions during stressful situations

increased the athletes' resiliency and adaptation to future stressful situations. In essence, adaptation and self-confidence reflect a positive self-reinforcing cycle in contributing to resilience: an increase in adaptive skills leads to greater self-confidence, further enhancing adaptation and resilience (Belem et al, 2014).

It should be noted that self-esteem is often seen as a personality trait that is stable and enduring, but, in fact, it can be developed (Mann et al., 2004). Programs have been developed to improve self-esteem among different populations, such as those experiencing poor body image, or those exhibiting antisocial behavior. In one study, 470 male and female students between 11 and 14 years of age took part in an interactive program aimed at improving self-esteem. Compared to the control group who received a personal development and health class, the experimental group was found to have improved self-image and self-esteem at the conclusion of the program and even 12 months later (O'Dea & Abraham, 2000). While the intervention program was considered to be successful and well-received, its limitations lie in the self-selection of the groups. Those who volunteered to take part in self-esteem education have greater motivation to improve their self-esteem. Furthermore, long-term permanent benefits past one year are unclear. Nevertheless, the importance of self-esteem, in general, cannot be overstated. Low self-esteem is a factor in depression and anxiety while high self-esteem is linked to improved mental health and resilience (Collins et al., 2018). As noted, athletes generally have high self-esteem because in order to succeed in competitive sports one needs to have the confidence and belief that they are competent. That confidence, in turn, gives way to the belief that they can change their outcomes.

3. Internal Locus of Control

Positive self-esteem is a key component of coping with stress, but it can only get one so far. Another characteristic that appears to have aided athletes in being resilient to stress is having an internal locus of control. This refers to a person's belief in their control of outcomes, rather than attributing results to external factors (Myers & DeWall, 2018). For example, if an athlete performs poorly in a sports competition, they would attribute it to their actions rather than to bad luck or a factor out of their control, and focus on how to improve next time. Individuals who have an internal locus of control will remain calm and adapt more effectively to situations of stress compared to individuals who have an external locus of control (Cazan & Dumitrescu, 2016). In a study of 60 athletic and 60 non-athletic female students between the ages of 19-26, those who were athletic tended to exhibit higher levels of internal locus of control than non-athletes. Statistical analysis of the data, gathered through questionnaires measuring loneliness and internal vs external locus of control, found a meaningful difference in the feelings of loneliness and locus of control between the two groups. The athletic group felt more directly responsible for their successes and losses as a result of their physical activities, and this led to a feeling of having more control in their lives (Samaei et al., 2012) while the non-athletic group experienced fewer feelings of control. Similarly, in their study of mental toughness among Olympic athletes and trainers, researchers identified many attributes that led to resilience. One attribute was having a mindset or attitude that their success was due to their own hard work. This reinforced their belief that success is achievable and that they could achieve whatever they set out for themselves (Jones et al., 2007). In another study of 140 Stanford student-athletes, internal factors such as locus of control, self-esteem, and mindfulness were more positively correlated with happiness, and a general feeling of happiness could in turn build resilience through the ability to persevere in the face of difficult situations (Denny & Steiner, 2009). Athletes as a group have a high internal locus of control, as the sports environment offers many opportunities to exert control over stressful situations that may arise (Samaei et al, 2012).

The importance of internal locus of control in building resilience is also generalizable to non-athletes. Among students of varying ages, having an internal locus of control led to greater resilience in stressful situations (Cazan & Dumitrescu, 2016; Georgescu et al., 2019; Kronborg et al., 2017). A sample of 41 psychology students completed Rotter's

Locus of Control Scale, Personal Behavior Inventory, the Resilience Scale, and the Self-Efficacy Scale, with results showing that an internal locus of control was equated with resilience, resistance to external pressure and prosocial behavior (Georgescu et al., 2019). An internal locus of control readily lends itself to resilience by allowing individuals to positively adjust to a stressful situation, either on their own or by seeking help. In contrast, subjects who had an external locus of control had lower levels of resilience. These individuals were socially passive and less effective in finding creative solutions to challenges (Georgescu et al., 2019). Despite the small sample size of this study, it demonstrates that internal locus of control is an important component in building resilience among non-athletes as well as athletes.

4. Social Support

Besides having a positive sense of self and an internal locus of control, scholars have pointed to social support as an additional vital factor in promoting resilience (Liu et al., 2018; Ozbay et al., 2007). Strong social support is noted to be one of the main elements involved in well-being and resilience to social and economic stress, while poor social support is associated with greater stress and depression (Liu et al., 2018). Social support provides security through a communal identity. Individuals who belong to a community or group in which they feel a sense of belonging and purpose will be less threatened by extremely stressful situations (Elcheroth & Drury, 2020). Social support may also have a physiologically positive effect on resilience through moderation of the hypothalamic, pituitary, and adrenocortical system (Ozbay et al., 2007), which are responsible for regulating body functions such as appetite, metabolism, and the fight or flight response, respectively, (and which are more likely to be in balance when one feels a strong amount of social support). On the other hand, a lack of belongingness has been associated with stress, anxiety, and low self-esteem in the population at large (Mohamed et al., 2014), and evidence suggests that social isolation impacts longevity as much as or even more than physical factors like smoking or obesity (Elcheroth & Drury, 2020).

Athletes who play team sports have a communal sense of identity and generally gain social support from teammates and coaches as they learn to work together towards a shared goal. Even athletes of sports considered to be individually oriented, such as tennis or swimming, benefit from identification with the team and the social support that stems from being a part of a larger group. This enables them to respond more positively to stress and to be more resilient in the face of mental or physical setbacks. For instance, athletes recovering from injuries benefited from having the support and empathy of those in similar circumstances (Galli & Gonzalez, 2015). Even the support of a single individual is sufficient; research by Levine (2003) shows that during stressful times, resilient individuals consistently had the support of at least one individual who assisted them as a nurturer or mentor. Additionally, social support was one of several factors in building resilience in a study of competitive athletes with spinal cord injury (Machida et al., 2013). While the development of resilience is multi-faceted, an overwhelming amount of research shows that social support is one of the primary factors involved in dealing with stress and building resilience (Ozbay et al., 2007). Athletes as a whole tend to experience social support which, along with other factors, enables them to be highly resilient individuals.

5. Developing Resilience

From these findings, we see that resilience is dependent on individuals' beliefs about themselves and also on their support environments. Since beliefs and environments can change over time and can vary in different situations, resilience levels may also fluctuate. Therefore, resilience can also be enhanced. To that end, researchers have implemented various programs to develop resilience among a variety of populations. Fletcher & Sarkar (2016) developed a "mental fortitude training" program to promote psychological resilience among athletes preparing for the Olympics. The program emphasized the importance of a multifactorial approach using a supportive environment, a positive mindset to challenge negative thinking patterns, and personal

characteristics such as self-confidence and optimism. Of particular importance was helping individuals evaluate the stress they encountered, identifying negative thoughts and emotions, and replacing them with constructive thinking (Fletcher & Sarkar, 2016). Along these lines, rational emotive behavior therapy to change negative thought responses was effective in improving resilience in a sample of squash players (Deen et al., 2017).

One might argue that athletes are more flexible and receptive to such a program. However, non-athletic people can benefit from these behavior therapies and strength exercises as well. Research in resilience development among other populations (non-athletes) as well as in other countries has been shown to be effective against circumstantial stressors. Using a similar combination of psychological and cognitive therapies, Li et al. (2017) conducted an intervention program aimed at increasing resilience among 790 children in China who had one or both parents that contracted HIV/AIDS. The children received 20 hours of training skills in positive thinking, emotional regulation, and problem-solving. Positive parenting skills and community activity training were also provided to caregivers and community workers in some cohorts. Compared to control groups that did not receive the intervention, the experimental group reported increased control over their lives, ability to regulate emotions, and levels of resilience. This continued at 6 and 12 months follow-ups (Li et al., 2017). A variety of therapeutic programs including life skills education, mindfulness meditation, and stress training have been implemented to aid in improving resilience, and more interventions are likely (Liu et al., 2018). However, implementing resilience-building programs is challenging. Like other psychological concepts that cannot be observed easily, resilience requires operationalization using specific definitions and tools, such as questionnaires and physical assessments as in the case of athletes. Policymakers need to collaborate to decide how to operationalize resilience for the intended population, deciding what to measure and the time involved. In any case, the understanding of resilience in athletes has already been applied to help diverse populations in different programs.

6. Discussion

Each of the studies provides support that resilience is a developable trait, and several common factors that promote resilience were identified. More specifically, enhancing psychological traits such as confidence and self-esteem was important in promoting positivity and resilience (Belem et al, 2014; Cazan & Dumitrescu, 2016; Collins et al., 2018; Jones et al., 2007). Developing cognitive skills related to problem-solving was also significant as it led to emotional regulation and a sense of control (Deen et al., 2017; Jones et al., 2007; Samaei et al., 2012). Furthermore, social support was necessary in improving resilience among both athletes and non-athletes (Fletcher & Sarkar, 2016; Li et al., 2017). Understanding resilience and the factors in its development have allowed researchers to develop effective programs that have enhanced resilience among specific groups.

However, the limitations of each program need to be considered. The samples studied were very specific, so it is difficult to say that the same program will have the same therapeutic effects on different individuals. The mental fortitude program (Fletcher & Sarkar, 2016) and the rational emotive behavior therapy (Deen et al., 2017) applied to athletes would need to be refined and validated in other populations to confirm similar outcomes, since one could argue that athletes have a mindset that already encourages them to be more resilient than non-athletes. In Li et al.'s (2017) study, subjects were from a specific geographic location in China and it is unclear whether their findings could be replicated in countries with different cultural or socioeconomic standards. In all cases, the generalizability of the data requires following a large sample over time. In addition, each of the studies is limited in that subjects self-reported their psychological well-being and resilience levels, which may be inaccurate. A survey may produce inaccuracies from phenomena such as the framing effect and the social desirability bias. Furthermore, stress is a subjective term that people of different ages, ethnicities, and gender identities perceive and adapt to differently. It is important to identify these internal and situational differences in order to address and measure resilience accurately.

For these reasons, researchers trying to understand resilience have focused first on measuring baseline or pre-stress levels of each person, then examining the stressor event, and finally looking at the resilience levels after the stress (Bonanno et al., 2015). In a review of subjective well-being after major life events such as divorce or death, Luhmann et al. (2012) similarly utilize a "process perspective," which examines well-being and adaptation in the same individual over time, rather than across different individuals.

Despite the limitations of these studies, the research is promising, providing a good foundation for the development of resilience in people of all ages and backgrounds. This knowledge can empower healthcare professionals to develop strategies that utilize stress to maximize resilience and well-being for the general population, particularly relevant when faced with shared stressors such as the Covid-19 pandemic and its far-reaching effects on individuals worldwide.

7. Conclusion

When adverse situations arise, resilience is necessary to maintain positive mental health. Individuals with low levels of resilience may not be able to deal effectively with stress, are likely to have low self-confidence and experience increased levels of anxiety. This can lead to a self-perpetuating cycle of negativity. Athletes regularly experience mental and physical stress, as they must exert themselves when training and in competition, all the while dealing with the uncertainty of outcomes. Despite being constantly exposed to stress as part of a competitive environment, athletes of all ages tend to be more resilient due to their experience in the face of adversity (González-Hernández et al., 2020). Therefore, scholars can consider athletes' behaviors, psyches, and environments to be prime areas of study in understanding how to cultivate resilience. This paper reviewed the literature examining the concept of resilience and identifying the factors that are important to its development, with a focus on athletes. These include having a positive sense of self, an internal locus of control, and a strong social support system. An athlete's ability to function in constantly demanding circumstances provides a framework with which to understand competitive resilience and that framework is applicable to the entirety of the general population. The findings raise hope that techniques for enhancing resilience factors are generalizable to any type of adverse situation since resilience is required for consistent wellbeing in an inevitably stressful life.

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Understanding Parkinson's Disease from the Inside Out

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Abstract

Parkinson's disease (PD) is a relatively common neurodegenerative disorder caused by dopamine deficiency and characterized by tremor and motile difficulties. Activities of the neurotransmitter dopamine contribute to the high energy demands of neurons in the substantia nigra (which are lost in the disease), which the mitochondria of these cells work to meet. Mutations in the genes *SNCA, PINK1,* and *LRRK2* can disrupt mitochondrial function in susceptible neurons through over- or underactivity. Like the gene mutants, pesticides and MPTP also impair mitochondrial activity, unlike smoking, which protects vulnerable neurons. L-DOPA, often in combination with other drugs, is the most frequent medical prescription for PD, but surgical procedures may be used for younger patients. Drugs protecting mitochondrial components of neural cells may especially help with PD. In this review, we aim to study the biological mechanisms through which these genetic and environmental risks lead to PD and how various treatments may combat pathogenesis.

Keywords: Neurodegeneration, SNCA, LRRK2, PINK1, External Factors, L-DOPA, Brain Stimulation

1. Introduction

The common neurodegenerative disorder Parkinson's disease (PD) affects over 7 million people worldwide (Cresto, et al., 2019). Patients with Parkinson's disease experience a loss of dopaminergic neurons in the substantia nigra pars compacta (SNpc) region of the brain (Ge, et al., 2020). This degeneration of substantia nigra cells results in a deficiency in the neurotransmitter dopamine, which is synthesized in the substantia nigra and necessary for proper motion control. As a result, symptoms such as tremors; difficulty with walking, moving, coordination, and speech; rigidity; stooped posture; insomnia; and constipation indicate the pathological phenotype (*Parkinson Disease,* 2008). Also, brain cells of PD patients often contain protein aggregates known as Lewy bodies (LBs), usually made up of ∝-synuclein protein. While their role is controversial, these aggregates may interfere with crucial cell functions by impairing other proteins (Cresto, et al., 2019). Disease onset typically occurs in elderly patients (older than 60), but in around 5-10% of cases, characterized as early-onset PD, symptoms appear before 40 (Brouwer, et al., 2015). Numerous risk factors have been associated with both types, with genetic mutations often linked to early-onset, and environmental exposures more often linked to late-onset PD (Brouwer, et al., 2015).

Nevertheless, mitochondrial dysfunction in nigral cells appears to be involved in both of the neurodegenerative pathways. The objective of this literature review is to analyze the results of multiple studies regarding the role of three of the most prominent PD related genes that especially affect mitochondrial function- *SNCA*, *LRRK2*, and *PINK1* - and three environmental exposures in neurodegeneration. Furthermore, we aim to

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understand how these possible causes may enhance pharmaceutical measures for symptom improvement. This is the first of two papers in a series, the second of which describes our own statistical analysis of how the genotype of a Parkinson's patient can be used to predict their response to medications.

The rest of the paper is organized as follows: in Section 2, we provide an overview of the role of mitochondria in dopamine-producing cells as well as dopamine itself in Parkinson's disease. Section 3 discusses the three genes and how mutations in them can increase the risk of Parkinson's. In Section 4, environmental factors are studied with respect to Parkinson's risk. Section 5 reviews how various treatments may be more effective for different patients. Finally, Section 6 concludes the paper.

2. Dopamine and Mitochondria

PD patients lack dopamine, a neurotransmitter (a molecule released at the axon of a nerve cell that carries information to nearby cells) (Finley, 2014). In healthy patients, dopamine represses signals coming from the motor cortex of the brain and passing through the basal ganglia to prevent sudden jerks (*Parkinson Disease*, 2008). Dopamine released by substantia nigra cells also activates the brain's corpus striatum, a region of the basal ganglia, so insufficient dopamine levels mean that subsequent targets of the corpus striatum also suffer, and the entire motile pathway becomes impaired (*Parkinson's Disease,* 2001).

At the cellular level, dopamine processing generates free radicals which places increased strain on mitochondria, the double-membraned organelles responsible for producing usable energy in cells of dopaminergic neurons in the substantia nigra (Franco, et al., 2021). The large and spread-out axonal networks, the many synaptic connections, and the presence of unmyelinated axons in dopaminergic neurons all further increase the energy requirements of these cells (Ge, et al., 2020). Thus, dopaminergic mitochondria likely work to meet these energy needs until they are unable to, at which point neuronal cell death occurs (Franco, et al., 2021). Furthermore, damage in the mitochondria has been observed to lead to increased levels of mitochondrial DNA in the bloodstream, which draws immune cells to the site to initiate a potentially harmful inflammatory response (Kwon, 2021). Both of these processes contribute to the mitochondrial deterioration and subsequent neurodegeneration of substantia nigra cells that results in the dopamine deficiency seen in PD patients.

3. Genetic Factors

Growing evidence increasingly suggests that genetic factors play a role in Parkinson's disease through specific mutations which affect the function of dopamine-producing neurons. In this section, we will explore how abnormal gene products from three genes - *SNCA, LRRK2,* and *PINK1* - may interact with each other and contribute to pathogenesis. While other gene mutations have also been listed as Parkinson's risk factors, the first two of these three genes are commonly cited as two of the most prevalent risk factors, and the last, *PINK1*, though not as common a risk factor, plays a crucial role in the mitochondria of cells affected by PD.

3.1 The SNCA Gene and ∝-synuclein

Found on chromosome 4 in the human genome, the *SNCA* gene codes for ∝-synuclein, a protein that helps control the release of neurotransmitters, proper functioning at synapses, and the ability of dopaminergic neurons to alter their connections (Campêlo and Silva, 2017). It further plays a role in vesicle movement and membrane activity and comprises most of the Lewy bodies observed in brains of PD patients (Cresto, et al., 2019). Through these mechanisms, the importance of *SNCA* to PD pathology emerges. Products of *SNCA* mutations can change the processes required for normal vesicular transportation and protein processing in neuronal cells. ∝-synuclein also affects disease pathology by interacting with other PD-related genes, which will be discussed more thoroughly in the following sections (Franco, et al., 2021). Mutations in these genes may in turn contribute to ∝-synuclein neurotoxicity if these genes affect the handling of ∝-synuclein through vesicular transportation

mechanisms. This may increase the aggregation of the protein and dopaminergic neurodegeneration (Franco, et al., 2021).

Like many PD-related proteins, ∝-synuclein impacts mitochondrial fission and fusion dynamics (Cresto, et al., 2019). Fission - division of mitochondria - naturally leads to the production of smaller mitochondria and promotes the elimination of damaged portions by creating smaller loads for autophagy. In contrast, fusion produces longer mitochondria that allow for more efficient oxidative phosphorylation to meet greater energy requirements (Ge, et al., 2020). Aggregation of ∝-synuclein likely stimulates processes that remove proteins needed for mitochondrial fusion, abnormally shifting the balance towards fission (Cresto, et al., 2019). Consequently, oxidative phosphorylation and energy production may decrease.

Despite the proposed cellular impacts, few studies associate variants of *SNCA* to specific PD phenotypes, and some studies yield contradictory findings. Nevertheless, three polymorphisms in *SNCA* - REP1, rs2736990, and rs356219 and rs356165, located in the promoter, an intron, and 3' region, respectively - have often been linked to early-onset/familial PD (Campêlo and Silva, 2017). Similar polymorphisms are expected to affect sporadic PD but this context has been studied less extensively.

Finally, thus far, ∝-synuclein's aggregation into Lewy bodies has been considered from a negative perspective. This view gains support when considering that postmortem PD diagnosis consists of scanning for these protein aggregates (Espay and Stecher, 2020). However, while this Lewy body pathology occurs in almost all variations of Parkinson's, recent research suggests that its role may not be harmful. Rather, the protein aggregates may have a protective function consequent to the onset of previous, unknown cellular occurrences (Gearing & Srinivasa). Cellular particles that may have directly neurotoxic effects, though, are ∝-synuclein oligomers and protofibrils (Espay and Stecher, 2020). In line with this idea, a study showed that cells expressing a pathological mutation - G2019S in *LRRK2*, which will be discussed later - had a higher proportion of fibrillar oligomeric ∝-synuclein compared to those without the mutation (Nam, et al., 2021). Thus, it appears that PD-prevalent genotypes associate more frequently with these toxic forms. Given the presence of such aggregation and oligomerization on the more cognitive end of the neurological disease spectrum, near disorders such as Alzheimer's, it also makes sense that certain *SNCA* variants have been found to be associated with increased cognitive decline in PD patients (Espay and Stecher, 2020; Ramezani, et al., 2021). Despite these new revelations and the ubiquity of protein aggregation in many neurological diseases, more research still needs to be done to determine the precise function and possible defensive role of ∝-synuclein in PD.

3.2 *PINK1* in Neurogenesis and Mitochondrial Function (with *Parkin*)

The *PINK1* gene codes for PINK1, a serine/threonine kinase consisting of 581 amino acids (Meamar, et al., 2021). Early-onset Mendelian inherited PD (autosomal recessive) is thought to be related to biallelic *PINK1* mutations. Furthermore, PINK1 serves as an important protein in mitophagy (autophagic destruction of mitochondria), mitochondrial function, and oxidative stress (Brown, et al., 2021).

Studies by Brown et al. (2021) suggested that throughout life PINK1 contributes to neurogenesis (the generation of neurons from neural stem cells). In fact, a lack of PINK1 in zebrafish led to fewer dopaminergic neurons in larvae and adults, as well as malfunctioning mitochondria and affected morphology (Brown, et al., 2021). During the study, they observed that zebrafish without properly functioning PINK1 experienced similar rates of neurogenesis compared to the controls in the TPp (an ascending dopaminergic neuron population) and the PVO (locally-projecting dopaminergic neurons of the paraventricular organ) regions in early life, but growth stopped in later life (Brown, et al., 2021). The metabolic shift from the cytoplasmic process glycolysis to the mitochondrial process oxidative phosphorylation that is associated with neural stem cell differentiation may contribute to this issue. The PINK1 variant in neural stem cells is observed to decrease oxidative phosphorylation and force an

increased reliance on glycolysis. This decreases the mitochondria's ability to produce additional ATP in the case of sudden demand (Brown, et al., 2021). Given that differentiation presents high metabolic demands, where this ability and the extra energy of oxidative phosphorylation would be very important, the PINK1 mutation can clearly hinder dopaminergic neurogenesis. However, a lack of PINK1 did not appear to affect global neurogenesis, implying a preference for dopaminergic neurons and indicating its role in PD (Brown, et al., 2021).

Regarding mitochondrial function, PINK1 has an important function of removing and/or replacing all or parts of damaged mitochondria. Localized to the mitochondria, PINK1 is normally inactive. In the event of mitochondrial damage, activation occurs on the damaged mitochondria. Subsequently, in its activated state, PINK1 phosphorylates ubiquitin on the mitochondrial surface and engages Parkin protein from the cytosol (Sekine, 2020). The binding of Parkin to this phospho-ubiquitin activates Parkin so that it can tag multiple mitochondrial proteins for destruction. At the same time, PINK1 phosphorylates additional mitochondrial proteins, increasing the number of ubiquitin chains on the mitochondria, thus creating a positive feedback loop with Parkin (Sekine, 2020). In healthy mitochondria, the PARL protein assists in PINK1 destruction through cleavage at the inner mitochondrial membrane in order to block ubiquitin phosphorylation, Parkin recruitment, and mitochondrial destruction. If mitochondrial damage is present, PINK1 builds up in the outer mitochondrial membrane, but a mutant product of *PINK1* undergoes destruction by the mitochondrial protease OMA1, preventing this buildup of PINK1 (Sekine 2020). While this mechanism would suggest that cells lacking PINK1 or Parkin would accumulate damaged mitochondria, this has not consistently been observed, suggesting additional roles for these two proteins in mitochondrial quality control in the central nervous system (Ge, et al., 2020).

In fact, another aspect of this quality control occurs through the regulation of mitochondrial fission and fusion. Based on some studies, PINK1 and Parkin may normally stimulate fission and restrict fusion. This can preserve mitochondrial health by isolating damaged areas (Ge, et al., 2020). Thus, greater expression of fission proteins may improve harmful effects of too much fusion, which is associated with faulty PINK1 and Parkin proteins, and minimize some PD symptoms (Ge, et al., 2020). For less severe mitochondrial damage, PINK1 and Parkin may help form mitochondrial-derived vesicles. These vesicles assist in the removal of specific dysfunctional proteins, rather than entire mitochondria. Often, MDVs formed by PINK1 and Parkin have been shown to get rid of defective elements of the electron transport chain involved in oxidative phosphorylation (Ge, et al., 2020). In yet another way, PINK1 and Parkin help regulate mitochondrial health by promoting the production of mitochondrial proteins near the surface of these organelles. In neurons, whose long structures increase the expense of transport and likelihood of misfolding errors in transit from the nucleus to the mitochondria, this localized synthesis can be especially useful. A lack of PINK1 negatively affected targeting of nuclear-encoded mitochondrial RNAs to the mitochondria in multiple cell lines (Ge, et al., 2020).

Finally, in sporadic cases of the disease, ∝-synuclein aggregates may trap Parkin proteins and impede the PINK1/Parkin pathway that aids in mitochondrial quality control, further contributing to neurodegeneration (Ge, et al., 2020). In addition, animals lacking PINK1 experienced increased sensitivity to the loss of dopaminergic neurons by the external neurotoxin MPTP (Franco, et al., 2021). Evidently, PINK1 plays crucial roles in the survival of dopaminergic neurons, both by assisting in the differentiation of new ones and regulating the energy producing mechanisms in existing ones alongside Parkin. These processes provide many possible ways that PINK1 mutations may result in PD pathology and the loss of dopaminergic neurons.

3.3 *LRRK2*: Its Independent Role and Possible Effect on ∝-synuclein and PINK1

Mutations in *LRRK2*, which codes for leucine-rich repeat kinase 2 (LRRK2), account for 3-4% of all PD cases, and the missense mutation G2019S most often correlates with PD by stimulating harmful activity of the kinase (Gonzalez-Hunt, et al., 2020). Increased LRRK2 kinase activity results in a mitochondrial loss

of function and greater mitochondrial DNA (mtDNA) damage. In line with these observations, LRRK2 inhibitors have been shown to act as neuroprotection in PD-applicable cell and rodent models. After inhibition, mtDNA damage returned to control levels - and relatively quickly (Gonzalez-Hunt, et al., 2020). Because pathogenic mutations in *LRRK2* do not severely increase kinase activity, Gonzalez-Hunt et al. (2020) suggested that medium levels of LRRK2 kinase inhibition should be enough to fix the PD phenotype. Too much inhibition resembled a loss of all LRRK2 protein, which was associated with effects on the kidneys and lungs, but too little inhibition led to a lack of neuroprotection in clinical studies (Gonzalez-Hunt, et al., 2020). While these mutations typically associate with familial cases of PD, results of such studies could have important implications for sporadic PD because LRRK2-related PD patients show similar clinical and neuropathological characteristics to sporadic PD patients (Gonzalez-Hunt, et al., 2020). Rodent models of sporadic PD and postmortem observations of brains of sporadic PD patients support this idea, as these models showed abnormally high levels of mtDNA damage in substantia nigra dopaminergic neurons (Gonzalez-Hunt, et al., 2020). Also, studies indicated that animals completely missing *LRRK2* or excessively expressing human variants of the gene (in other words, animals producing either no LRRK2 protein or too much of it) struggled with intracellular vesicle movement and function as well as protein handling. In these studies, the G2019S mutation specifically seemed to affect neuronal homeostasis and morphology (Franco, et al., 2021).

LRRK2 may also play important roles with other gene products, especially ∝-synuclein. For example, the *LRRK2* protein product may phosphorylate ∝-synuclein, which could affect PD development, though more data is needed to verify this idea (Franco, et al., 2021). G2019S may increase accumulation of ∝-synuclein, contributing to Lewy body formation and quickening the aggregation of ∝-synuclein in vesicles or lysosomes (Nam, et al., 2021). However, phosphorylation of ∝-synuclein on Ser129 serves as an effective marker for its aggregation because phosphorylated-synuclein levels are low when not aggregated, and results from certain studies indicate that this phosphorylation is not directly done by LRRK2, a potential opposition to the G2019S aggregation hypothesis (Cresto, et al., 2019). Nevertheless, interactions with 14-3-3 proteins propose a possible mechanism for the pathological association of the two proteins. A region of LRRK2 binds to 14-3-3 proteins, which perform many cellular functions, including blocking pro-apoptotic factors to stimulate cell survival. This binding promotes consistent cytoplasmic distribution of LRRK2 and may block LRRK2 kinase activity. Less binding leads to LRRK2 gathering in cytoplasmic pools and increases harmful kinase activity (Cresto, et al., 2019). This event can occur if the 14-3-3 proteins get trapped in Lewy bodies, which involve ∝-synuclein. LRRK2 and ∝-synuclein also act together to affect mitochondrial function. Mutant forms of the proteins have been shown to reduce the production of ATP and the mitochondrial membrane potential while increasing oxidative stress, contributing to mitochondrial deterioration in dopaminergic neurons (Cresto, et al., 2019). Likely, LRRK2 and ∝-synuclein also increase the toxicity of inhibitors of mitochondrial complex I, which acts in the electron transport chain used in oxidative phosphorylation (Cresto, et al., 2019).

LRRK2 also works with the protein products of other PD-related genes, such as *PARK2*, *PARK7, PINK1,* and *VPS35* to aid in lysosomal and organelle activity. Most of the proteins encoded by these genes contribute to the handling of proteins and their destruction (Franco, et al., 2021). Malfunctioning mechanisms could lead to cell damage. While the role of LRRK2 in Parkinson's still requires further study, excessive kinase activity clearly contributes to the toxicity of mutant forms of the protein, and LRRK2 also appears to have a profound effect on other proteins involved in disease progression (Franco, et al., 2021).

Many other genes have been linked to PD, and this review covers three. Franco et al. provide descriptions of the roles of many more genes possibly involved in the disease (Franco, et al., 2021). However, the three featured in this review appear to have some of the most significant effects on mitochondrial malfunction in dopaminergic neurodegeneration.

4. External Factors

The dysfunctional protein products of mutated genes have not been extensively studied in the context of sporadic PD, which usually emerges later in life. However, significant associations have been drawn between various environmental exposures and the risk of developing PD later in life. Pesticides and MPTP (a chemical found in some illegal drugs which produces free radicals) increase the risk for PD (Campêlo and Silva, 2017; *Parkinson's Disease*, 2001). Conversely, many studies have shown an inverse relationship between cigarette smoking and PD pathogenesis (*Parkinson's Disease*, 2001).

Pesticides have been shown to increase susceptibility to PD by promoting damage to the substantia nigra (*Parkinson Disease,* 2008). One pesticide, rotenone, acts as a mitochondrial complex I inhibitor, which would impair oxidative phosphorylation (Ge, et al., 2020). Support for these claims comes from studies such as that conducted by Brouwer et al. (2015) in the Netherlands. The team used mortality data from the large Netherlands Cohort Study and gathered information on occupational exposures to find associations between the exposures and PD-related death (Brouwer, et al., 2015). Of the environmental factors studied, only pesticides and extremely low frequency magnetic fields (ELF-MF) appeared to have an important correlation with PD, and the findings regarding pesticide use, though non-significant, were consistent with other studies. The study did not find a significant association with the duration of exposure or cumulative exposure to pesticides and PD mortality, though. While none of these results achieved statistical significance, pathology resulting from pesticide use still has important implications for the onset of PD, given its reproducible results across studies and the proposed mechanisms for mitochondrial dysfunction (Brouwer, et al., 2015).

MPTP has a similarly harmful effect regarding PD risk. As mentioned previously, MPTP, a byproduct of illegal production of the opioid desmethylprodine, leads to the synthesis of free radicals, which can increase oxidative stress (Ge, et al., 2020; *Parkinson's Disease*, 2001). In the body, MPTP gets converted to MPP+, a mitochondrial complex I inhibitor like rotenone. This can cause acute-onset parkinsonism with selective SNpc neuronal degeneration, yet again emphasizing the importance of proper mitochondrial function in preventing the loss of dopaminergic substantia nigra neurons (Ge, et al., 2020). In addition, MPTP may interact with genetic risk factors to further increase the vulnerability of these dopaminergic neurons to degeneration. For example, animals lacking proper PINK1 protein showed increased sensitivity to MPTP-induced dopaminergic neuron deficiency (Franco, et al., 2021). Likewise, in studies with mice, MPTP more severely affected those with the *LRRK2* G2019S mutation and did not harm mice without ∝-synuclein (Cresto, et al., 2019). In all of these cases, MPTP, like many other factors affecting the onset of Parkinson's, appears to impair the mitochondria in dopaminergic neurons, either directly or through proteins.

Surprisingly, in the observations of Brouwer et al. (2015), the percent of current smokers with PD cases was fewer than that of non-smokers for both genders. In addition, smokers saw lower PD mortality than non-smokers (Brouwer, et al., 2015). This relationship has gained more support in meta-analyses than other environmental factors, such as alcohol consumption (Campêlo and Silva, 2017). Multiple mechanisms have been proposed for its neuroprotection. Cigarette smoking may decrease levels of monoamine oxidase B (MAO-B), an enzyme that assists in dopamine decomposition (Campêlo and Silva, 2017; *Parkinson's Disease*, 2001). A reduction in MAO-B allows dopamine levels to increase while hydrogen peroxide production and oxidative stress decrease. Cigarette smoking may also lead to increased cytochrome P-450 enzyme activity, which promotes the processing of antipsychotic drugs and the detoxification of harmful substances such as MPTP (Campêlo and Silva, 2017). Furthermore, changes in the genes coding for cytochrome P-450 have been shown to interact with chemicals in tobacco smoke, though the process behind these interactions remains unknown (Campêlo and Silva, 2017). Thus, smoking may indirectly restore mitochondrial function in dopaminergic neurons by blocking the dangers of other toxins.

5. Treatment Options

Regardless of the cause of onset, PD currently has no cure, so patients seek various forms of symptom management. Levodopa (L-DOPA) remains the most common pharmaceutical treatment, but surgical procedures such as pallidotomy, thalamotomy, and deep brain stimulation provide relief in certain cases. These treatments, including the pros, cons, and circumstances that accompany them, will be explained in the subsequent text.

5.1 L-DOPA and Drug Therapies

Currently the most effective drug treatment for PD, L-DOPA consists of a dopamine precursor to replace the neurotransmitter lost throughout the disease. Unlike dopamine itself, the chemical can cross the blood-brain barrier through an active transport system, where it then gets converted into dopamine by amino acid decarboxylase (AADC) (Sian, et al., 1999). This addition helps relieve some motor symptoms caused by dopamine insufficiency, such as tremor, bradykinesia, and jerkiness. Strong and consistent response to L-DOPA occurs within the first one to three years of administration (Lane, 2019). This period is also referred to as the ON-phase or honeymoon period, and patients typically experience significantly better quality of life. Nevertheless, progression of the disease leads to decreased responsiveness to L-DOPA (Lane, 2019).

The relief provided by L-DOPA may also come at a cost, as the drug often comes with significant side effects, especially with long-term use (Lane, 2019). These effects include gastrointestinal issues, hemorrhage, and depression/confusion. Later, motor variations and L-DOPA induced dyskinesias (LID) may arise and often require dose reduction. While rare in the first year of treatment, a study reported the frequency of LID as up to 90% by nine years post-treatment initiation (Lane, 2019). The dyskinesias can be choreic, consisting of unusual movement (often in the neck and limbs), or dystonic, consisting of long-lasting muscle contractions. It is typically seen as uncontrollable motion and occurs at the peak-dose of L-DOPA, when the plasma L-DOPA concentration is highest, or at the end or beginning of the L-DOPA dose, when L-DOPA levels are low (Lane, 2019). This unique side effect is thought to be linked to the severity of striatal dopaminergic denervation. Increased risk of LID has also been associated with MPTP exposure, longer Parkinson's duration and higher L-DOPA dose (both of which correlate with PD severity), earlier onset of PD, and certain genetic variations (Lane, 2019). Despite the controversies with L-DOPA, patients often prefer LID to worsening PD symptoms, maintaining L-DOPA relevance in PD therapy.

In an effort to minimize some of these effects, L-DOPA can be administered with other drugs. For example, carbidopa inhibits L-DOPA degradation outside the blood-brain barrier, so less external L-DOPA therapy produces the same effect (Rao, 2015). MAO-B inhibitors, such as selegiline, are also used and seem to protect substantia nigra cells from free radical damage (*Parkinson's Disease*, 2001). Furthermore, Manalo and Medina (2020) used the nematode *C. elegans* to suggest that caffeine may be taken with L-DOPA as a neuroprotectant. Dopaminergic neurons were better protected and abnormal motion was decreased when caffeine was provided in an environment with high dopamine concentration. This is an especially interesting result when considering that caffeine has been shown to protect from PD, as well (Manalo and Medina, 2020).

To delay L-DOPA use, doctors may prescribe dopamine agonists such as Ropinirole and Pramipexole in the early stages of PD. These drugs function by activating dopamine receptors on cell surfaces. The side effects of such therapies include fewer motor variations and shorter duration of effects compared to L-DOPA at the cost of decreased symptom and impulse control (Rao, 2015).

5.2 Surgery

For patients with earlier onset Parkinson's who no longer respond to medical treatments, surgery may be used. Thalamotomy, careful destruction of the thalamus, and pallidotomy, careful destruction of part of the Globus Pallidus interna (GPi), are two examples (*Parkinson Disease*, 2008). A more common and safer treatment, deep brain stimulation, consists of inserting an apparatus similar to a

pacemaker to electrically stimulate parts of the brain with dopamine deficiency (*Parkinson Disease*, 2008). This procedure causes less damage to brain tissue and can be reversed (Khabarova, et al., 2018). It can also decrease the frequency of dyskinesias and tremor, while reducing pharmaceutical therapy dosage (Rao, 2015). Using information from the previous sections, these surgical procedures would likely be more valuable in genetic PD cases, as these typically appear at a younger age and leave patients more time to develop pharmaceutical resistance. Nevertheless, surgical risks should be considered, and the procedure should only be used for appropriate surgical candidates when medical options have failed.

6. Discussion and Concluding Remarks

As we have seen in the previous sections, the destruction of dopaminergic neurons in the substantia nigra of the brain significantly contributes to the development of PD. Through analyzing the current research, we have undertaken a comprehensive study of three major genetic players and three major environmental factors that alter the risk of this dopaminergic neurodegeneration. The effects of *SNCA*/∝-synuclein, PINK1, and LRRK2 on mitochondrial activity, viability, and damage all demonstrate how studying genes involved in mitochondrial processes is critical to minimizing the loss of neurons in the substantia nigra. This idea is echoed by the neurotoxic effects of pesticides and MPTP and the protective effect of smoking. Current medications aim to combat the dopamine deficiency in Parkinson's, but given the cases of early onset often associated with genetic causes, surgery is also a valid treatment consideration. In addition, due to the negative side effects that come with almost all current treatments, research continues to seek a cure. Perhaps a drug that targets mitochondrial function could be a future possibility, especially one that exerts protection on complex I of the electron transport chain. This therapy would allow mitochondria to continue producing energy in demanding dopaminergic neurons, even if genetic or environmental toxins impair the functions of their components. Nevertheless, the exact mechanisms of PD development are still quite obscure, making optimal treatment difficult.

In our future studies, we utilize this paper's information to conduct a data analysis on the effectiveness of some current therapies for variously caused PD cases. We will use Parkinson's data from FoxDen through the Michael J. Fox Foundation to compare specific genetic mutants with the severity of Parkinson's symptoms. Through this study, we hope to gain additional insights on the impact of mutant genetic products and external factors on the effectiveness of medication.

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How Does COVID-19 Impact the Relative Bargaining Power of the Workers?

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Abstract

This paper takes a new look at the impact of COVID-19 on worker relative bargaining power over wages in the USA more than a year after the onset of the pandemic in early 2020. The empirical analysis uses a Differences-in-Differences technique and the equilibrium of the Nash Bargaining model to estimate the treatment effect on the relative bargaining power of workers. The average weekly wages data is from the U.S Bureau of Labour Statistics, the median gross profit data from Ready ratios and the COVID-19 restrictions data from an American daily, USA Today. There is no indication of a statistically significant average treatment effect of COVID-19 restrictions on bargaining power, suggesting that the effect of COVID-19 and restrictions varies widely across industries.

Keywords: Nash Bargaining Model, Differences-in-Differences Estimation, Bargaining Power

1. Introduction

How does COVID-19 impact the relative bargaining power of the workers? The paper explores the bargaining power of workers with respect to wage negotiations with their employers in the age of COVID-19 and the role that essential workers have played in the employer-employee relationship during the pandemic. The onset of COVID-19 restrictions represent a natural experiment, potentially influencing the bargaining process between firms and workers. This unanticipated event is exploited to assess the impact of COVID-19 restrictions on worker bargaining power. The empirical analysis relies on the Nash bargaining model and the Differences in Differences estimation technique that allows to isolate the average treatment effect that COVID-19 and the ensuing restrictions have had on worker bargaining power. The case of the United States of America is used to track the impact of the pandemic for a year from its beginnings in March 2020 until March 2021. The empirical analysis uses industry-level data from the U.S Bureau of Labour Statistics and Ready Ratios, comparing outcomes before and after the pandemic started.

2. Background

The COVID-19 pandemic has disrupted lives, pushed the hospital system to its capacity, and created a global economic slowdown. As of September 15, 2020, there have been more than 6.5 million confirmed COVID-19 cases and more than 195,000 deaths in the United States. The pandemic has precipitated an unprecedented health and economic crisis, creating extraordinary challenges for households and businesses. Worker bargaining power is the ability of an employee to command higher wages or benefits and set terms about their working conditions. Since the 1950s, worker power has generally been on the decline as the power of

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corporations and shareholders grew and union strength fell. But now the nation has the most job openings it has ever had since the Bureau of Labor Statistics started tracking data in December 2000. There were 10.1 million job openings recorded at the end of June 2021. That means that for every available 100 jobs, there were only 94 unemployed people available. The balance of power had shifted to the worker for the first time in decades. Employees were using their newly-found bargaining position to demand more from their employers –they wanted decent wages, career progression and greater flexibility to come with their job.

The past year has also increased the value placed on wider benefits such as healthcare, childcare and sick leave. The COVID-19 induced labor market collapse has impacted industries differently, hitting mainly (at least in this early stage) the low-wage services and retail sectors of the economy. The service sector, and particularly its low-wage segment, experienced by far the largest drop in employment. In the leisure and hospitality industry, which includes restaurants and hotels, employment fell by nearly half between February and April 2020. Other services, which include repair and maintenance services, personal and laundry services, and services to private households, were the second most impacted, with more than 20% of employment lost by April.

Some economists are skeptical as to whether any potential changes to worker power are permanent. Worker protection policies, unions and norms of fairness haven't strengthened much during the pandemic. The pandemic-related labor shortages won't be resolved overnight, even when expanded unemployment benefits end.

3. Literature Review

Several studies have documented the enormous impact of the COVID-19 pandemic on labor outcomes in both developed and less-developed countries. For example, Baek et al.(2020), Jin Cho et al.(2020), Couch et al.(2020), Genoni et al,(2020), Kikuchi et al.(2020). Most of the available evidence, however, focuses on the early months of the pandemic. This paper examines the medium-term effects of the COVID-19 pandemic on labor outcomes in one of the hardest-hit countries in the world by using the differences-in-differences estimation and the Nash bargaining model.

Differences-in-Differences estimation is one of the most important identification strategies in applied economics. (Card and Krueger 1993) studied the impact of a New Jersey rise in the minimum wage on employment in fast-food restaurants using the differences-in-differences technique. The paper uses a two-period dataset, February 1992 (before) and November 1992 (after). On April 1, 1992, New Jersey's minimum wage rose from 4.25 to 5.05 per hour. The minimum wage in neighboring Pennsylvania stayed constant. Card and Krueger collected data on employment at fast-food restaurants before and after the wage increase in the two states. The treatment is the increase in the minimum wage, the treated group is New Jersey fast-food restaurants and the control group Pennsylvania fast-food restaurants. By using DiD, the paper implicitly assumes parallel trends. The authors conclude that the minimum wage increase had no negative effect on fast-food restaurant employment.

The Nash equilibrium is a decision-making theorem within game theory that states a player can achieve the desired outcome by not deviating from their initial strategy. It has been widely applied and adapted in economics and other behavioral sciences. Binmore et al.(1986) established the relationship between the static axiomatic theory of bargaining and the sequential strategic approach to bargaining. They consider two strategic models of alternating offers. The models differ in the source of the incentive of the bargaining parties to reach agreement: the bargainers' time preference and the risk of breakdown of negotiations. Each of the models has a unique perfect equilibrium. When the motivation to reach agreement is made negligible, in each model the unique perfect equilibrium outcome approaches the Nash bargaining solution with utilities that reflect the incentive to settle and with the proper disagreement point chosen. The results provide a guide for the application of the Nash bargaining solution in economic modeling.

4. Methods

The equilibrium of the commonly known Nash

Bargaining Model is used to estimate the bargaining power of a worker. Collective bargaining is the process by which working people, through their unions, negotiate contracts with their employers that determine their terms of employment, including pay, benefits, hours, leave, job health and safety policies, ways to balance work and family, and more. It is a way to solve workplace problems. It is also the best means for raising wages in America. Indeed, through collective bargaining, working people in unions have higher wages, better benefits and safer workplaces.

The basic strategic bargaining model between two parties starts with the first party suggesting an offer that the second party can choose to accept or reject. If the second party accepts the offer the bargaining stops and the outcome is the offer of the first party. However, if the second firm rejects the offer, it will come back with a counter offer after some time. Now the first party can choose to accept or reject the offer. Again, if the offer is accepted the bargaining stops with that outcome, otherwise the first party comes back with a counter offer after time. The bargaining game continues with this procedure until either an agreement is achieved or until it is evident that an agreement can never be reached.

The measure of relative bargaining power is defined from the equilibrium of a simple Nash Bargaining model between workers and their employers: simply the ratio of wages to profit for a particular industry, in a particular state at some point in time.

$$y_{ist} = w_{ist} / \pi_{ist}$$

where w_{ist} is the wage in state s in industry i at time t and π_{ist} is profit in state s in industry i at time t.

The differences-in-differences technique is used next to measure the effect of COVID-19 on worker's bargaining power. DID is a quasi-experimental design that makes use of longitudinal data from treatment and control groups to obtain an appropriate counterfactual to estimate a causal effect of some intervention. DID is typically used to estimate the effect of a specific intervention or treatment (such as a passage of law, enactment of policy, or large-scale program implementation) by comparing the changes in outcomes over time between a population that is enrolled in a program (the intervention group) and a population that is not (the control group). In this case, the "interventions" are COVID-19 restrictions, which are used to define the control and treatment groups to mimic a controlled experiment.

In order to estimate any causal effect, three assumptions must hold: exchangeability, positivity, and Stable Unit Treatment Value Assumption (SUTVA). The parallel trend assumption is the most critical of the assumptions to ensure internal validity of DID models. It requires that in the absence of treatment, the difference between the 'treatment' and 'control' group is constant over time. Another important assumption is the Stable Unit Treatment Value Assumption, which implies that there should be no spillover effects between the treatment and control groups, as the treatment effect would then not be identified. Furthermore, the control variables should be exogenous, unaffected by the treatment. By using DID, this paper implicitly assumes the above assumptions.

This paper formally explores the patterns in the data by estimating a DID model which compares outcomes across states and industries, some of which were impacted with COVID-19 restrictions, before and after the beginning of the COVID-19 pandemic in March 2020. Specifically, the following regression model is estimated:

$$y_{ist} = \gamma_i + \alpha_s + \lambda_t + \delta D_{ist} + \epsilon_{ist}$$

where y_{ist} is the labour's relative bargaining power in industry i, state s and at time t. γ_i is the industry fixed effect, α_s is the state fixed effect and λ_t is the time fixed effect. In other words, any factors that influence bargaining power that do not vary across states and time will be controlled for with the industry fixed effect. Corresponding explanations can be given for the state and time fixed effects. D_{ist} is the dummy variable which equals 1 if industry i in state s at time t is under covid restrictions and 0 when not. ϵ_{ist} is the error term. The coefficient delta δ in the econometric specification captures the treatment effect of COVID-19 restrictions on workers' relative bargaining power. Combined with the fixed effects, these specifications control for variation in worker bargaining power due to differences across industries,

across states, and across time periods. The remaining variation in bargaining power turned out to be a result of COVID-19 restrictions.

5. Data

The empirical analysis aims to examine the impact of the COVID-19 pandemic on labor market outcomes over time. The data is collected for 19 industries in 53 US states and territories. The 19 industry sectors are listed according to the North American Industry Classification System (NAICS) code order which includes Agriculture, Forestry, Fishing and Hunting (NAICS 11), Mining, Quarrying, and Oil and Gas extraction (NAICS 21), Utilities (NAICS 22), Construction (NAICS 23), Manufacturing (NAICS 31-33), Wholesale Trade (NAICS 42), Retail Trade (NAICS 44-45), Transportation and Warehousing (NAICS 48-49), Information (NAICS 51), Finance and Insurance (NAICS 52), Real Estate and Rental Leasing (NAICS 53), Professional and Technical Services (NAICS 54), Management of Companies and Enterprises (NAICS 55), Administrative and Waste Services (NAICS 56), Educational Services (NAICS 61), Healthcare and Social Assistance (NAICS 62), Arts, Entertainment and Recreation (NAICS 71), Accommodation and Food Services (NAICS 72), Other Services except public administration (NAICS 81). The variables are average weekly wages, median gross profit ratio and COVID-19 restrictions that vary by industry and state. The data is collected for the first quarter from 2017-2021. This resulted in 5000 industry-state-time observations. The paper relies on three primary sources to collect data for the empirical sample. It uses average weekly wage data from the U.S. Bureau of Labour Statistics. The profit data is collected from Ready Ratios, an online software that produces a complete financial analysis of a company's statements. The COVID-19 restrictions data is collected from an American daily called USA Today.

This paper assumes the profit for an industry to be the same across all states. Therefore, the variation in the measure of bargaining power across states in a given industry and time period comes through variations in wages. This assumption is motivated by the limitations in profit data. It can be observed that the profit data is disaggregated by industry and time but isn't disaggregated by state. The unit of the profit data is percentage. It is also assumed that the COVID-19 restrictions have remained the same as 2020 in 2021.

The equilibrium of the Nash microeconomic foundation is used to derive the worker's bargaining power with firms over compensation. For industry i in states at time t, the relative bargaining power of the worker is defined as wage by profit i.e .It should be noted that due to data limitations, the wage data varies across industries, states, and times while the profit data only varies across industry and time.

6. Results and Discussion

Table 1 contains descriptive statistics for the empirical sample and Table 2 displays the main results of the Differences-in-Differences estimation for the impact of COVID-19 restrictions on average worker bargaining power. The 4 main variables are wage, profit, bargaining power and the COVID-19 restrictions treatment indicator. With respect to the regression model, the dependent variable is relative worker bargaining power and the independent variable is COVID-19 restrictions for each industry and state. Looking at all these variables individually, the average weekly wage is 1256, average profit is 0.316, and the average bargaining power is 3228. The percentage of observations that are treated are 0.0326 and the rest are in the control group.

Table 1: Descriptive Statistics for the empirical sample

Variables	*Mean*	*Standard Deviation*	*Median*	*Min / Low Percentile*	*Max / High Percentile*
Wage	1256.	791.	1036	188	9145
Profit	0.316	0.239	0.350	-1.51	0.709
Bargaining Power	3228.	4610.	2971.	-38012.5	29677.68
Covid Restric-tions	0.0326	0.178	0	0	1

The standard deviation of wage is 791, profit is 0.239 and bargaining power is 4610. The median wage is 1036, median profit is 0.350 and median

bargaining power is 2971. The minimum value or the lowest percentile wage is 188, profit is -1.51, and bargaining power is -38012.5. The maximum value or the highest percentile wage is 9145, profit is 0.709, and bargaining power is 29677.68.

There are 6 models that measure the average treatment effect of COVID-19 restrictions on relative bargaining power of the workers by controlling for differences across industries, states and time by use of fixed effects. The stars (*) in models 1, 2 and 5 explain that there is a statistically significant average treatment effect of COVID-19 restrictions on worker's bargaining power. But, Model 6 is preferred as it controls differences in bargaining power between industries, across states, and between time periods. The results of Model 6 suggest that there is no average treatment effect of COVID-19 restrictions on average worker bargaining power. Comparing the different versions of Model 6, it can be seen that most of the variation in bargaining power is driven by differences in industry. It can be explained by comparing the R^2 measure. R^2 is a statistical measure in a regression model that determines the variance in the dependent variable that can be explained by the independent variable. When R^2 is equal to zero, it means that there is no variation in the dependent variable i.e. the worker bargaining power. The closer it gets to one, the more it explains variation in the worker bargaining power. The R^2 measure in Models 1, 4, and 6 include the industry fixed effect and Models 2, 3, and 5 do not. The industry fixed effect explains a much greater share of variation in worker bargaining power compared to state and time differences. When state and time effects are controlled i.e Model 2, 3 and 5, it can be seen that there is a negative treatment effect of the COVID-19 restrictions on the bargaining power. This implies that COVID-19 restrictions reduced the bargaining power, before considering the variation due to industrial differences in wages. When variations across industries and time are also controlled i.e Model 6, there is no longer a statistically significant treatment effect of the COVID-19 restrictions on average. These two results together suggest that the impact of COVID-19 restrictions varies widely across industries.

Table 2: Main Results of the Differences-in-Differences estimation

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Covid Restrictions	0.0336* (0.0143)	0.2901*** (0.0159)	-0.3056 (0.1341)	0.0427 (0.1445)	0.3002*** (0.0166)	0.0534 (0.1468)
Fixed effects						
Industry	Yes	No	No	Yes	No	Yes
State	No	Yes	No	No	Yes	Yes
Time	No	No	Yes	Yes	Yes	Yes
R^2	0.47448	0.02089	0.01568	0.48730	0.03388	0.50688

7. Conclusion

This paper examines the average treatment effect of COVID-19 on relative bargaining power of the workers in the USA. It was found that once the differences across industry-state-time are controlled, there is no impact of COVID-19 restrictions on the bargaining power. Further study of this topic would benefit from richer data, such as wages for individual workers and profits for individual firms. It should also be noted that only the wage of the average worker is considered in the analysis. It would also be interesting to see how this impact varies across worker skill groups.

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The Addicted Brain: The Neurological Implications of Addiction in Adults Versus Adolescents

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Abstract

Addiction is a growing concern among the healthcare community as harmful addictive behaviors stemming from various stimuli, such as alcohol and drugs, continue to heighten amongst adults as well as adolescents. In addition to the negative neurological implications of addiction, it is essential to recognize that this addiction has a contrasting effect on an underdeveloped brain compared to a fully developed one. Multiple articles on addiction to stimuli, written by experts in the neuroscience and neuropsychology field, were examined to determine how addiction affects brain function, including long-term and short-term effects, neurotransmission and neuronal circuits, adaptation, regrowth, etc., and treatment of adults versus adolescents. While most of the negative neurological implications of addiction are identified and analyzed, it is also concluded that most of the effects of addiction which commonly occur in adults also take place in the adolescent brain. Additionally, adolescents are susceptible to a greater degree of risk due to the brain's underdeveloped state, leading to an increasingly grueling road to recovery in all aspects.

Keywords: Neuroscience, Addiction, Brain, Disorder, Neurotransmission, Neuroadaptation, Circuit

1. Introduction

Addiction is a complex brain disorder in which an individual is compulsively engaged in rewarding stimuli, despite its detrimental outcomes (NIDA, 2018). Many possible stimuli (e.g., drugs) can cause addiction. Different factors such as biology (genetics), environment (family and friends), or development (biological and environmental factors combined) can cause addiction. Although the decision to take the stimuli is usually voluntary, continued use can lead to severe changes in the brain, leading the process of withdrawal to be highly grueling and painful (NIDA, 2018). Due to the several interconnected circuits in the brain working together to perform certain functions, the brain uses various neurotransmitters to coordinate and perform these actions. In a cognitively normal brain, a neuron releases a neurotransmitter into a synapse where it attaches to receptors in the receiving neuron, leading to changes in the receiving cells. Since there are not nearly as many neurotransmitters as neurons in the brain, molecules called transporters recycle the neurotransmitter and guide it back to its original neuron. This process allows neuron signaling to occur.

Nevertheless, when addiction is introduced into this cycle, the process of neurotransmission and neuron signaling can drastically change. For example, when drugs such as marijuana or heroin are presented to the brain, neurons activate due to the drugs' chemical structure mimicking neurotransmitters in the body. Consequently, the drugs attach to the receptors in a neuron, and unlike a natural

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neurotransmitter, abnormal messages are transmitted throughout the network. This shifts the brain's balance and leads to critical changes in humans' behavior and cognitive function.

Key parts of the brain which are negatively impacted by addiction include the basal ganglia, extended amygdala, and prefrontal cortex. The basal ganglia are involved in the brain's role in positive forms of motivation, including the "reward system" known to cause euphoria when using stimuli during the course of addiction. The extended amygdala plays a role in stressful feelings, allowing a person to seek out the comfort stimuli. The prefrontal cortex, which controls our ability to think and make decisions, is affected by addiction in that the shifting balance of this circuit and that of the basal ganglia and extended amygdala cause an individual to seek a stimulus compulsively (NIDA, 2020).

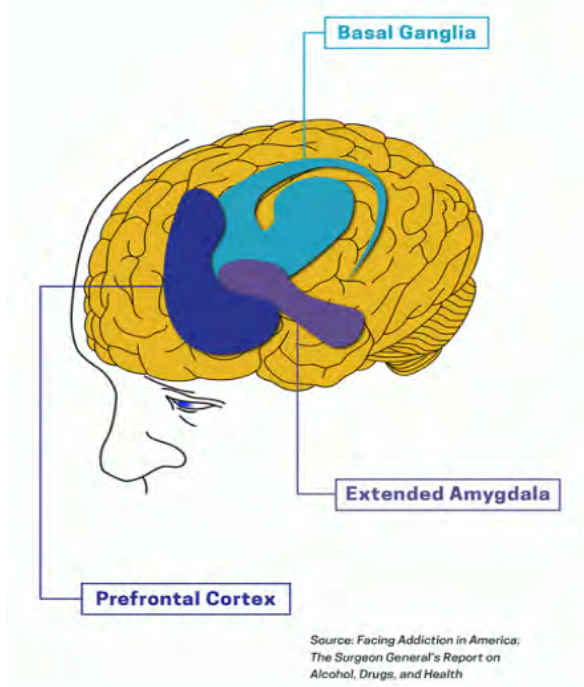

Figure 1. Parts of the Brain Affected by Addiction. (NIDA, 2020).

Addiction is a harmful disorder, but when adolescents become prey to it, the danger of brain damage and cognitive impairment is maximized. Since the brain fully develops at the age of 25, adolescents' brains are very prone to addiction. The prevalence of drugs and alcohol is widespread among teenagers, and the possibility of addiction among this population has significantly increased (Schramm-Sapyta et al., 2009). While the effects of addiction on brain functionality are more commonly known regarding a fully developed brain, it is also essential to understand the key differences between addiction in an adolescent's brain versus that of an adult. With this literature review, differentiating between addiction in an adolescent brain versus the same in an adult brain can shine light upon the effects of addiction on two key populations; this may lead to further development in patient-specific (based on whether the patient is an adolescent or adult) treatments based on a given's patient particular neurological state at the time of seeking rehabilitation. Additionally, with continued research regarding this topic, innumerable individuals will be assisted with targeted therapies, treatments, and medications for both adolescents and adults.

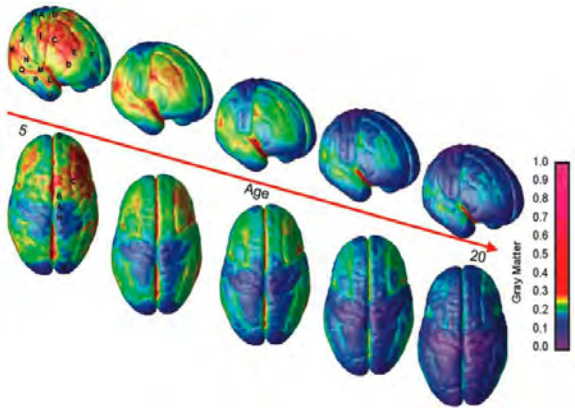

Figure 2. Sequence of Cortical Grey Matter Maturation from early childhood into adulthood. (Hammond et al., 2014).

2. Short-Term Effects

There are many effects of addiction on the whole body. Common short-term effects of any type of addiction include permanent cognitive disruption or impairment, confusion, seizure, problems with remaining conscious, respiratory suppression, low heart rate, and vomiting (Mosel, 2021).

The chances of these effects occurring are heightened when the individual is under 25 years old. In addition to the eminent heart, respiratory, and digestion problems associated with addiction, severe

neurological impairments can occur. When a more senior individual faces the problem of fighting addiction, their brain is already fully developed, meaning that it has completed its cycle of establishing connections between neurons. The part of the brain which is developed last as an adult, the prefrontal cortex, serves as the most important and fragile part of the brain when exposed to addiction. Since it controls the most important actions of an individual, such as decision making, its neuronal connections need to be fully developed, complex, and strong. With these types of refined connections in the brain, the risk of permanent cognitive impairment and the chances of confusion and seizures are lowered (Goldstein and Volkow, 2011).

However, when an adolescent is in the question, there is an increased probability for the brain to be permanently impaired or damaged. Since the brain is still in the process of "sculpting" a number of these neurological connections, unused or unwanted links are removed, and longer chains of nerve cells are constructed for information to be processed much more efficiently. If these circuits cannot be fully developed during adolescence, the chance of cognitive impairment or permanent damage is very likely (Winters & Arria, 2011).

3. Long-Term Effects

Possible long-term effects of addiction include permanent brain damage, depression, anxiety, confusion, memory problems, coordination difficulties, Wernicke-Korsakoff Syndrome (a result of poor nutrition), and, in severe cases, death (Mosel, 2021).

The long-term effects of addiction are similar to the short-term effects, yet they are further heightened. Mental health disorders such as anxiety and depression are also possible effects. This is most likely due to the dejected feeling of addiction and the lack of optimism that can occur while a patient tries to withdraw from the given stimuli but repeatedly fails without help from a professional. Disorders such as these can be very harmful to adolescents because they cannot learn how to cope with these feelings, especially with problems such as peer pressure and social media. Furthermore, it is challenging for young individuals to accept that they have a mental health problem.

In addition to the damage to the prefrontal cortex, there is a possibility for the hippocampus, the part of the brain responsible for memory, to be damaged or shrunken. Hippocampal damage at a young age can be harmful to mental/neurological health and an individual's social and academic life. Memory loss can cause a person to not perform to their potential in school and lose trust and accountability from their peers. Although it is not very likely that an adolescent will die from addiction, it is possible that anyone (adult or adolescent) can die from the neurological, digestive, heart, respiratory, or mental health effects and aftermath of addiction (Winters and Arria, 2011).

4. Neurotransmission and Circuit Systems

An essential neurotransmitter regarding addiction and the neurobiology behind it is dopamine (NIDA, 2017). This neurotransmitter plays a vital role in the brain's reward system. When the individual is exposed to addictive stimuli, a sense of contentment is felt, leading them to consume more and more of that stimuli. The natural or artificial stimulants activate the dopaminergic pathway (mesolimbic dopamine pathway), leading to increased dopamine levels in the nucleus accumbens. Humans who are addicted to something yearn for this type of feeling, allowing the dopamine levels to fluctuate constantly. When these levels increase, the person continuously needs more stimuli to feel that same level of contentment. This increasing level of stimuli inevitably leads to addiction.

Nicotine serves as a significant agonist to the neurotransmitter acetylcholine. People addicted to tobacco, e-cigarettes, etc., usually have varying acetylcholine levels. Contrary to popular belief, the brain has nicotinic receptors, which are essential to brain functionality. However, when the individual is addicted to nicotine, its effects are exerted by acting on this receptor for acetylcholine. Some of these receptors are located in the cell bodies of dopamine neurons, leading to an increase in dopamine release, thereby increasing a person's reward feeling (Tomkins and Sellers, 2001).

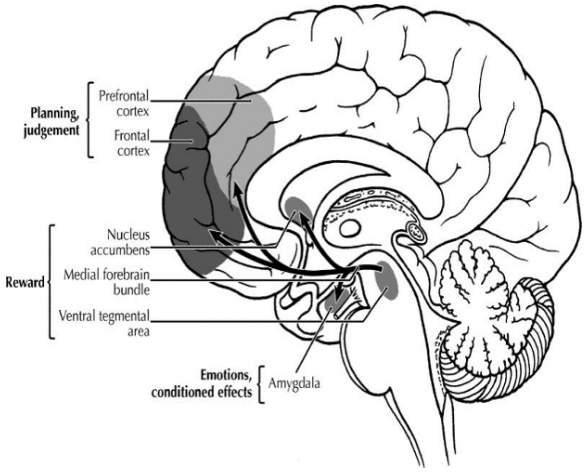

Figure 3. Reward System in the Brain: How Individuals Choose to Continuously Consume Stimuli. (Tomkins and Sellers, 2001).

The neurotransmitter serotonin is essentially responsible for stabilizing mood, condition, feelings, learning, memory, and much more. Its neurobiology is complex and multifaceted but is known to have a crucial role in behavioral adaptation to stress (inclusive of addictive phenotypes). This neurotransmitter comes into play after it has been established that a person is addicted to stimuli. The feelings that are associated with addiction are similar to that of depression or anxiety. These serve as disruptions to the brain's serotonin levels, making it much harder to regulate these emotions. This creates an individual more vulnerable to addiction because they rely on that stimulant to make them feel better (Patkar et al., 2016).

All of these neurotransmitters play a major role in the addicted brain. It is crucial to consider the difference or increased number of effects that could occur if adolescents are exposed to addiction. The rewarding feeling from a dopamine release will continue to grow and allow the young individual to consume much more significant amounts of the stimulant (because they are likely unaware of a safe limit). If the person is addicted to nicotine (which is very likely especially now because of the increased availability of e-cigarettes in high schools), their acetylcholine levels will fluctuate, and increased use of nicotinic receptors to feel that sense of contentment. In addition to the neurological effects, the adolescent's mental health can be drastically affected by fluctuating serotonin levels, allowing them to damage their relationships with their family and friends at a young age. This will lead to the addiction being further fostered. Again, since adolescents are young and their brains are underdeveloped, these changes will be more substantial than those for an adult.

5. Neuroadaptation

For an individual to establish addictive behavior towards a given stimulant, positive reinforcing effects (i.e., reward feeling) are critical. However, both positive and negative reinforcing effects are needed to maintain consumption of stimuli and develop the addiction. Neuroadaptation is a modulatory process that can increase reinforcement with repeated exposure.

Counteradaption is a term inclusive of the processes initiated to oppose the acute effects of stimuli. Counteradaptive processes include tolerance (represents a reduction in the stimulant's effect; tolerance to the desired result could likely stimulate increased use in attempting to experience the initial intensity and feeling) and withdrawal (the symptoms are usually opposite from the initial effect when the stimulant is removed altogether. This counters the same acute effects from the stimulus) (Roberts and Koob, 1997).

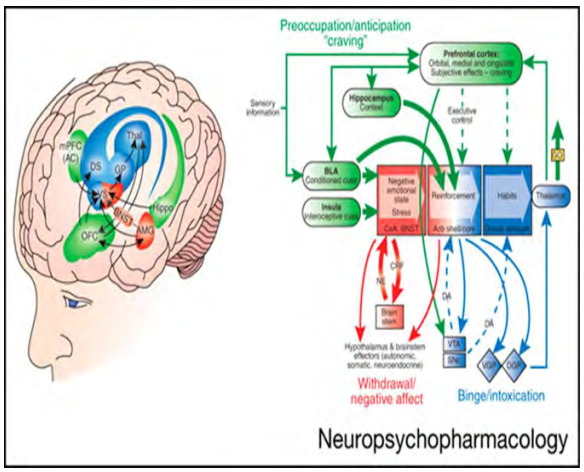

Figure 4. Neurocircuitry schematic illustrating the combination of adaptations in circuit systems across the addiction cycle (binge, withdrawal, craving). (Hammond et al., 2014).

The process of neuroadaptation is much faster for an adolescent due to their strong reward system. This makes young individuals vulnerable targets for addiction. In turn, the counter-adaptive process will be much more difficult (Hammond et al., 2014).

6. Regrowth

When a person withdraws from their addiction, more time spent in abstinence allows for the brain to recover and regrow the damaged circuits in the brain. Slowly, the brain starts functioning the way it used to and becomes very active.

Research has shown that adult-born neural and glial progenitors can promote recovery from addiction. In simple terms, progenitors are the offspring of stem cells that can self-renew and survive or mature into different types of cells (e.g., neurons, glial cells). Adult neurogenesis and gliogenesis can contribute to the regulation of addiction, especially in the hippocampus and cortex. The loss of newborn progenitors in these parts of the brain can determine the vulnerability of addiction that an individual can possess. Furthermore, the normalization of addiction-impaired neurogenesis helps reverse neuroplasticity, which is formed during abstinence, thereby helping reduce exposure and promoting regrowth (Mandyam and Koob, 2012).

Of course, the adult-born progenitors will not assist in the recovery of an adolescent due to the underdevelopment. This is another sign indicating the dangers of addiction in adolescents. Since there is less hope for regrowth, permanent brain impairment or damage is likely.

7. Treatment

There are various treatment methods for addiction. Addiction treatment usually includes group and therapy sessions where recovery skills are also obtained. Some include Cognitive Behavioral Therapy (CBT), Contingency Management, Motivational Interviewing (MI), Dialectical Behavioral Therapy (DBT), Rational Emotive Behavior Therapy (REBT), Matrix Model, and 12 Step Facilitation (Miller, 2021).

Treatment methods for adolescents include Motivational Enhancement Therapy, Adolescent Community Reinforcement Approach (ACRA), Contingency Management, Family Behavioral Therapy, Brief Strategic Family Therapy (BSFT), Multidimensional Family Therapy (MFT), Assertive Continuing Care, Peer Recovery Support Services, and a Recovery High School (Miller, 2021).

Although there are many different types of treatments available for different types of addiction disorders, it is necessary to observe that there are different types of therapy for adults compared to adolescents. Most of the therapies for adults focus on bettering themselves and trying to prevent relapse. Adolescent therapy focuses on the family aspect in addition to the individual. It is important to consider the family environment from which the child was coming from, which may or may not have led to addiction. Bettering the atmosphere at home or in schools greatly affects the number of adolescents struggling with addiction.

8. Conclusion

Addiction is a brain disorder manifested by compulsive substance use despite harmful consequences. Adolescents can be significantly more harmed by addiction due to the underdevelopment of the brain. The brain's circuit systems are not fully developed and can be permanently damaged from this disorder. Moreover, the reward system of the brain is the strongest during adolescence, allowing young individuals to become more vulnerable to addiction. Due to the low number of developed neuronal circuits, it becomes even more difficult for the young brain to recover from addiction.

At this point, teenagers are struggling with addiction to nicotine, alcohol, drugs, etc., because it is widely available around them. A consideration is an improved environment around these young individuals. Peer pressure and social media culture are very pervasive amongst high school and middle school students. If a child observes their peers engaging in an activity, it is likely for them to join. This is the result of an impressionable mind, common in developing brains. A young individual should be around a positive social and academic environment and have strong relationships with their family and

peers.

Addiction is tough to cope with and recover from because it requires immense mental and physical strength. Adolescents especially experience great hardships due to their young age and inexperience in life. Research regarding this topic must be continued because it will allow light to shine upon better therapies, treatments, medications, and possibly, preventive action of addiction, which can assist millions worldwide.

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The Effects of Culture and Education on the Formation of Body Image and Exercising Behaviors: Focusing on Korean Female High School Students Who Attend an International School

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Abstract

The study investigates the effects of culture and education on the body image formation and exercising behaviors of Korean female high school students who attend an international school in South Korea. The study focuses on the concept of body image to examine how respondents perceive actual and desired self-images compared to Korean and U.S. female college students. The primary methodologies are chi-square test and difference in mean t-test. A self-administered survey was conducted, and the responses were compared to the survey results of the study of Lee and Moon (2018). The findings revealed that Chadwick International (CI) students have similar way of thinking with U.S. female college students except for how others perceive their appearance. As a result, CI students showed similar exercising behaviors with U.S. female college students. This study emphasizes that education, as a sub-concept of culture, has a prominent effect on the formation of the body image and resultant exercising behavior of female students. Therefore, we urge the introduction of school education programs that help improve student's physical and psychological well-being.

Keywords: Body Image, Culture, Education, Chi-Square Test, T-Test

1. Introduction

Various factors influence the formation of the body image of female students. Body image can be perceived and evaluated differently depending on culture (Jung and Lee, 2006). Considering that the ideal body shown through the media and the frequency of exposure is different in every region, the perfect beauty is diverse depending on the culture. It is said that comparing the standard with one's appearance is because the measure and degree of comparison differ depending on which culture one belongs to (Fallon, 1990). In particular, the degree of interest and involvement in women's behavior in managing their appearance through body-related exercises, skincare, and makeup varies according to culture, such as individualism and collectivism (Markus and Kitayama, 1991).

Recently, women's interest in muscle building, which was thought to be the exclusive domain of men, is increasing, and such high interest is leading to action (Park and Chen, 2017). Jung and Lee (2006) investigated the existence of cultural differences between the dieting behaviors and body image perception of Korean and U.S. female college students. In a similar vein, Lee and Moon (2018) investigated the body image and dieting behaviors of Korean and U.S. female college students.

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According to Jung and Lee (2006), most women feel a difference between their current and ideal appearance. This difference, the degree of conformity, may vary depending on the individual's formed body image. The degree of conformity to the body image is the point of view of the theory of self-congruity. The theory of self-congruity states that the body image, defined as the totality of thoughts and feelings toward oneself, is different for every individual (Sirgy, 1982; Johar and Sirgy, 1991; Sirgy et al., 1991). The cause of this difference was explained as cultural factors according to individualism and collectivism (Markus and Kitayama, 1991).

Both Korean and U.S. female college students had the perception of wanting to lose their current weight. Still, the ratio of Korean female college students was significantly higher than that of U.S. female college students (Lee and Moon, 2018). On the other hand, the percentage of U.S. female college students was relatively higher than that of Korean female college students where they thought others perceived their weight as normal. This can be seen to imply that U.S. female college students have a positive view of their bodies compared to Korean female college students (Lee and Moon, 2018).

Our study was conducted by dividing weight training and cardiovascular activities regarding exercising behaviors following the methodology proposed by Lee and Moon (2018). Considering exercising behaviors as related to education, the study aims to broaden the understanding of high school girls by examining how exercising behaviors change depending on the influence of culture, education, and the degree of body image conformity. According to the culture to which an individual belongs (individualism or collectivism), it is said that women have various levels of exercising behaviors that meet the expectations and beauty standards of the culture to which they belong (Jung and Lee, 2006). In particular, it is said that women in most non-Western societies, belonging to a collectivist culture, tend to compare their appearance with those of others and are sensitive to other people's opinions on their appearance compared to women in Western societies of individualistic culture. In a similar vein, previous studies showed that women in non-Western cultures consider dieting behaviors important and actively participate in diet-related activities (Lee et al., 2001; Lennon et al., 1999). This suggests that Korean female students are more aware and concerned about appearance-related information than American female students. In addition, this indicates that Korean female students tend to underestimate their physical attractiveness and are more critical of their bodies than U.S. female college students, which means that the gap between Korean female students' body image and their ideal body is more significant compared to U.S. female students.

Chadwick International (from now on referred to as CI) in 2021 has a suitable social experiment environment where many Korean students are provided with American education, which allows us to compare the effects of culture and education on their body image and exercising behaviors. Lee and Moon (2018) investigated the factors that formed the body image of Korean and U.S. female college students and the effect of the formed body image on their exercise behaviors. The results of their study are compared to the results of our study conducted through the same questionnaire. The survey resulted in 30 total responses (30 from Korean female high school students who attend an international school in South Korea).

Previous studies on body image formation have been conducted in various fields. First, factors that influence body image formation are family, friends or peers, teachers, society, media, et cetera (Ata et al., 2006; Ryu, 2019; Ra, 2020). According to Ata et al. (2006), low self-esteem and social support, weight-related teasing, and greater pressure to lose weight were associated with adolescents' negative body image and eating attitudes. According to Ra (2020), weight bias internalization increased considerably as the social pressure related to appearance increased. In contrast, it decreased when teachers and adolescents' relationship was close. Female children exposed to thinness-promoting messages (TPM) indicated a higher body image dissatisfaction than those not exposed to such messages. According to Ryu (2019), the discrepancies between BMI and subjective perception of body image showed significant differences according to parents' country of origin.

Several studies discuss the moderating effect of differences according to the subject's gender, age, or occupation (college major) on body image formation (Harrison, 2000; Maeng and Han, 2017; Yoon and Jung, 2018). These are studies about female college students, high school students, elementary school students, male students, dance majoring college students, etc. According to Harrison (2000), watching TV increased eating disorders in 3rd-grade children and their stereotypes about obese bodies. According to Maeng and Han (2017), gender, age, economic status, academic performance, and subjective health status have significant influences on the distortion of adolescent body image. According to Yoon and Jung (2018), the ideal body image of high school girls majoring in Korean dance is generally conceptualized as an abstract and ideal body, a body one could not have: the efforts of high school girls to achieve the ideal body image were derived from rigorous physical training, basic and extreme dieting, plastic surgery, medical procedures, medication, and basic body shape management such as acupuncture massage and physical therapy.

Other than that, several studies concern the effect of body image on certain behaviors such as depression and exercising behaviors (Maeng and Han, 2017). These include psychological well-being (dissatisfaction, depression, self-esteem), stress and suicidal thoughts, exercise, and health care. According to Maeng and Han (2017), body image distortion in adolescents significantly affects depression.

Finally, there are comparative studies similar to this study. These include gender comparison, international comparison, cultural comparison, etc. According to Grogan (2017), women generally have higher levels of body dissatisfaction than men. Women often want to lose weight, whereas men are equally likely to want to be heavier or lighter and want to be more muscular at all ages. However, sexuality, age, and psychological factors such as self-esteem and the internalization of body ideals impact these differences.

Our hybrid method is a methodology that uses the findings of previous studies as data. This method is used when multiple studies address a related question. For example, the hybrid method was used in Carlsen et al. (1992), research on male fertility declining over the previous 50 years, since conducting research over the previous 50 years was impossible. Carlsen et al. (1992) uses data from multiple studies conducted throughout those years.

According to Herrera Ortiz et al. (2021), systematic literature reviews/meta-analyses of clinical trials are considered the best evidence in clinical research; thus, if performed appropriately, they can save resources by avoiding the development of unnecessary clinical trials.

Our study adopted the hybrid methodology, which combines past and current findings. Furthermore, the effects of the approximate four-year gap between Lee and Moon (2018) and our study and the differences between college and high school students on the quality of our study are negligible.

Our study compares the different nature of culture and education in the United States and South Korea. It aims to determine whether culture or education has a more significant impact on female high school students' body image formation and exercise behaviors. Our study assesses the similarity between Korean female high school students who attend an international school and US female college students and Korean college students who attend a Korean university regarding how they perceive their bodies. Also, our study aims to determine whether the relationship between body image formation and exercise behaviors is the same for all three groups of female students. The indicators of our statistical test procedures are the significance levels of chi-square test statistics of the responses to each question on the questionnaire from Lee and Moon (2018) regarding the formation of the body image and t-test statistics of those regarding exercising behaviors of Korean female high school students who attend an international school.

The contribution of our study is multifold. First, we separate culture and education, a sub-concept of culture, confirming their relative influence through statistical test procedures and showing that adolescents can form desirable exercising habits through school education. Our study takes a step toward school education programs that help students develop healthy body image and support students' physical and psychological well-being. Another

methodological uniqueness also deserves a note. We combine our data with those from previous literature. Our innovative hybrid method is helpful for researchers under research budget constraints.

The remainder of this paper is organized as follows. We introduce the data and variable calculations in section 2. In section 3, we discuss our findings. Concluding remarks appear in the final section.

2. Empirical Analyses

2.1 Hypothesis

This research can be divided into two large parts: perception of body image and choices of time spent on exercises. This research has four research hypotheses as follows.

Hypothesis 1-1

The perception of body image of CI female students will be closer to that of Korean female college students.

Since CI female students are Koreans living in South Korea, the influence of Korean media and Korean culture on their perception of their ideal body image and their self-image is inevitably significant. According to the results of studies examining the relationship between mass media and body image, it is known that in most cases, body image-related media messages affect women's body image satisfaction and self-satisfaction (Myers and Biocca, 1992; Stice and Shaw, 1994; Harrison and Cantor, 1997; Turner et al., 1997).

Hypothesis 1-2

The perception of body image of CI female students will be closer to that of U.S. female college students.

The influence of education and teachers cannot be ignored. Jones et al. (2004) showed that internalization mediated the relationship between appearance conversations and body dissatisfaction for both boys and girls. In addition, internalization, appearance criticism, and BMI directly contributed to body dissatisfaction for both boys and girls. Therefore, the perception of body image of CI female students may be similar to that of U.S. female college students.

Hypothesis 2-1

The exercising time of CI female students will be similar to that of Korean female college students.

CI Korean students interact with their Korean family members every day. Therefore, Korean culture inevitably influences their lifestyle choices. Suppose culture inclusive of family environments has a prominent influence on the body image formation of CI female students. In that case, their exercise time may also be similar to that of Korean female college students.

Hypothesis 2-2

The exercising time of CI female students will be similar to that of U.S. female college students.

Since CI students spend a lot of time exercising and receive American education every day, their exercising time may be similar to that of U.S. college students. The need to consider more fully the contribution of experiences with peers to internalization and body image is especially crucial during adolescence when peer relationships play an increasingly prominent role in well-being and adjustment (Hartup, 1996). Table 1 displays the possible outcomes of our study.

Table 1. Sixteen possible outcomes

Outcome	H1-1	H1-2	H2-1	H2-2	Conclusion
1	Accept	Accept	Accept	Accept	Indeterminate
2	Accept	Accept	Accept	Reject	Exercising time similar to Korean
3	Accept	Accept	Reject	Accept	Exercising time similar to U.S.
4	Accept	Accept	Reject	Reject	Indeterminate
5	Accept	Reject	Accept	Accept	Body image similar to Korean
6	Accept	Reject	Accept	Reject	Body image and exercising time similar to Korean
7	Accept	Reject	Reject	Accept	Body image similar to Korean but exercising time similar to U.S.
8	Accept	Reject	Reject	Reject	Body image similar to Korean

9	Reject	Accept	Accept	Accept	Body image similar to U.S.
10	Reject	Accept	Accept	Reject	Body image similar to U.S. but exercising time similar to Korean
11	Reject	Accept	Reject	Accept	Body image and exercising time similar to U.S.
12	Reject	Accept	Reject	Reject	Body image similar to U.S. female
13	Reject	Reject	Accept	Accept	Indeterminate
14	Reject	Reject	Accept	Reject	Exercising time similar to Korean
15	Reject	Reject	Reject	Accept	Exercising time similar to U.S.
16	Reject	Reject	Reject	Reject	Indeterminate

2.2 Chi-Squared Test

The chi-squared test used in our study determines whether there is a statistically significant difference between the two groups' choices. Suppose the null hypothesis, which states that no statistical difference exists between two groups (e.g., male vs. female), is true. In that case, the test statistic computed from the observations across both gender groups follows the X^2 distribution. A higher chi-square statistic means a more significant difference between the two groups.

We can use p-values to determine whether the correlation is statistically significant. The confidence level is equivalent to (1 – the significance level). If the significance level is 0.01, the corresponding confidence level is 99%. The correlation is statistically significant if the p-value is less than the significance level.

To determine whether the two groups are similar, we compare the p-value to the significance level. If the null hypothesis is true, we expect the same proportion of data in each group regardless of the other. Having obtained the expected values, we compare them with the two groups' observed values. To do this, we calculate the chi-square statistic.

Let us explain with a more specific example.

We wish to know whether there is an association between becoming an ARMY (BTS fans) and the gender of the participants. For example, two groups of non-K-pop fans undergo two weeks of viewing a video of BTS every day. One group consists of 100 male participants, and the other consists of 90 female participants. After two weeks, we asked them whether they had become an ARMY. For males, 50 replied ‘Yes,’ and 50 replied ‘No,’ and for females, 70 replied ‘Yes,’ and 20 replied ‘No.’ We can display this data in a 2 × 2 contingency (frequency) table, shown in table 2.

We test the equivalent null hypothesis of (the proportion of eventual BTS fans in the male group = that in the female group) and (the proportion of eventual non-BTS fans in the male group = that in the female group). To test this hypothesis, we compare what to expect if the hypothesis were true with what we observed. We observed 120 out of the total 190 participants who became an ARMY (63%). Therefore, if there is no association between becoming an ARMY and the gender of the participants, we expect 63% of each gender group to become an ARMY:

63% of 100 = 63 males should become an ARMY, and

63% of 90 = 57 females should become an ARMY.

Table 2. Becoming a fan (observed)

Gender	Became an ARMY		
	Yes	No	Total
Male	50	50	100
Female	70	20	90
Total	120	70	190

We observed 70 out of the total 190 who did not become an ARMY (37%). Therefore, if there is no association between becoming an ARMY and the gender of the participants, we expect 37% of each gender group not to become an ARMY:

37% of 100 = 37 males should not become an ARMY, and 37% of 90 = 33 females should not become an ARMY.

We can draw the contingency table (table 3), where the figures are the expected frequencies.

Table 3. Becoming a fan (expected)

Gender	Became an ARMY		
	Yes	No	Total
Male	63	37	100
Female	57	33	90
Total	120	70	190

Having obtained these expected values, we compare them with what we observed. To do this, we calculate the X^2 statistic shown below.

$X^2 = \Sigma \text{ (Observed - Expected)}^2 / \text{ Expected}$ Eq. 1

Subtract each expected value from the corresponding observed value. Square this result, then divide by the corresponding expected value. Calculate this quantity for each cell in the table and find the sum. Thus, the value of X^2 is 15.33.

The *X2* statistic is small when the null hypothesis (no difference) is true since we calculate the expected values assuming the null hypothesis is true. The term (Observed - Expected) will be small if the observed data lies close to the expected data.

Since our chi-square statistic is 15.33, the p-value is less than 0.01. Therefore, we reject the null hypothesis. That is, there is a statistical difference between becoming an ARMY with respect to the gender of the participants.

2.3 Data Analysis

Chadwick International (CI) was founded in Songdo International City, Republic of Korea, in 2010. According to Mr. Hill, the Head of School, CI has 1400 students enrolled from PK to grade 12 as of 2022.

CI high school consists of 380 students, and 160 students are females. The high school has 59% Korean, 18% American, and 23% international students, according to the passports submitted during the application. Female students are 77% Korean, 16% American, and 7% international. The community is inclusive and welcoming. However, Korean students mainly engage with and speak Korean with each other. Also, some students, including myself, submitted American or international passports but have Korean parents and are fluent in Korean. Furthermore, the school celebrates Korean holidays. Therefore, school culture is considered more Korean, especially for Korean students.

On the other hand, school education is ever so American. The school schedules academic curriculum and semesters according to the U.S. academic calendar, and the faculty follows academic integrity guidelines based on the U.S. educational system. In addition, the school continuously educates equality and inclusion regarding race, gender, sexual orientation, personal interests, etc., via club recruitments and educational events.

The survey of this study was conducted through Google Forms in December 2021. Finally, 30 responses were found to be valid and were used in this study (table 4). Invalid responses are cases where the respondents are not Koreans nor females.

One of the critical variables of this study is education. Therefore, if the impact of education is significant, if the period of attending CI is short, the educational effect may be insufficient, and respondents' responses may be similar to those of Korean female college students. In the case of this study, 80% (24 out of 30) of the respondents had attended school for three years or more. Therefore, we judged that there was enough attending time for the effects of American education to occur.

Table 4. Descriptive statistics

Variables	N	Min	Max	Mean	Standard deviation
Grade	30	9	12	10.43	0.97
Duration at CI[®]	30	1	4	3.37	1.15
Body weight	30	0	2	0.47	0.57
Muscle	30	1	2	1.43	0.50
Body image	30	2	4	2.50	0.63
Image perceived by others	30	2	4	2.47	0.57
Hours of weight training[®]	30	1	3	1.73	0.98
Hours of cardiovascular activities[®]	30	1	5	3.33	1.29

[®]In this study, unlike Lee and Moon (2018)'s, which uses a continuous variable, for the convenience of the students (respondents) in answering the survey, the range of responses was determined, and the maximum value of the range was used as the variable value. For example, if the student selected '2-3 hours' as their exercising time, the variable value was entered as 3.

Since weight perception and body image are categorical variables, the average has no special meaning. In the table above, the continuous variable relates to hours of exercise. The exercise was divided into weight training and cardiovascular activities in the survey conducted. However, in this case, for the convenience of the respondents, the range of each option was given as well. Therefore, the meaning of the average was diluted.

3. Discussion

Although our study is an international comparison, Korean and U.S. female college students were not directly surveyed. Instead, data from Lee and Moon (2018) were used. An integrated display of the survey responses of our study and the data from Lee and Moon (2018) is shown in table 5 and 7.

The results of the chi square test using the table 5 are shown in table 6 below. In the case of Lee and Moon (2018), Korean and U.S. female college students responded differently to the three questions other than regarding their own body image. Our study found that CI students' responses to "I think I am very under-weighted" question were also similar to Korean and U.S. female college students as shown in table 6. Please refer to the appendix for more on detailed survey questions.

On the other hand, when looking at the first "I'm trying to Lose my weight" question, CI female students showed a statistically significant difference from Korean female college students at a significance level of 5%. The same results were demonstrated for the second "I'm trying to Lose my muscle mass" question. The interpretation of these results will be comprehensively explained with the exercising behaviors below (table 8).

Lastly, looking at other people's perception of their own body, CI female students differed from Korean female college students (5% significance level) as well as U.S. female college students (1% significance level) (table 6). Since this question seeks judgment based not on a respondent's perspective but on the culture in which the respondent belongs, it is natural for Korean female CI students to respond more similarly to Korean female college students. However, in the case of the CI sample, the fact that no student selected choice 1 (very under-weighted) or choice 2 (somewhat under-weighted) or both out of 5 choices for three questions, as shown in table 5, seems to have had an effect.

Table 5. Integrated survey responses: Categorical variables

Questions		Korea		CI		U.S.	
		N	%	N	%	N	%
I'm trying to	Lose my weight	149	77	17	57	74	60
	Maintain my weight	38	20	12	40	49	39
	Gain my weight	5	3	1	3	1	1
	Total	192	100	30	100	124	100
I'm trying to	Lose muscle mass	4	2	0	0	1	1
	Maintain muscle mass	64	33	17	57	61	46
	Build muscle mass	125	65	13	43	70	53
	Total	193	100	30	100	132	100
I think I am	Very underweight	1	1	0	0	0	0
	Somewhat underweight	14	7	0	0	8	6
	Normal	109	56	17	57	78	58
	Somewhat overweight	54	28	11	37	46	34
	Very overweight	16	8	2	6	3	2
	Total	194	100	30	100	135	100
Other people would see me as	Very underweight	6	3	0	0	1	1
	Somewhat underweight	35	18	0	0	15	11
	Normal	107	55	17	57	96	73
	Somewhat overweight	36	19	12	40	15	11
	Very overweight	10	5	1	3	5	4
	Total	194	100	30	100	132	100
Note: Reconstruction of table 1 from Lee and Moon (2018)							

Table 6. Chi-square test results

Questions	Hypothesis	Chi-square statistics	Conclusion
I'm trying to lose/maintain	CI = Korea	6.27**	Reject (5% significance

/gain my weight			level)
	CI = U.S.	1.22	Accept
I'm trying to lose/maintain/ build muscle mass	CI = Korea	6.49**	Reject (5% significance level)
	CI = U.S.	1.23	Accept
I think I am very underweight/ some-what underweight/normal/somewhat overweight/very overweight	CI = Korea	3.10	Accept
	CI = U.S.	3.43	Accept
Other people would see me as very underweight/ some-what underweight/normal/somewhat overweight/very overweight	CI = Korea	12.10**	Reject (5% significance level)
	CI = U.S.	16.58***	Reject (1% significance level)

*, **, *** denote significance at the 10, 5 and 1 percent level, respectively.

Table 7. Integrated survey responses: Numerical variables

	Korea		CI		U.S.	
Questions	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Weight training	0.8	1.8*	1.7**	0.9	1.5	1.8*
Cardiovascular activities	1.5	2.7*	3.3**	1.2	3.2	2.7*

*The research of Lee and Moon (2018) has no information on variance. Therefore, after assuming the same variance between the two groups; Korean and the U.S., the variance was calculated through inverse calculation of their t-statistic. This is a limitation of our research.

**In this study, unlike Lee and Moon (2018)'s, which uses a continuous variable, for the convenience of the students (respondents) in answering the survey, the range of responses was determined, and the maximum value of the range was used as the variable value. For example, if the student selected '2-3 hours' as their exercising time, the variable value was entered as 3.

Table 8. Hours of exercise t-test results

Questions	Hypothesis	t statistics	Conclusion
Weight training	CI = Korea	3.91***	Reject (1% significance level)
	CI = U.S.	0.99	Accept
Cardiovascular activities	CI = Korea	5.66***	Reject (1% significance level)
	CI = U.S.	0.28	Accept

*, **, *** denote significance at the 10, 5 and 1 percent level, respectively.

The test results showed that CI female students spent more time exercising than Korean college students. The results were similar to U.S. female college students. Combining this with the analysis of body image described earlier, CI female students were closer to U.S. college students in terms of their behaviors regarding weight and muscle. As a result, the exercise method and duration were similar with U.S. female college students. Overall, our results approach outcome 11 (table 1).

This study expands its scope by applying the theory of self-congruity (Litvin and Kar, 2004; Quester et al., 2000; Sung and Choi, 2012), which was limited to studies relating cultural factors with body image, on the study of the influence of education. Since CI female students had similar way of thinking with Korean female college students regarding others' perception of their appearance, this study supports that the body image presented by the media affects female students' ideal body image. However, since CI female students showed similar responses with U.S. female college students regarding their body image and exercising behaviors, the degree to which media exposure had little effect on value perception is interpreted as supporting the study of Lee and Moon (2018), which states that Korean and U.S. female college students have different criteria of evaluating their appearances. This, in turn, affects their exercising behaviors. This study has its academic significance in subdividing the scope of applying the theory of self-congruity by introducing the educational environment as an influencing variable of exercising behaviors.

Furthermore, although the general standards of beauty are similar worldwide, it is meaningful that this study empirically revealed the influence of culture on women's body image formation and that the educational environment affects the impact of body image on exercising behaviors. As pointed out by Jung and Lee (2006), this study is conducted by

applying the influence of education on the study of body image under collectivist culture. According to the results of our study, education has a significant impact on female students' body image formation. Therefore, this research suggests introducing education programs for healthy body image formation.

4. Conclusion

This study aims to examine the effects of culture and education on body image formation by separating the influence of culture and education on body image formation of Korean female students who attend an American high school that offers American education. The study also aims to shed light on the differences between the exercising behaviors of CI female students and Korean female college students in different educational environments and CI female students and U.S. female college students in two different cultural areas.

The results showed that CI female students showed similar perceptions with Korean female college students only regarding others' perception of their appearance and at the same time similar perceptions with U.S. female college students regarding their body image and exercising behaviors. In other words, it can be said that social and cultural communication related to appearance directly affects the behavior of teenage women but also indirectly affects the formation of social norms. The results of this study support that the cultural factor has different influences on how female students evaluate their body image, as stated in studies that apply the theory of self-congruity (Litvin and Kar, 2004; Quester et al., 2000; Sung and Choi, 2012). According to individualistic and collectivist cultures, cultural factors explain the causality of this difference, and western societies were considered to have a high tendency toward individualism (Markus and Kitayama, 1991). However, the results of our study differ from those of previous studies that point out that Korean female students are relatively dissatisfied with their appearance compared to U.S. female students (Park, 2000; Jung and Lee, 2006; Kim and Kim, 2007). We conclude that school education changes the students' body image as shown in our paper.

Another methodological uniqueness also deserves a note. We combine our data with those from previous literature. Our innovative hybrid method is helpful for researchers under research budget constraints. In short, our innovative hybrid approach is both cost efficient and purpose-rational.

The limitations of this study are as follows. First, the survey respondents for testing the hypotheses are limited to female high school students who attend an international school in Incheon, South Korea. We are not able to survey both female high school students in Korea and the U.S. Instead, we use the college students' data from Lee and Moon (2018). Also, there is a possibility that the influence of socio-cultural communication may work differently depending on age groups. For example, in the growing stage, adolescents are physically changing and psychologically sensitive. In this regard, it is necessary to pay attention to the interpretation of our study results.

Second, in our study, unlike Lee and Moon's, which uses a continuous variable, for the convenience of the students (respondents) in conducting the survey, the range of responses was asked, and the maximum value of the range was used as the variable value. As the survey was conducted online, meaningful research results could be derived; however, there is a possibility that the accuracy may decrease.

Third, the research of Lee and Moon (2018) has no information on variance. Therefore, after assuming the same variance between the two groups, the variance was calculated through inverse calculation from the t-statistic. In other words, there may be differences between the accurate results based on precise information on variance and the results of applying the variance calculated through inverse calculation of the t-statistic, which is directly related to the purpose of our study. Therefore, in the follow-up study, it is suggested to directly survey all respondents to calculate the accurate variance to analyze the groups accordingly and investigate the differences between them.

Lastly, this study investigates the influence of culture and education on body image formation and exercising behaviors. However, the study cannot

determine the types and aspects of educational environments that affect body image formation and exercise behaviors. Therefore, as a follow-up study, it is considered meaningful to investigate the causal relationships between education systems, body image formation, and exercise behaviors.

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Appendix

Questionnaire:

Part A. Demographic questions
Do you consider yourself a Korean female student?
I am in grade ?
How long have you been attending Chadwick International?

Part B. Body Image questions (5-point Likert scale)
At present, I'm trying to Lose my weight.
At present, I'm trying to Lose my muscle.
I think I am very under-weighted.
When looking at me, most other people would think I am very under-weighted.

Part C. Exercising behaviors (Numerical variable)
On average, how much time do you spend on weight training in a week?
On average, how much time do you spend on cardiovascular activities in a week?

null geodesics at the marginally anti-trapped surface generalizes the "flare-out" condition.

As was true in the static case, this generalized definition led to generalized conclusions regarding energy conditions. It was shown that dynamic wormholes have two throats, one for each direction of travel along them. For each of them, the NEC is either violated or on the verge of being violated (Hochberg and Visser, 1998).

At this point, it is clear that wormholes inevitably violate the NEC and, therefore, require exotic matter. However, the theorems which guarantee this violation do not address how much exotic matter is needed in such spacetimes. As mentioned in section 2.3, some quantum effects are known to generate small energy condition violations (for a more detailed study of known energy condition violations, see chapter 12.3 of Visser, 1995). In other words, if wormhole solutions require sufficiently small amounts of exotic matter, energy requirements may become less of an obstacle to the existence of such geometries. To find out how much exotic matter is needed to sustain traversable wormhole geometries, Visser, Kar, and Dadhich quantified the amount of ANEC-violating matter by using the integral $\oint(\rho - \tau)dV$, similar to the simplest formula for total mass, $\oint \rho dV$. When using this integral for a wormhole whose field only deviates from Schwarzschild in the region from the throat out to some radius a, they found lower and upper bounds to the ANEC integral (see energy condition 6 in section 1). As a result, they concluded that it is possible to construct traversable wormholes with arbitrarily small quantities of ANEC-violating matter by a choice of suitable a and $\phi(r)$ (Visser, et al., 2003).

3.3 Wormholes and Black Holes

Hayward also made significant contributions to the definition of wormholes. His approach was to study the relationship between black hole and wormhole geometries. He provided a general definition of black holes in terms of their trapping horizons (types of hypersurfaces foliated by marginal surfaces) and derived general laws of black hole dynamics (Hayward, 1994). This prompted the discovery of a unified first law of black hole dynamics and relativistic thermodynamics in spherically symmetric general relativity (Hayward, 1998b), followed by further contributions to black hole thermodynamics (Hayward, 1998a).

He then realized wormholes and black holes are very similar: in terms of local properties, both are defined by the presence of marginally trapped surfaces and may be defined by outer trapping horizons. For a static black hole, the event horizon is an outer trapping horizon, and for a static wormhole, the wormhole throat is a double outer trapping horizon. The difference is in the causal nature of the trapping horizons. As such, black holes and wormholes can be locally defined by outer trapping horizons that are respectively achronal (space-like or null) and temporal (time- like) (Hayward, 1999). In this framework, Hayward (2009) derived the laws of wormhole dynamics in spherical symmetry, analogous to the laws of black hole dynamics, and suggested a new area of wormhole thermodynamics.

Using the Callan-Giddings-Harvey-Strominger (CGHS) 2D dilaton gravity model (Callan, et al., 1992), Hayward (2002) provided examples of construction of wormholes from black holes (by irradiating a static black hole with a massless ghost Klein-Gordon field, one with a negative gravitational coupling) (Koyama and Hayward, 2004), operation of wormholes for transport or signaling (by demonstrating that the wormhole stays traversable for a long time when a small enough pulse is sent through it), maintenance of an operating wormhole (by preceding the pulse sent to demonstrate operation with one of equal and opposite energy, returning the wormhole to its initial state), and collapse of a wormhole to a black hole (by "switching off" the supporting ghost radiation from both sides of the wormhole). Black holes and wormholes are thus interconvertible, which can be understood in terms of changes in the causal nature of the geometry's outer trapping horizon. If one assumes the supply of a ghost field to be reasonable, Hayward's model makes the possibility of wormholes as technological tools more tangible by providing specific mathematical means for the use of such solutions. His idea of creating wormholes from black holes is particularly useful, since black holes are better known objects which have been proven to exist.

3.4 Stability and Assembly

One important aspect of traversable wormhole solutions not covered in the previous sections is wormhole stability (requirement 6). This is because numerical simulations that allow for a study of stability require formalisms that separate the Einstein field equations, and the reader is not expected to be familiar with such approaches. Here, the results obtained from using these techniques are summarized with the purpose of situating the reader in the current research scenario.

The 2+2 approach to general relativity (in which the gravitational field is decomposed with respect to two intersecting foliations of null surfaces) has been used to simulate a numerically stable static EBMT wormhole. The simulated wormhole was, however, unstable to perturbations (Hayward, 1993). More recently, the 3+1 formalism (in which spacetime is split into three-dimensional space and time) was used to demonstrate the dynamic instability of EBMT wormholes (González, et al., 2008), and analytic work has been done to explore linear instability of dynamical wormholes (Bronnikov, et al., 2012). Overall, most results show that potentially traversable wormholes are unstable. This adds to the lack of plausibility of such solutions, previously pointed out due to their energetic requirements (section 2.3).

Wormhole assembly (requirement 7) was, like stability, unapproached in previous sections. This is because little is known about potential wormhole assembly mechanisms. To create a shortcut between two regions of space, the topology of spacetime would have to be altered, which is likely impossible. Therefore, one would need to find an existing wormhole and fit it to their needs. One way this could be accomplished is through the spacetime foam, the quantum fluctuation of spacetime on small scales due to quantum mechanics (Wheeler, 1955). Small wormholes could form and vanish due to these fluctuations in a fraction of a second. Advanced civilizations could somehow amplify one of them and stabilize it with exotic matter. It is worth noting that even if microscopic wormholes did form due to quantum fluctuations, physicists do not yet know any possible mechanisms for amplifying them. As mentioned in the previous section, mechanisms for creating wormholes from black holes have also been proposed. The problem then becomes, once again, the need for exotic matter.

3.5 Rotating Wormholes

Non-EBMT wormholes have also been proposed and studied, with a big focus on generalizing Morris and Thorne's work to stationary, rotating, axially symmetric wormholes. In 1998, Teo constructed the stationary and axially symmetric generalization of the EBMT wormhole by following the same method as Morris and Thorne did in their article: finding the most general metric with the desired symmetries and examining the conditions under which it would describe a traversable wormhole. The general metric for a stationary, axisymmetric spacetime is

$$ds^2 = -N^2dt^2 + e^u dr^2 + r^2K^2[d\theta^2 + sin^2\theta(d\varphi - \omega dt)^2] \quad (29)$$

and the general metric for a traversable wormhole with such symmetries, which he obtained after imposing the flare- out condition at the throat and traversability requirements 1 and 2, is

$$ds^2 = -N^2dt^2 + (1 - \tfrac{b}{r})^{-1}dr^2 + r^2K^2[d\theta^2 + sin^2\theta(d\varphi - \omega dt)^2] \quad (30)$$

where N, b, K and ω are functions of r and θ. Here, N is the analog of the redshift function ϕ in Equation 2 (in the limit of zero rotation and spherical symmetry, it reduces to $e^{\phi(r)}$). It must be finite and nonzero to avoid horizons and curvature singularities. As in the static case, b is the shape function which obeys $b \leq r$. At the throat, it must be independent of θ to avoid curvature singularities and satisfy the flare-out condition. It is important to note that by imposing the flare-out condition, Teo arrived at Equation 21, which, as it did in the static case, leads to the necessity of exotic matter. In the metric above, K determines the proper radial distance and ω controls the angular velocity of the wormhole.

Teo's work showed that stationary, axisymmetric wormholes violate the null energy condition. However, it did not consider what type of matter could generate this geometry. To address this,

Bergliaffa and Hibberd (2000) showed that the metric in Equation 29 can only be generated by a fluid with a nonzero stress tensor if two additional conditions restricting the Einstein tensor are met. They also show that neither a perfect fluid nor a fluid with anisotropic stresses could generate the wormhole whose metric is given in Equation 30.

Finally, in 2004, Kuhfittig generalized Teo's solution to a time-dependent rotating wormhole by assuming ω to be a function of r, θ, and t. His results showed that the magnitude of the angular velocity may have little effect on the weak energy condition violations of axisymmetric wormholes. However, increasing angular velocity makes these violations less severe for spherically symmetric solutions. He also found that the violation of the WEC by time-dependent axially symmetric wormholes is much less severe than the violations required by the EBMT wormhole. The radial tidal constraint (Equation 24) becomes easier to meet due to the rotation.

In general, efforts to generalize the EBMT wormhole to rotating solutions have been motivated by practical arguments: if an advanced civilization were to construct a wormhole, it would most likely be rotating and changing with time. All solutions studied so far have been found to inevitably violate the energy conditions.

3.6 Wormholes in beyond-GR Theories

Wormholes have been studied in the context of different gravity theories, like R^m gravity and string theory. The reader is not expected to be familiar with such theories, but advances related to these wormholes are mentioned here for the completeness of this Recent Progress section. Bronnikov, Konoplya, and Zhidenko studied the instabilities of AdS wormholes (Bronnikov, et al., 2012). Recently, Maldacena and collaborators have been constructing traversable wormholes with string theory-motivated arguments. Specifically, they have analyzed wormholes in nearly-AdS_2 gravity (Maldacena, et al., 2017), studied the formation of SYK wormholes (Maldacena and Milekhin, 2020), proposed traversable wormholes within the Randall-Sundrum model (Maldacena and Milekhin, 2021), and proposed bra-ket wormholes (Chen, et al., 2021).

Traversable wormholes leading to causality violations are not allowed due to the achronal averaged null energy condition (a weaker version of the ANEC with no known violations) (Graham and Olum, 2007). However, sufficiently long wormholes (for which it takes longer to go through the wormhole than through the ambient space) could be supported by quantum effects. Maldacena, Milekhin, and Popov (Maldacena, et al., 2018) found an example of this by considering a solution which can be viewed as a pair of entangled black holes with an interaction term generated by the exchange of fermion fields responsible for generating a negative Casimir-like vacuum energy. The two black hole throats are joined to each other by a spacetime that looks like $AdS_2 \times S_2$, but in global coordinates. This solution is embedded in the Standard Model by making its overall size small compared to the electroweak scale. This discovery sparked new interest in wormholes within the theoretical physics community, since it is an example of a wormhole solution which causes no causality violations and is supported by a known quantum violation of the ANEC.

4. Conclusion

Despite the pedagogical value of wormhole geometries, the possibility of constructing them in the foreseeable future seems slim. Wormhole solutions found in general relativity have thus far been dynamically unstable and typically require large amounts of exotic matter to achieve static stability. Even though wormholes which either do not require exotic matter or can be supported by known energy condition violations have been proposed, they only exist in the context of beyond-GR theories of gravity.

The main reason to continue studying wormhole geometries is to better understand the limits of general relativity and energy conditions. Wormhole research has led to interesting developments in numerical relativity (Hayward, 1993), research on hyperfast travel (Krasnikov, 1998), and research on energy condition violations (Kar, et al., 2004), including the quantum inequalities (Ford and Roman, 1978).

In light of the mathematical connections between wormhole and black hole geometries, one might hope

that wormholes could someday become as observationally justified as black holes. However, there is an important physical distinction to keep in mind. Black holes were predictions from general relativity resulting from natural stress-energy tensors, meaning that the conditions under which a black hole can spontaneously form are not hard to find in nature. On the other hand, traversable wormholes are "reverse-engineered" solutions: some requirements are listed which the desired solution must satisfy; a metric is found which satisfies those conditions; and the stress-energy required to form such a geometry is computed, leading to the realization that the required material has never been observed or predicted in sufficient amounts. Therefore, wormholes remain a theoretical exercise for the time being, except in the realm of science fiction.

While it is certainly possible for unexpected technological advances to change this current scenario, a theorist who is interested in predicting observable results might take a different approach to wormhole research. Equipped with the rigorous definitions of wormhole geometry discussed here, rather than attempting to construct a geometry obeying traversability requirements, one might instead ask the question: what is the most physically realistic scenario in which there is a chance of detecting a region of spacetime obeying the flare-out condition of a wormhole throat? This could help develop constraints on the energy scales of naturally occurring wormholes, if they exist. In other words, one might shift the focus from finding traversable wormhole solutions to investigating the most plausible wormhole solution and its potential observable consequences, even if it is non-traversable.

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The Overlap of Brand Community and Word of Mouth

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Abstract

Brand community, groups of people formed and centered around the brand's consumption, is not a new concept to brands and researchers. For decades, companies have attempted to establish and strengthen brand communities to bring greater benefits for both businesses and consumers. This review paper will compile previous research on the impact of brand community on customer-brand relationships. The effects of social media and word of mouth on brand community will also be covered in this literature. Furthermore, there will be propositions on the influence of word of mouth on brand community development, which will be illustrated through the comparison and analysis of companies Amazon and Shopee–a leading e-commerce platform in Vietnam. This manuscript will provide valuable resources for companies, especially in developing economies, on how to generate brand loyalty, brand trust, and customer engagement. It will also serve as a foundation for future research on the overlap of brand community and word of mouth.

Keywords: brand community, word of mouth, customer-brand relationships, e-commerce, targeted messaging, interdependent self-construal

1. Introduction

Characterized by a sense of togetherness and belonging, community describes a group of people sharing similarities and practices (Muniz, et al., 2001). Although community is a familiar social concept that has existed in humanity since time immemorial, brand community was not recognized or extensively researched until 2001 (Muniz, et al., 2001). For the last several decades, companies have created communities to increase brand loyalty and strengthen customer-brand relationships (Kaur, et al., 2020). Before social media existed, companies built brand communities primarily through community events such as the Harley Davidson Posse Ride and Camp Jeep. Brand communities in the past were largely offline, however, for the past 15 years, social media has gathered people together, transforming brand community from a geographical concept to a "shared identity" (Muniz, et al., 2001; Gruzd and Haythornthwaite, 2013). By harnessing social media, brands can leverage this "shared identity" to create much stronger communities.

This review paper will reacquaint consumer researchers with the intersection of brand community and social media and highlight word of mouth as the keystone in fostering strong customer relationships. Although research on brand community and on word of mouth individually is abundant, there is little research or literature review on the overlap of these two marketing topics. Companies can refer to this literature as a guide to building strong brand communities to boost customer loyalty and satisfaction. Future work can build upon this

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literature review to study the potential of word of mouth in building brand community.

2. Brand Community

Brand community describes a group of customers with emotional attachment and long-term interest in a brand (Muniz, et al., 2001). Since it was first brought to academic attention in 2001, brand community has been considered a prominent method to foster strong customer-brand relationships (Muniz, et al., 2001; Cova, et al., 2006; Habibi, et al., 2014; Schouten, et al., 2007). The strength of a brand community relies on its customer engagement. (Schau, et al., 2009). As customers engage and form relationships in the brand community, they develop a stronger connection to the brands, therefore making them more loyal (Stokburger-Sauer, et al., 2013). Their interaction is largely based on the need to exchange information and is therefore voluntary, which reduces the need for continuous enforcement from companies to maintain the brand communities (Brodie, et al., 2013).

Researchers have shown that brand community offers great benefits to brands by creating good customer-brand relationships (Jang, et al., 2008; Hur, et al., 2011; Brodie, et al., 2013; Habibi, et al., 2014). For instance, customers with higher levels of community engagement have greater brand trust (Habibi, et al., 2014). Brand community also makes customers emotionally invested in the brand, which substantially enhances brand loyalty (Brodie, et al., 2013; McAlexander, et al., 2002; Stokberger-Sauer, et al., 2013). Customers with previously weak bonds with brands are found to develop higher brand satisfaction after having brand community experience (McAlexander, et al., 2002). These increases in brand trust, loyalty, and satisfaction demonstrate strong relationships with both returning and new customers and overall highlight the advantages of brand community (Jang, et al., 2008; Hur, et al., 2011).

There are two major branches of research on brand community: online brand community and offline brand community. While both forms of community share certain characteristics such as voluntary consumer engagement and the spread of information resources, the place in which the community occurs influences the characteristics of each group.

2.1 Offline Brand Communities

Offline brand communities maintain customer engagement and community commitment through in-person brandfests and activities (Muniz, et al., 2001). Despite the ubiquity of social media, offline brand communities still play a crucial role in attracting customers with weak brand identification and boosting brand satisfaction (McAlexander, et al., 2002). This is because offline events allow members to network, gain brand experience, and exchange information in person (Hur, et al., 2011). One example of offline events is brandfest, a social gathering where customers can engage with brands and products. Camp Jeep, for example, allows customers to experience different car models and gain useful insight into their vehicles through the "Jeep 101" course. By providing consumers with valuable information, Jeep brings customers a sense of support that makes them more connected and loyal to the brand (McAlexander, et al., 2002). The ability to engage with other Jeep customers and enjoy brand experiences at the event also strengthens customer-brand identification–the main driver of brand trust and brand advocacy (Stokburger-Sauer, et al., 2013). Another notable example of offline brandfests is the Harley-Davidson cross-country rally that increased community kinship from 79% to 83% (Fournier, et al., 2000). These examples demonstrate a key point that customer engagement is important to the success of offline brand communities (Schau, et al., 2009). Compared to online events, offline brandfests still offer some advantages such as in-person product experience and face-to-face interaction. Overall, offline brand communities are fundamental to the relationships between brands and customers for the genuine and personal experience they provide.

2.2 Online Brand Communities

Online brand communities utilize virtual platforms to allow customers to interact and exchange information (Jang, et al., 2008). With technology, online brand communities exist almost

everywhere: forums, websites, social media, etc (Laroche, et al., 2012). While online communities do not allow for face-to-face interaction, there are various ways to create customer engagement virtually. One example is community Q&A, where members engage by asking and answering inquiries. The act of inquiring and responding forges a sense of support among members that brings brand warmth to the community (McAlexander, et al., 2002). As brand warmth is one of the five drivers of customer-brand identification, such interaction can strengthen brand communities and enhance brand loyalty (Stokburger-Sauer, et al., 2013). The example of community Q&A also indicates that online brand community still provides customers the means to connect and engage like offline communities do (Stokburger-Sauer, et al., 2013). Member engagement in online communities is most effective when done out of voluntarism rather than rewards, which suggests that a strong virtual community should be driven by consumers' need for information rather than the need for benefits (Hur, et al., 2011; Brodie, et al., 2013). Overall, virtual communities exhibit several similar characteristics to an offline community such as voluntary engagement and information inquiry. However, offline communities offer direct brand experience and stronger connections through in-person interaction, while online communities allow for broader social networks and easier ways to share information.

3. Word of Mouth

Word of mouth is the spread of information from one person to another through daily dialogues (Berger, 2016). What differentiates word of mouth from paid advertising is the difference in how information travels. With word of mouth, individuals willingly pass on information, whereas information is forced into people's lives in paid advertising (Berger, 2016). Some examples of word of mouth include referral codes, product reviews, or customer experience (Sun, et al., 2006). As information distribution is a way brand community members interact, word of mouth is fundamental to creating customer engagement, especially in online brand communities (Brown, et al., 2007). To understand how word of mouth facilitates brand community, it is important to examine different word of mouth strategies.

One of the crucial elements for generating word of mouth is emotions. High-arousal emotions, such as fear and anger, are more successful at prompting people to pass on information (Berger and Milkman, 2012). Flash sales are a notable example. The announcement of flash sales often provokes fear of missing out on customers due to the short duration of sales (Przybylski, et al., 2013). This prompts customers to take action immediately, which includes spreading information on flash sales, raising brand awareness, and generating customer engagement.

Practicality is another element that contributes to word of mouth. There are numerous examples of practical values. Receiving discounts for every successful referral is a practical value. Useful tips and tricks in how-to articles are practical values. Practicality incentivizes the spread of information as people desire to appear helpful to others (Berger, 2016). Likewise, the voluntary act of sharing helpful information like discount codes in brand communities also stems from people's desire to be helpful members of the communities. This spread of information ultimately increases brand awareness and facilitates customer engagement. The two examples of emotions and practical value above illustrate how brands can use word of mouth to raise brand awareness and build active virtual brand communities.

In terms of impact, word of mouth remarkably surpasses traditional advertising (Buttle, 1998; Chevalier and Mayzlin, 2016). It is nine times more effective than advertising in influencing customer purchase behavior (Buttle, 1998). This is because word of mouth provides trust–people are more likely to consider recommendations from their close networks rather than their acquaintances (Brown and Reingen, 1987). Word of mouth is also more cost-efficient than traditional advertising. The willingness of people to pass on information reduces the cost and efforts of dispersing information for businesses. Lastly, word of mouth causes people to engage with each other, such as by sharing discount codes, which fosters community engagement and kinship. Since customer engagement results in greater

brand trust, brand loyalty, and brand satisfaction, brands should utilize the overlap of word of mouth and brand community to build stronger customer relationships (Habibi, et al., 2014; Chevalier and Mayzlin, 2006).

4. Overlap of Brand Community and Word of Mouth

The above example of sharing discount codes in brand communities is one illustration of how word of mouth can foster close customer-customer relationships that develop community kinship. Brands should leverage the influence of word of mouth to create similar experiences to benefit their communities. Another way to do so is through user-generated stories, such as customer reviews. Stories distribute and reinforce information much more effectively than facts and figures do (Berger, 2016). The sharing of customer experience among members passes on brand information, such as brand values or product recommendations, that can further strengthen customer-brand relationships and influence purchase decisions. Since word of mouth occurs both online and offline, it gives brands the flexibility to promote customer engagement in their communities. Companies that are developing online brand communities should highly consider word of mouth as a method to establish an engaging community. Besides practicality, emotions, and stories, there are other factors that can maximize the effectiveness of word of mouth in brand community, which will be discussed in the next section.

4.1 Guidance for Using Word of Mouth in Brand Communities

Companies often grapple with the type of message they send to consumers, especially whether to use targeted or more general messages. While mass messaging is more affordable due to its versatility, targeted messaging is more appealing to a specific audience. As different customers hold different opinions and beliefs, non-targeted ads may create conflicts in the messages delivered and thus decrease their effectiveness (Farahat and Bailey, 2012). However, having multiple targeted ads for multiple demographics is not any better as it can cause confusion and damage to the brand image. Instead, identifying with a niche group will help brands craft consistent and specific messages that allow customers to identify with the brands and make the brands seem more trustworthy. Since customer-brand identification is one valuable benefit of brand community, it suggests that targeted messaging is significant to brand community development. Additionally, people tend to develop stronger ties with individuals with similar interests, beliefs, backgrounds, etc (Brown and Reingen, 1987). Having a specific message catered to a specific group will increase the propensity of sharing in that circle. Therefore, companies that utilize targeted messaging to generate word-of-mouth conversations can more effectively build brand communities with higher customer engagement levels. Formally:

P1: Targeted advertising increases the effectiveness of word of mouth in building a strong brand community.

Of the characteristics that differentiate people, their self-perceptions as independent from or interdependent with others are gaining increasing research focus. Independence is the focus on oneself, while interdependence is one's consciousness of other people. Interdependent individuals often hold a collectivist mindset, which emphasizes the group's needs and goals over individual desires. The difference between these two construal types can be perceived through group interaction, where independent individuals act on their own needs and interdependent individuals are more attuned to the needs of others. The greater consciousness of their group identity causes interdependent people to feel more obliged to assist others in group settings, whether by sharing useful information, referral codes, or customer experience in brand communities. This sense of kinship among interdependent-oriented people allows for more community engagement, which is what forms strong brand communities (Steffes and Burgee, 2009; Xu-Priour, et al., 2014). Formally:

P2: People with interdependent construal are easier to

establish brand communities and generate word of mouth.

4.2 Illustrating Propositions Through Amazon and Shopee

Amazon and Shopee are two e-commerce companies that provide sellers and buyers the virtual platforms to connect and exchange. Founded in 1994, Amazon is the world's biggest online retailer with 2.4 billion monthly visits. On the other hand, Shopee only gains 70 million visits each month. The platform has only existed in Vietnam for 5 years (to Amazon's 27). By building a brand community on social media, Shopee was able to dominate the e- commerce sector of Vietnam within 4 years. And by having monthly flash sales, Shopee is able to encourage customers to frequently engage in word of mouth by sharing discount codes. These flash sales are also the online brandfests for customers to interact and network in order to strengthen the community. Meanwhile, Amazon attempted to build a diverse brand community through the Amazon Influencer Program, which gathers influencers from different fields to share recommendations on Amazon products on social media.

However, as Amazon utilizes the reach of influencers to raise brand awareness, it also creates confusion about its brand image as influencers in different fields–such as beauty, health and fitness, and technology–appeal to different demographics, which hinders Amazon from appealing to the customers in the most genuine way. On the other hand, by forming a brand community for Vietnamese people, Shopee is able to create a more close-knit community. Their success in building brand community is reflected through the many community groups on Facebook that are created solely for sharing Shopee promo codes, with one up to 300,000 members and 630 posts a day. Meanwhile, the average review rate on Amazon is 1-2%, meaning that there are only 1 to 2 reviews for every 100 orders. This low review rate indicates little customer engagement in the Amazon brand community. As the biggest retailer, Amazon should face little difficulty in building a strong brand community, but the comparison above shows otherwise. Shopee, despite existing for only 5 years, has a much more active community.

There are several reasons for the low customer engagement in the Amazon community. The first reason is the target audience. Operating in a country where online shopping is most popular among young adults, Shopee mainly serves people from 18 to 30 years old. Meanwhile, Amazon targets multiple age groups, from teenagers to old-aged adults. Though Shopee seems to be at the disadvantage of having a smaller set of customers, it actually benefits the company in targeted messaging. As illustrated in the first proposition, in which targeted messaging enhances the effectiveness of word of mouth, the single group that Shopee caters to helps the company generate greater word of mouth, resulting in greater customer engagement in its brand community. While Amazon serves the people in America, a culturally diverse country, Shopee serves the people in Vietnam, where they share the same language, culture, and ethnicity. The homogenous population in Vietnam allows for more word-of-mouth engagement and easier spread of information.

Lastly, Amazon and Shopee differ in the cultural values of the country they operate in. Cultures can differ in the extent to which they are interdependent. If Americans uphold an independent mindset, Asian countries like Vietnam are more interdependent and collectivist (Zhang and Neelankavil, 1997). Based on the second proposition, in which interdependent self-construal facilitates community development, the strong sense of togetherness in Vietnam allows Shopee to more easily build a strong brand community and encourage members to engage in word of mouth. Word of mouth is also particularly effective in attracting new customers as it creates brand visibility and brand awareness (Berger, 2016). In fact, research shows that accessibility and awareness are the two strongest factors influencing the performance of e-commerce platforms in Vietnam (Tran, 2019). This demonstrates that generating word of mouth on interdependent customers can be significantly advantageous for businesses, especially in e-commerce.

5. Discussion

The literature review highlights brand community as a powerful tool to strengthen customer-brand

relationships in order to generate greater values for businesses and consumers. This emphasis on brand community points out that after-sales service, such as brand education or brand experience, leads to higher customer retention and acquisition. The paper also underscores the relevance of word of mouth in brand community, where customer engagement is an essence of a successful brand community. Companies can leverage the influence of word of mouth to create more engagement in their communities. The propositions on targeted advertising and self-construal types advise brands to pay close attention to their customer demographics in order to create more effective marketing. Overall, the paper illustrates the profound impact of customer-brand relationships on customers' purchase decisions, which reinforces the great importance of customer service.

The review paper provides several suggestions on how brands can effectively build brand communities through word of mouth. Firstly, brands should define a target demographic to keep their core values and messages consistent. When brands align their images to the beliefs of their target audience, customers can identify more closely with the brands, thus resulting in greater brand loyalty. Secondly, the proposition on self-construal shows that businesses in interdependent countries should take advantage of the collective identity of interdependent people to encourage more customer engagement in brand communities. On the other hand, companies in independent nations like the US can consider interdependence priming as an alternative to build brand communities (Gardner, et al., 1999).

Since research on word of mouth and brand community is limited, it is crucial to advance the knowledge on the relationship between these two topics as a lynchpin to good customer-brand relationships. Researchers can also examine the influence of independent and interdependent self-construal on brand community. As self-construal is not strictly cultural, researchers should also study the effectiveness of interdependence priming in brand community development (Gardner, et al., 1999). Research on interdependence priming will help companies that target the American populations establish much more active brand communities.

6. Conclusion

The goal of this paper is to compile academic research on brand community and word of mouth and to highlight the potential of word of mouth in building brand community. By giving customers brand education and experience, brand community offers companies remarkable benefits such as increased customer trust, loyalty, and satisfaction. Since member engagement is fundamental to the strength and success of brand community, word of mouth can be utilized to foster interaction among community members. In addition, targeted advertising can increase word of mouth engagement, which is helpful to brand community development. It is also easier to form brand communities among interdependent-oriented individuals due to their collectivist mindset. The propositions on targeted advertising and self- construal types also explain why one company has a greater brand community presence than others. Future work should explore the relationship between brand community and word of mouth as well as self-construal to give businesses more suggestions for building good customer relationships.

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A Comprehensive Review of Dietary and Nutritional-based Therapeutic Approaches for ALS

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Abstract

Amyotrophic Lateral Sclerosis (ALS) is a fatal neurodegenerative disease that causes patients to progressively lose their motor function. This study reviewed research conducted on transgenic mice that have a human SOD1 transgene with mutations that replicate the physiological symptoms of ALS. One key approach that is used to extend the lifespan of ALS patients lies in nutritional and dietary management approaches, given that ALS patients tend to experience rapid weight loss and metabolic instability as the disease progresses. In this paper, the effects of the ketogenic diet and the Deanna Protocol are analyzed with regards to increases in mice motor performance and longevity. Transgenic mice put on the Deanna Protocol and mice on the ketogenic diet both experienced statistically significant increases in longevity and motor performance as compared to the baseline results of mice on a standard diet. While these results may seem promising, due to the nature of the differences between disease development and progression and the varying effects of the aforementioned diets between mice and humans, further research is still needed to conclude that the same diet-related benefits lie in human ALS patients as well.

Keywords: Neurodegenerative Diseases, Amyotrophic Lateral Sclerosis, Dietary Interventions, Transgenic Mice

1. Introduction

Neurodegenerative diseases, including Amyotrophic Lateral Sclerosis (ALS), have long been a focus of contemporary research. ALS is a neuromuscular disease that mainly affects upper and lower motor neurons responsible for controlling voluntary movements. Belonging to a broader group of motor neuron disorders, ALS is caused by the deterioration and death of motor neurons, which extend from the brain (upper motor neurons) to the spinal cord (lower motor neurons) and to muscles throughout the body. As they deteriorate, neural messaging from the brain to the muscles is severed, resulting in muscle weakening, atrophy, and twitching. Muscle weakness or stiffness are common early symptoms of ALS, and patients gradually lose the ability to speak, eat, move, and even breathe, as all voluntary muscles are affected. Patients subsequently experience muscle atrophy as the disease progresses as well as high metabolic rates, leading to rapid weight loss and eventual malnourishment.

To date, there are only two drugs approved by the

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U.S. Food and Drug Administration (FDA) for the treatment of ALS. The first of these drugs is Riluzole, sold under the brand name Rilutek. Riluzole was approved by the FDA in December 1995 and works to prevent the release of glutamate, which is one of the key causes of ALS when produced in excessive quantities. Based on several clinical studies, riluzole has been shown to decrease mortality rates and increase lifespans in some ALS patients. The second drug approved by the FDA to treat ALS is called edaravone, sold under the brand name Radicava. Edaravone is much more recent than riluzole, as it was approved by the FDA in May 2017, and it works to relieve oxidative stress that may cause motor neuron death.

However, as drug prices have remained high and accessibility to drugs has remained low, there has recently been a flurry of interest related to therapeutic, non-drug treatments for diseases like ALS (Morgan and Kennedy, 2010). About 5,000 people are diagnosed with ALS annually, with as many as 16,000 in the United States living with the disease at any given moment. The mean survival time after being diagnosed is three to five years, and there is currently no cure for the disease (Czaplinski, et al., 2006). Rather than addressing the underlying causes of ALS, current treatments generally serve to alleviate symptoms and increase patient longevity as much as possible with a focus on regulating patients' metabolic activity.

Studies show that the majority of ALS patients undergo metabolic changes, such as hypermetabolism, that lead to shorter survival and a faster functional decline (Steyn, et al., 2018). Hypermetabolism is defined as a significant increase in the body's metabolic activity. Although the origin of this metabolic dysfunction in ALS patients is unknown, research suggests that impaired mitochondrial function, present in motor neurons and muscles of these patients, may lead to the development of this condition (Muyderman and Chen, 2014). Due to the increase in resting energy expenditure caused by the shift in metabolic function, ALS patients have shown a decline in their body mass index (BMI). Not all ALS patients experience hypermetabolism; however, those who do tend to have a lower motor neuron score, indicating motor neuron degeneration, than ALS patients who are normo-metabolic (Ferri and Coccurello, 2017).

BMI is a measure of tissue mass based on height and weight, and individuals are classified as underweight, average weight, overweight, or obese. Studies have shown that individuals with lower BMIs have a higher risk of developing ALS. ALS patients generally have a very low BMI because they lose a significant amount of weight due to muscle atrophy from disuse and because they are generally unable to consume enough calories to maintain their weight. As such, a potential therapy to prolong the lifespan of ALS patients could be based on high-calorie diets and nutritional management in order to promote weight and metabolic stabilization (Dardiotis, et al., 2018).

Currently, there is no cure for ALS, and such nutritional-based therapeutic treatments would likely be used to improve ALS patients' quality of life and extend their lifespans rather than treating the disease itself and reversing its progression. This report will review the effectiveness of two existing nutritional-based approaches to treating ALS: the ketogenic diet and the Deanna Protocol.

The ketogenic diet consists of eating high-fat, low-carb foods, depriving the body of carbohydrates and forcing it to enter a simulated state of starvation in which the body uses fat to produce ketone bodies, which can be used for energy by cells (Swink, et al., 1997). The diet was originally created to treat childhood epilepsy in the early 20th century and its use continued for around two decades before antiepileptic drugs became popular and the use of the ketogenic diet declined (Wheless, 2008). However, in recent years, it has become increasingly popular and is being hailed as a potential treatment for a variety of other neurological conditions and disorders apart from epilepsy, including ALS.

While on the ketogenic diet, patients enter a state of ketogenesis, a biochemical process in which ketone bodies are produced that normally occurs during the night or when dieting/fasting. These ketone bodies are produced from fatty acids and amino acids that are broken down and then converted into acetyl-CoA through beta-oxidation. Ketone bodies are a form of energy used when the body is low on its supply of glucose. Ketones are produced

when the body burns fat for energy because it does not have enough readily available carbohydrates to fuel the body. Ketone bodies are produced primarily in the mitochondria of liver cells and, once produced, they are stored as fatty acids. Some examples of ketone bodies are acetone, acetoacetate, and beta-hydroxybutyrate.

Another dietary-based treatment option for ALS is the Deanna Protocol, a nutritional supplement that targets cell metabolism (ALSUntangled, 2013). Given that ALS is characterized by the death of motor neurons which can be attributed to an excess of glutamate, the Deanna Protocol consists of a multitude of supplements that work against glutamate excitotoxicity. The Deanna Protocol works to deliver AKG (arginine alpha-ketoglutarate) to cells, thus serving as an alternative energy source that the mitochondria can use to keep cells alive (Simplesa, 2018). Similar to the ketogenic diet, the Deanna Protocol does not work to cure ALS; rather, its goal is to improve patients' quality of life and increase their longevity.

This review will examine the effectiveness of the ketogenic diet and Deanna Protocol for ALS treatment, and it is anticipated that these diets will improve the quality of life and slow down motor neuron death of ALS patients, thereby increasing their lifespan.

2. Inclusion and Exclusion Criteria

The clinical studies analyzed in this review were carefully selected to ensure the collection of the most accurate and generalizable results. Generally, any studies that showed bias, did not focus on diet or nutrition, or had any confounding variables such as weight or drug treatments, were not included in this review. More stringent requirements were used for criteria like mouse type, where only studies analyzing two specific transgenic mouse strains (SOD1-G86R/G93A) to minimize inconsistencies caused by different strains of mice responding differently to treatments. Included below is a table detailing the inclusion and exclusion criteria used for this review.

Table 1. Inclusion/Exclusion Criteria

Inclusion	Exclusion
Mice Strain (SOD1-G86R/G93A) SOD1, a gene located on chromosome 21, was first implicated in the development of ALS in 1993. This was the first ALS gene to be identified and the G86R and G93A mutations of the SOD1 gene have been studied in transgenic mouse models (Pansarasa, et al., 2018). The SOD1-G86R and G93A mice are used to study neuromuscular disorders such as ALS because the mutation causes these mice to express neurodegenerative behaviors similar to those experienced by ALS patients (Matsumoto, et al., 2006).	Biases Studies with any form of bias that could have potentially impacted the collected data and results of the experiment(s) conducted were not included.
Mice Gender Male mice are primarily used and preferred over female mice in mice studies as it is a common perception that the hormonal cycle of the females may result in data variability (Smit, 2017). Similar to the menstrual cycle experienced by women, female mice undergo a similar process called the estrous cycle in which mice experience changes in hormonal concentrations. However, this dependence on male models unfairly affects the understanding of disorders and diseases in women. Since ALS affects both men and women equally, the hormonal	No or Minimal Mention of Diet/Nutrition Studies that did not have a focus on analyzing dietary/nutritional-based treatments were not included in this report.

differences in males and females are important to consider when evaluating the efficacy of potential treatments and future research conducted using mice models should not be restricted to male mice alone. (Rozenbaum, 2019).	
Survival Test For quantitative data, only research that kept track of and tested the longevity and mean survival of the mice on the different nutritional and dietary plans was included.	Additional Supplementation/Drugs Studies in which the transgenic mice were tested on any additional supplementation, drug treatment, or physical therapy regimen were not included.
Mice Age Younger mice were favored in the analyzed studies, and all mice were euthanized after the studies were completed.	Overweight/Underweight Mice Studies analyzing overweight and underweight mice were not included in this review to ensure the accuracy of lifespan and metabolism-related measurements taken during the studies. However, such studies should be considered carefully in future reviews, as potential treatments may impact patients of different body types in different ways.
Recency of Studies For the most relevant and up-to-date information and data, only clinical studies conducted after 2003 were included in this report.	

3. Results

In the first study, conducted by researchers at the University of South Florida, 48 male SOD1-G93A mutant transgenic mice were used to test the effects of Deanna Protocol-based and ketogenic diets on disease progression. As stated earlier in the inclusion/exclusion criteria, only male mice were used to minimize data variability due to periodic hormonal concentration shifts in female mice. In this study, four main groups were being analyzed: a control group (mice on the standard diet), mice on the ketogenic diet, mice on Deanna Protocol-based supplements, and mice on the ketogenic diet with Deanna Protocol-based supplements. Motor function was assessed using the tests listed in the table below, and food consumption, weight, and age were all noted throughout the course of the experiment.

In this experiment, survival lengths of all three groups were longer than that of the control group, demonstrating that both the ketogenic diet and the Deanna Protocol have positive effects on lifespan extension. Using the quantitative data included with the study, a relative risk value of 7.03 was calculated between mice on the ketogenic diet with Deanna Protocol-based supplements and mice on the standard diet.

Table 2. Authors and Demographics for Study 1

Authors	Demographics
Ari, et al., 2014	14 B6SJL-Tg (SOD1-G93A) mutant transgenic mice from the Jackson Laboratory. Food consumption and body weight monitored 3 times a week. Animals were received at 9 weeks of age, while treatment and a one-week training period began at 10 weeks of age. Experimental period started at 11 weeks of age from when tests were performed weekly until animals were euthanized. Groups: Standard Diet (SD; Control, n=13); SD+DP (n=12); Ketogenic Diet (KD, n=11); or KD+DP (n=12). Accelerating Rotarod Test, Grip Test, Hanging Wire Test performed once weekly to assess motor function.

This relative risk value represents the ratio of the probability of mice on the Deanna Protocol combined with the ketogenic diet living longer than the baseline age of 125 days versus the probability of mice on the standard diet without any additional treatments living longer than 125 days. Similarly, a relative risk value of 8.07 was calculated between mice on the standard diet with Deanna Protocol-based supplements and mice on the standard diet, suggesting that Deanna Protocol-based supplements may have a more beneficial effect on patients when combined with a standard diet as opposed to the ketogenic diet, which had a calculated relative risk value of 4.00 when compared with the standard diet.

In the second study, conducted at the Université Louis Pasteur, the effects of a high-fat diet (modeled after the ketogenic diet) compared to a standard diet was tested using transgenic male mice with the G86R murine SOD1 mutation (Dupuis, et al., 2004). The high-fat diet consisted of regular chow, which is a high fiber diet with many complex carbohydrates and fats from a variety of vegetables, supplemented with 21% butterfat and 0.15% cholesterol (Warden and Fisler, 2008). Every ten days, body mass was recorded, and every five days, food intake was recorded. Once the mice could no longer roll over after ten seconds of being pushed to their side, they were euthanized and their time of death was recorded. Following euthanasia, the body composition of the mice was measured and analyzed.

The results of this study demonstrated that the high-fat diet was correlated with a 20% extension of the mean survival of the mice. Additionally, mice on the high-fat diet generally exhibited better motor performance than the control mice until their time of death. As predicted, the high-fat-fed G86R mice showed an increase in body mass and the retroperitoneal and epididymal fat pad mass. The study's findings suggest that in addition to improving metabolic status, a high-fat/ketogenic diet may also serve to enhance motor neuron function, allowing the mice to live longer while improving their quality of life.

In the third study, conducted at the Icahn School of Medicine at Mount Sinai, experiments were performed to test the effectiveness of the ketogenic diet as a novel therapeutic treatment for ALS. SOD1-G93A transgenic mice were tested in this study, with one group being fed standard laboratory food while the other was fed food according to the ketogenic diet (KD). This study measured motor performance, survival, and motor neuron count, while also tracking blood ketone levels to verify that the mice on the ketogenic diet had elevated blood ketone levels.

Table 3: Authors and Demographics for Study 2

Authors	Demographics
Dupuis, et al., 2004	Male SOD1-G86R mutant transgenic mice obtained from the animal facility at the Université Louis Pasteur. Male SOD1-G93A mutant transgenic mice obtained from The Jackson Laboratory. Body mass was recorded every 10 days, and food intake was measured every 5 days. Mice were isolated at 4 weeks of age, and the regimen began at 6 weeks of age. Body composition was measured by biochemical analysis of carcasses. Mice were killed when they could no longer roll over within 10 seconds of being pushed on their side, and this time point was used as the time of death.

Table 4: Authors and Demographics for Study 3

Authors	Demographics
Zhao, et al., 2006	SOD1-G93A transgenic mutant mice were used in this study. Experimental mice were fed according to the human ketogenic diet. Blood ketone levels were measured in the KD-fed mice to ensure that the diet was producing the intended effects in the experimental mice. Motor performance in mice was measured using the rotarod test.

In the KD-fed mice, blood ketones were more than 3.5 times higher than the control group, indicating that the diet was working as intended. Additionally, the KD mice lost half of their motor

performance 25 days later than the mice in the control group, suggesting that the ketogenic diet may be able to slow the degradation of motor performance. Throughout the study, weight was measured three times, but there was no significant difference in weight between the two groups of mice: the standard fed mice had a mean weight of 23.5 g compared to 24.6 g in the KD fed mice. At the conclusion of the study, motor neurons were counted in the lumbar spinal cord. The KD-fed mice had considerably more motor neurons in the ventral horn when compared to the control group (9.382 ± 1.125 vs. 6.826 ± 0.607; ($p = 0.03$)), suggesting that the ketogenic diet may have protective effects that serve to slow down motor neuron death. An increase in motor performance was also observed in the experimental mice: the last standard-fed mouse failed the rotarod benchmark cutoff score of 50% 25 days before the last KD-fed mouse failed to achieve the same cutoff score, indicating that increased motor performance may be associated with the ketogenic diet.

Table 5: Authors and Demographics for Study 4

Authors	Demographics
Ari, et al., 2017	30 male B6SJL-Tg (SOD1-G93A) mutant transgenic mice obtained from the Jackson Laboratory. Two experimental groups were used: LOW (88% standard diet, 12% Deanna Protocol supplements) and HIGH (79% standard diet, 21% Deanna Protocol supplements). Body weight of all mice was measured at the beginning of the study and the conclusion of the study. When the mice reached an age of 112 days, the neurological score, a scale of 0-4 measuring the motor ability of the mice's hind legs, of each mouse was calculated and they were subsequently euthanized. Postmortem metabolomic profiling was performed on all mice to determine metabolic differences between control and experimental mice that could be associated with the DP-based intervention.

In the fourth and final study, conducted at the University of South Florida, the effects of the Deanna Protocol on 30 SOD1-G93A transgenic mice were analyzed. The control group was fed standard rodent chow (6.2% fat, 18.6% protein, 75.2% carbohydrate), while the experimental group was divided into two subgroups: LOW and HIGH, corresponding to the size of the dose of Deanna Protocol supplements each group was given. The LOW group was fed the standard diet with 12% consisting of Deanna Protocol supplements by weight, while the HIGH group was fed the standard diet with 21% consisting of Deanna Protocol supplements. At the end of the study, the body weight and neurological score (described in the table below) of all mice was recorded and analyzed.

This study affirmed the results of the other studies and concluded that a Deanna Protocol-based diet is associated with improved mitochondrial energy metabolism and influences the formation of specific metabolites that produce tangible benefits for motor function and performance. Ultimately, given that this study was able to identify the specific biochemicals and metabolites that responded to the Deanna Protocol, these outcomes serve to provide a more comprehensive understanding of potential metabolism-related therapeutic targets for future drug-based approaches for ALS treatment (Ari, et al., 2017).

4. Discussion

In this review, the effects of the ketogenic diet and the Deanna Protocol in the SOD1 mouse model were analyzed. While both seem to be worthwhile for further study, in particular, the effects of the Deanna Protocol are relatively difficult to study because most patients ingest dietary supplements and vitamins that may interfere with the study.

ALS patients frequently experience metabolic disruptions, and as a result, there is a need for treatments that have the ability to stabilize patients' metabolism and weight. Because the ketogenic diet is high in fat and low in carbohydrates, it mimics the effects of fasting and puts the body in a state of ketosis in which the body uses fat instead of carbohydrates for energy. During this process, the body produces ketone bodies from fat for use as an energy source, stabilizing insulin levels and

metabolic rate. The efficacy of several such approaches to ALS treatment is currently being tested.

The Deanna Protocol has a similar outcome as the ketogenic diet for ALS patients; however, the methodology is different. The Protocol consists of taking a cocktail of effective supplements that prevent glutamate excitotoxicity and mitochondrial dysfunction, both part of ALS pathology. The Deanna Protocol is a type of natural metabolic therapy that provides energy to dying nerve cells, thus preventing glutamate release and, therefore, muscular dystrophy. Although the supplementation portion of the Deanna Protocol is the critical component, the complete treatment includes exercise and massages. The Protocol has been studied in conjunction with the ketogenic diet, as examined in Study 1, supporting that the two treatments are complementary. While this review focused on the ketogenic diet and Deanna Protocol, further research should be conducted to determine the effectiveness of other existing therapeutic and nutritional-based treatments for ALS.

It is increasingly important to develop, research, and analyze therapeutic-based approaches to ALS treatment because of the lack of universally effective drug-based treatments, the high cost of purchasing the two available drug-based treatments, and the relatively lengthy process of obtaining FDA approval for new drugs. As mentioned earlier, currently, there are two drugs approved by the U.S. FDA for ALS treatment: namely, Radicava (edaravone) and Rilutek (riluzole). Edaravone produces a yearly cost of approximately $145,000 and corresponding treatment infusion sessions cost approximately $1,000, proving unaffordable for most, even with health insurance. A 1999 study measuring the cost-effectiveness of riluzole concluded that the lifetime survival gain was about 2.3 months per patient, with the incremental cost around $12,000, thus producing an annual cost of $62,609 (DiMasi, 2000). Although the study was performed in 1999, drug prices have risen substantially since then, making for an even more unfavorable cost-effectiveness ratio of riluzole versus care without riluzole. Usage of drugs such as riluzole and edaravone should not be considered the first resort because their effectiveness applies to a very limited subset of people and may result in several serious side effects, including contusions, gait disturbances, headaches, and unusual bleeding. As such, ALS patients often look towards dietary or nutritional-based treatment options to avoid the high risk and cost associated with the approved drugs that prove to be unaffordable for the majority of ALS patients. As new drugs continue to be developed to treat the causes of ALS, the availability of low-cost, easily accessible dietary interventions for the treatment of ALS must expand to help such patients.

5. Conclusion

Across the studies, diets based on both the Deanna Protocol and the ketogenic diet (and high-fat diets in general) were effective in increasing the motor neuron performance and lifespan of SOD1 transgenic mice. Treatments based on these diets could revolutionize the way in which medical professionals approach ALS treatment by allowing patients to decrease their dependence on costly drugs like riluzole and edaravone that are not universally effective in favor of less costly and more effective therapeutic, dietary-based approaches. However, while these results are promising, the studies reviewed focused on analyzing the efficacy of potential dietary therapeutics in transgenic mice, and in order to confirm that the same benefits lie in humans, further studies must be conducted on human patients. Larger-scale clinical trials should also be conducted to minimize potential errors arising from the relatively small sample sizes used in the reviewed studies and determine whether these benefits exist in larger populations as well. If proven to be effective in ALS patients, dietary-based treatments such as those described in this review could also be used to treat other neurological diseases whose mechanisms, development, and progression are similar to that of ALS.

Exercise has also been researched as a potential therapeutic approach to ALS. Studies have shown that mild and moderate endurance exercises have positive effects on ALS patients, while vigorous endurance exercises seem to have detrimental effects. When studied in mice, high-intensity endurance exercise significantly hastened the onset of motor neuron deterioration in male SOD1-G93A mice.

Swimming-based training usually delayed the onset of ALS in these mice, while running-based training in the same study showed no improvement (Tsitkanou et al., 2019). Even if there is evidence that supports the advantageous effects of exercise on ALS patients, it is likely not a sufficient intervention alone to significantly improve patients' quality of life and lengthen their lifespan, as repetitive physical activity can cause muscles to lose strength due to the overworked motor neurons. Often, pharmacological treatments for ALS need to be used alongside exercise. However, as these studies were tested on mice, they are not sufficient for drawing conclusions about the effect of exercise on human ALS patients. As such, further research is needed to conclude whether similar effects of exercise lie in human ALS patients as well.

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An Examination of the Friedmann Equations and Evolution of Universes

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Abstract

In this paper, we examine the Friedmann equations. The three types of solutions to the Friedmann equations are presented and studied. By analyzing a differential equation, the initial energy density corresponding to each type of solution is determined. Numerical solutions by computer algorithms are presented as examples. A 3D graph is created to illustrate the corresponding energy densities, and a formula is derived to determine if the end behavior of the universe falls under a specific category.

Keywords: Friedmann equations, Cosmology, Density Parameters

1. Introduction

The universe contains everything known to humanity, yet its real nature is still not thoroughly understood. With the current model, the basic structure of the universe in which the fundamental laws of physics are defined can be summarized as a combination of space and time, or space-time. As we will see later in the paper, certain measurable quantities are relative and can vary across reference frames, which are defined by the motion of the observer. The universe defined by space-time also contains various types of matter-energy densities, including ordinary and dark matter, radiation, and possibly dark energy.

When one takes a large scale, the universe has two basic properties: homogeneity and isotropy. A universe being homogeneous has no preferred location, and a universe being isotropic has no preferred direction. In other words, the universe is spatially symmetric on a large enough scale, no matter where you are and in which direction you look. These two properties allow the study of the universe, on a fundamental level, as a whole entity.

The spacetime itself also changes with time: the spatial dimension of the universe contracts or expands according to its current curvature and matter-energy composition. One should not confuse the change in space itself with objects moving towards or away from each other. To visualize the expansion of the universe, we can consider the 2D-surface of an inflating balloon: while points on the balloon don't move, the distance between them becomes larger. The expansion of the universe works in a similar way, except that the space is 3D. It is widely believed that our universe started in a "big bang" and expanded from a point, the singularity, to its current spatial dimension.

To mathematically describe the dynamics of the universe, the Friedmann equations were created based on Albert Einstein's theory of general relativity. Given the initial energy density and curvature of the universe, we can use the Friedmann equations to predict the size of the universe at a specific time.

The Friedmann equations were developed during the 1920s by Russian scientist Alexander Friedmann. However, in favor of the static model of the universe,

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Einstein originally commented that the Friedmann equations were merely a mathematical "curiosity". After Edwin Hubble concluded on the recession of distant galaxies that experience redshift, the Friedmann equations gained significant scientific importance and served as a tool to understand the evolution of our universe (Kay, n.d.). In this paper, I will solve the Friedmann equations in a fully general framework, predicting the evolution of universes, whether it be our own universe or other possible ones, under given initial conditions.

2. Background and Notations

2.1. The Scale Factor

The scale factor, denoted by $a(t)$, is a measure of the relative size of the spatial dimension of the universe. The time derivative of the scale factor, da/dt, represents the rate at which the universe contracts or expands. The relation between the scale factor and the space-time separation is given by:

$$\Delta s^2 = -c^2\Delta t^2 + a(t)(\Delta x^2 + \Delta y^2 + \Delta z^2) \qquad (1)$$

Here, Δs is the space-time separation, and Δt, Δx, Δy, Δz, represent respectively the separation in time component, and separation in spatial x, y, z direction. As shown, the $a(t)$ is a factor without units multiplied before the spatial dimension. As a factor without units is relative, the scale factor is not explicitly measurable. For simplicity, the scale factor is normalized to be one at the current moment ($a(t_{now})=1$).

2.2. Curvature

While the universe can expand or contract, its spatial dimension also has an intrinsic curvature. The curvature constant, κ, gives the sign of curvature. An isotropic and homogeneous universe can be positively curved ($\kappa = +1$), negatively curved ($\kappa = -1$) or flat ($\kappa = 0$). The radius of curvature R_0 represents how much the universe is curved. A flat universe resembles a plane in 3D while positive curvature corresponds to a sphere and negative curvature looks like a saddle.

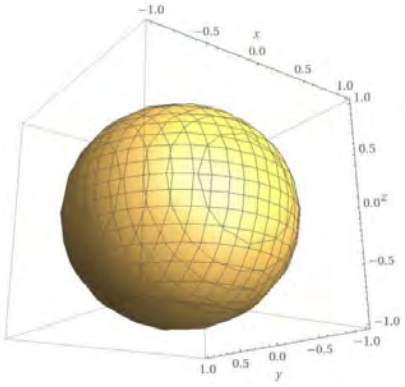

Figure 1. Positively curved 2D universe embedded in a 3D geometry ($\kappa = +1$).

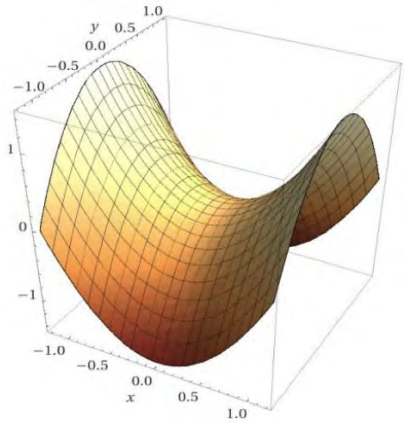

Figure 2. Negatively curved 2D universe embedded in a 3D geometry ($\kappa = -1$).

2.3. Energy Densities

The energy in the universe can be classified into three basic categories: baryonic matter, electromagnetic radiation, and the cosmological constant, the so-called dark energy. In a more general sense, the concept of baryonic matter can be extended to everything with mass moving at a much slower speed than light (non- relativistic). Electromagnetic radiation can include everything traveling at or near the speed of light (relativistic), such as neutrinos. These two energy components will be called 'matter' and 'radiation' in the remainder of this paper.

Mathematically, energy density, ϵ, is the amount of energy over a specific volume of space. Recall that by elementary thermodynamics, $P \times \Delta V$ = Work. Since $\epsilon = E/V$, there is a direct relationship between

pressure, P, and the energy density. Assuming $P = w\epsilon$, w be a constant for each of the substances mentioned above, one can determine the value of w through basic laws of physics.

Matter

From Einstein's mass energy law, the rest energy of a mass is $E = mc^2$. For low density gas particles that permeate most of the universe, $PV = NkT = \frac{1}{3}mv^2$. Substituting, $\epsilon = E/V = (3c^2/v^2)P$, so $w = \frac{v^2}{3c^2}$. Since matter is non-relativistic ($v << c$), $w_m = 0$.

Radiation

With the similar logic and intuition, since radiation is relativistic ($v \approx c$), so $w_r = 1/3$.

Cosmological Constant

The Cosmological constant is often denoted Λ. The discussion of the derivation energy density for cosmological constant is beyond the scope of this paper. We will take the
following two results:

1. $w_\Lambda = -1$
2. The energy density of the cosmological constant can be negative. That is, $\epsilon_\Lambda < 0$ exists, while such value is impossible for matter and radiation. A negative energy density of the cosmological constant, or dark energy, will "push" the universe apart and accelerate the expansion. Intuitively, one can think of dark energy as the opposite counterpart of gravity. A full derivation could be found in "Cosmological Constant" (Davis and Griffen, 2010). The total energy density will be the sum of energy from each component.

2.4. The Friedmann Equations

The Friedmann equation gives the relationship between rate of change of the scale factor and the universes' current composition:

$$H^2(t) \equiv \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3c^2}\epsilon(t) - \frac{\kappa c^3}{R_0 a^2(t)} \quad (2)$$

$a(t)$ is the scale factor. $\epsilon(t)$ is the energy density. G is the universal gravitational constant and c is the speed of light. κ is the curvature constant and R_0 is the radius of curvature. H is defined as the Hubble parameter.

In this equation, energy density becomes a variable as the spatial dimension of the universe changes. Therefore, to solve for $a(t)$, Another differential equation is needed to relate $a(t)$ and $\epsilon(t)$. The fluid equation, also called second Friedmann equation, serves this purpose:

$$\dot{\epsilon} + 3\frac{\dot{a}}{a}(\epsilon + P) = 0 \quad (3)$$

Where P denotes the pressure of the universe. As discussed above, $P = w\epsilon$, where the value of w varies across different types of energy.

$$\dot{\epsilon} + 3\frac{\dot{a}}{a}\epsilon(1 + w) = 0 \quad (4)$$

Integration with separation of variables gives

$$\epsilon(a) = \epsilon_0 a^{-3(1+w)} \quad (5)$$

Going back to the cosmological constant, since $w_\Lambda = -1$, the energy density of the cosmological constant is indeed a constant over scale factor.

2.5. Critical Density and the Density Parameter

Define the critical density at current time $\epsilon_{c,0}$ as the energy density necessary for the universe to be flat ($\kappa = 0$):

$$H_0^2 \equiv \frac{8\pi G}{3c^2}\epsilon_{c,0} \quad (6)$$

H_0, the Hubble constant, is unique for each universe and explicitly measurable. Since H_0 is constant in Friedmann's equation, if $\epsilon > \epsilon_c$, κ must be positive, which corresponds to a positive curvature. Similarly, $\epsilon < \epsilon_c$ implies a negatively curved universe.

To compare energy density with critical density, we use the density parameter to normalize the energy density. Define the density parameter, Ω_0, as the ratio of energy density to critical density.

$$\Omega_0 \equiv \frac{\epsilon_0}{\epsilon_{c,0}} \quad (7)$$

Based on the discussion above, $\Omega_0 < 1$ implies a negative curvature while $\Omega_0 > 1$ implies a positive curvature. Manipulating the above equation:

$$\Omega_0 = 1 + \frac{\kappa c^3}{R_0 H_0^2} \quad (8)$$

$$\frac{\kappa c^3}{R_0} = H_0^2(\Omega_0 - 1) \quad (9)$$

Considering result from equations 2, 5, and 9

$$H(a)^2 = H_0^2\left(\frac{\Omega_0}{a^{3+3w}} + \frac{1-\Omega_0}{a^2}\right) \quad (10)$$

2.6. The Final Equation to Solve

Like energy density, the density parameter is summed up by components. Therefore, substituting the values of w for each of the three types of energy into equation 10 will yield:

$$\frac{H^2}{H_0^2} = \frac{\Omega_{r,0}}{a^4} + \frac{\Omega_{m,0}}{a^3} + \Omega_{\Lambda,0} + \frac{1-\Omega_0}{a^2} \quad (11)$$

where $\Omega_{m,0}$, $\Omega_{r,0}$ and $\Omega_{\Lambda,0}$ represent the initial (t = 0) density parameters for matter, radiation, and cosmological constant.

$$\Omega_0 + \Omega_{r,0} + \Omega_{m,0} + \Omega_{\Lambda,0} \quad (12)$$

Recall that H = $\frac{\dot{a}}{a}$ and H_0 is a constant. Thus, the equation is simplified to a first order differential equation. The equation relates da/dt, the rate of expansion, with $a(t)$, the current spatial dimension. Also note that different energy compositions, $\Omega_{m,0}$, $\Omega_{r,0}$ and $\Omega_{\Lambda,0}$, are multiplied to different powers of $a(t)$ and thus contribute to the expansion of the universe at different degrees. Changing the initial density parameters will generate universes with drastically different end behaviors.

At a very small value of $a(t)$, $\Omega_{r,0}$ will dominate the left-hand side, making radiation the biggest factor in the early stages of the universe. As $a(t)$ increases, the mass term dominates. When $a(t)$ becomes large enough, the cosmological constant term will dominate and determine the evolution of the late universe. As we will see later in the paper, knowing the cosmological constant and curvature (Ω_0) allows one to completely predict the end behavior of the universe.

2.7. Possible End Behaviors of Universes

Transforming equation 11

$$\left(\frac{da}{dt}\right)^2 = H_0^2\left(\frac{\Omega_{r,0}}{a^2} + \frac{\Omega_{m,0}}{a} + \Omega_{\Lambda,0}a^2 + 1 - \Omega_0\right) \quad (13)$$

First, to keep the function in real space, the left side of equation 13 must not be negative, and because of the nature of squares, there can be two solutions of different signs. For certain values of the density parameters, the left side is positive for all positive values of $a(t)$ (scale factor is always positive). In such cases, one can safely take the positive value of da/dt without running outside the domain. Thus, da/dt remains positive, and the universe will expand forever. We call this case the *Big Chill,* and an example of its dynamics is shown in Fig. 4. In the figure below and the set of graphs that follows, we explicitly and arbitrarily choose the parameters to illustrate each type of universe.

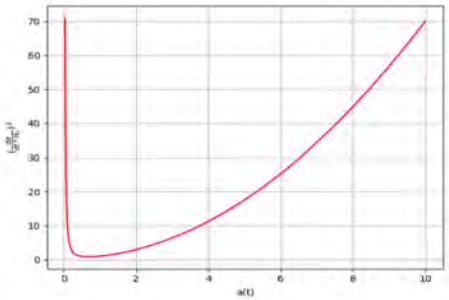

Figure 3. The function shown in this series of graphs is obtained from equation 13 by dividing over H_0^2.The numbers in this specific graph were arbitrarily chosen to illustrate a Big Chill Universe ($\Omega_{r,0}$=*0.08*, $\Omega_{m,0}$=*0.2* and $\Omega_{\Lambda,0}$=*0.7*). Asdiscussed, roots in $(da/dt)^2$ marks the time when the universe contract to avoid imaginaries. For the number chosen, the equation has no positive root, implying a never-ending fate of expansion.

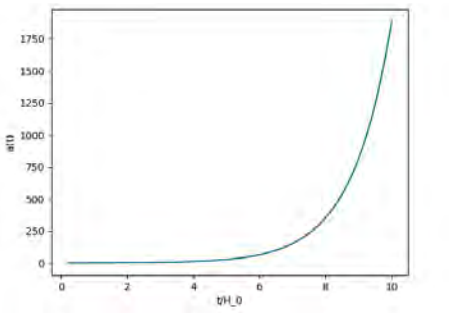

Figure 4. The change in scale factor over time corresponding to the Big Chill universe shown in figure 3. H_0 is the Hubble time, a big number used to normalize time. ($H_0 \approx 1.4\times10^{10}$ years). Here, the universe expands to approximately 1800 times its original dimension and will continue to expand with increasing speed.

If the left side equation is only positive for small values of a, the equation will be imaginary beyond a critical scale factor, at which the left side is zero. Thus, the universe must contract once it reaches such a critical scale factor, and we do this mathematically by taking the negative square root solution. In this case, the universe expands to a maximum spatial dimension and contracts back to a singularity, which is given the name *Big Crunch*.

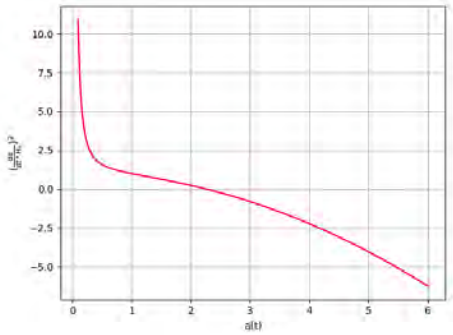

Figure 5. The graph of a Big Crunch universe. As shown, the function is negative for big scale factors. When the scale factor reaches approximately 2.2, the root where $(da/dt)^2$ turns negative, the universe must start to contract, taking the negative solution of da/dt.The density parameters in this specific graph were arbitrarily chosen to illustrate a Big Crunch Universe. ($\Omega_{r,0}= 0.08$, $\Omega_{m,0}= 0.2$, $\Omega_{\Lambda,0}= -0.2$)

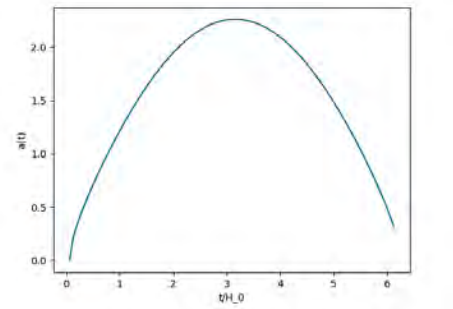

Figure 6. The change in scale factor over time corresponding to the Big Crunch universe in figure 5. In the period of six Hubble times, this universe expands to $a(t) \approx 2.2$ and crunches back to a singularity.

Alternatively, if the left side is only positive for large values of a, the universe starts with a positive scale factor, contracts to the critical scale factor, and bounces back to expand forever. This corresponds to taking the negative solution before reaching the critical scale factor and taking the positive one afterwards. This case is named the *Big Bounce*.

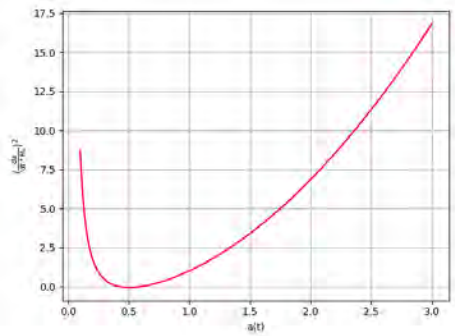

Figure 7. The density parameters and initial scale factor are arbitrarily chosen to illustrate Big Bounce ($\Omega_{r,0} = 0.08$, $\Omega_{m,0} = 0.2$ and $\Omega_{\Lambda,0} = 2$, $a_0 = 4$). The function for this Big Bounce universe is negative for an interval between 0 and 1. Thus, if the universe contracts from a higher initial scale factor (4 in this case), it will need to reverse and expand back to avoid imaginary da/dt.

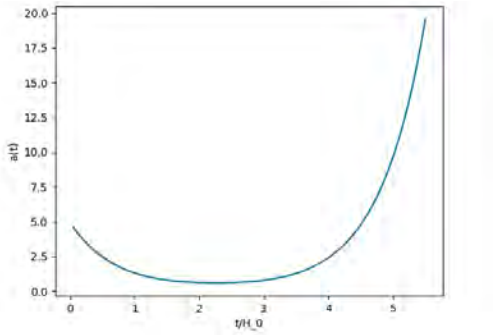

Figure 8. The change in scale factor over time corresponding to the Big Bounce universe in Fig 7. One can see that the universe starts by contracting but "bounces" back into expansion at $t \approx 2.5 H_0$.

3. Results and Discussion

According to the observational data on the density parameters, our universe will have the fate of expansion to eternity. This section examines other possibilities of the density parameters and the corresponding behavior of those universes, answering the essential question of "what if things were different".

We will start by examining the corresponding end behaviors for each combination of density parameters. Because the scale factor is always positive, equation 13 will have the same sign as:

$$\Omega_{r,0} + \Omega_{m,0}a + \Omega_{\Lambda,0}a^4 + (1 - \Omega_0)a^2 \qquad (14)$$

We can analyze the number of positive roots and sign of the end behavior of the above polynomial to

determine if it belongs to Big Crunch, Big Bounce or Big Chill. By definition, $\Omega_{m,0}$ and $\Omega_{r,0}$ are positive, so the type of end behavior is completely determined by the values of $\Omega_{\Lambda,0}$ and Ω_0.

- If $\Omega_{\Lambda,0} < 0$, meaning a negative energy density from the cosmological constant, the polynomial has a negative leading coefficient and will be negative for large $a(t)$. This corresponds to a Big Crunch case.
- If $\Omega_{\Lambda,0} = 0$, without energy contribution from the cosmological constant, the end behavior of the polynomial depends on Ω_0, which relates to curvature of the universe.
    - The polynomial has a negative end behavior if $\Omega_0 > 1$, which implies positive curvature. This means that a positively curved universe without the cosmological constant will end in Big Crunch.
    - The polynomial has a positive end behavior if $\Omega_0 \leq 1$, which implies negative or zero curvature. This means that a negatively curved or flat universe without the cosmological constant will expand forever (Big Chill).
- If $\Omega_{\Lambda,0} > 0$:
    - If the universe is negatively curved or flat ($\Omega_0 \leq 1$), the positive values of all coefficients will make this a Big Chill case.
    - If the curvature is positive ($\Omega_0 > 1$), interesting behaviors arise, and will be discussed in detail shortly.

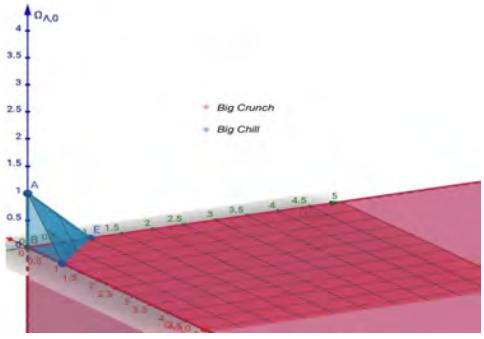

Figure 9. 3D graph of density parameters showing end behaviors (The region that is not shaded can have multiple behaviors and will be discussed in the next section)

If $\Omega_{\Lambda,0} > 0$ and $\Omega_0 > 1$, as discussed previously, equation 14 will have a positive end behavior. According to theDescartes rule of sign, the equation can have zero, one, or two positive roots. For the zero-root case, the universe will obviously end in Big Chill.

If it has two positive roots, the equation will be negative for the interval between the roots. Thus, if the universe starts from a small spatial dimension, it will reach a critical scale factor from the smaller root side and crunch back.

If the universe starts with a large enough spatial dimension, it will reach the larger root and reverse to end in a Big Bounce. We classify this type of universe as a combination of Big Crunch and Big Bounce. Figure 7. can be referenced for this type of universe.

With the help of a computer, one can map out the boundaries in ($\Omega_{m,0}$, $\Omega_{r,0}$, $\Omega_{\Lambda,0}$) space between Big Chill and such Big Bounce/Big Crunch universes

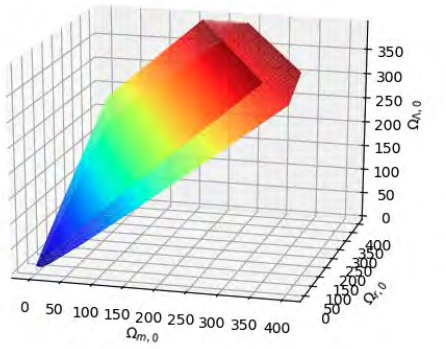

Figure 10. The plot of the boundary in a larger window (0-400). The colored region represents energy densities corresponding to the Big Chill universe; the empty space surrounding it represents the Big Bounce cases. Thus, when a large range of density parameters is considered, Big Bounce and Big Crunch are the fate for most universes.

Alternatively, the classification can be determined by the value of a determinant, however it will give a notoriously long implicit function.

Let

$$s = \frac{3\Omega_{m,0} + \sqrt{9\Omega_{m,0}^2 + 32\Omega_{r,0}(\Omega_0 - 1)}}{4(\Omega_0 - 1)} \tag{15}$$

and define the determinant to be:

$$\Delta = 2\Omega_{r,0} + \Omega_{m,0}s - 2\Omega_{\Lambda,0}s^4 \tag{16}$$

$\Delta \geq 0$ corresponds to the Big Bounce/Big Crunch case, while $\Delta < 0$ implies a Big Chill universe.

As shown, the boundaries are approximately planar. In the limit of $\Omega_{m,0}$ approaches infinity, s is a finite constant, so that the second equation will approach a plane as $\Omega_{m,0}$ becomes larger.

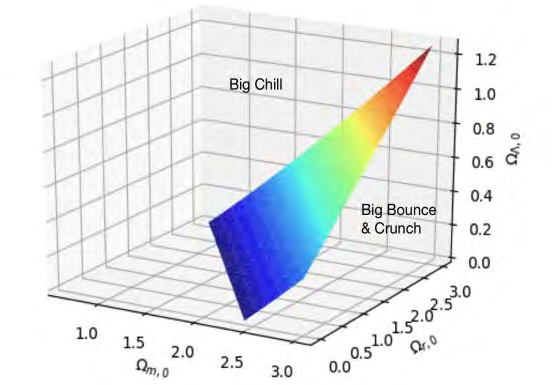

Figure 11. The boundary near the origin. By analyzing the figure, one can see that among universes with small but positive curvatures, the ones with larger energy contribution from the cosmological constant will more likely end in a Big Chill.

4. Conclusion

The Friedmann equations enable the study of the change of the universe's overall spatial dimension over time. The examination of possible solutions to the Friedmann equations provides an insight into the end behaviors of universes: Big Chill, Big Crunch, Big Bounce. The range of initial energy density for each final destiny is both graphed and solved analytically, which provides a simple way to predict the end behavior. The paper gives a fully generalizable framework to classify the evolution of the universe through both numeric and analytic approaches-it allows us to study the universe's past and future based on only a few parameters. As new data of the energy composition of our universe is released, the results from this paper can contribute to the analysis of its fate.

Acknowledgment

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Investigation of Impacts of Hurricanes on Water Quality in Savannah River, GA USA

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Abstract

The purpose of this study was to examine the impacts of hurricanes and storms to the water quality along the Savannah River in three consecutive years. Data was collected from the United States Geological Survey (USGS) on different water quality parameters, including turbidity, dissolved oxygen (DO), conductivity, and salinity. Three surface water stations along the Savannah River were selected to collect data from - each in the upper, middle, and lower parts of the river. The data for the month October in years 2017, 2018, and 2019 were chosen to be collected for each variable as these dates correspond to Hurricane Nate, Hurricane Michael, and Tropical Storm Nestor. Based on the data collected, this study compared the different water quality variables before and after the storm and hurricanes. From the graphs created the trends of a general increase in turbidity, increase in dissolved oxygen as well as decrease in salinity along the river during the periods of the storm and hurricanes. This study also found an increase and decrease of conductivity values, which were more affected by the location. Data analysis found that the storms and hurricanes disturb water quality, which could be characterized by the sampling locations; the station's position on the streams.

Keywords: Hurricane, Water Quality, Savannah River

1. Introduction

Although the most common type of natural disaster in Georgia is severe thunderstorms, Georgia has also been exposed to many hurricanes formed in the Atlantic Ocean and the Gulf of Mexico (Georgia Disaster History, 2021). Since the coast of Georgia aligns with the Atlantic Ocean, which holds a high-pressure system called "Bermuda High," it has been considered that the coast of Georgia has a low chance of impact by landfalling storms (Strother, 2019). As a result, the hurricanes from the tropics end up on the left, curve and head northward, and do not move into the coastal areas of Georgia (Strother, 2019). This may lead one to consider that there is less vulnerability to hurricanes in Georgia; however, as experienced by historic storms, this does not mean that Georgia is not vulnerable to significant damages resulting from natural tragedies. A few examples of historical hurricanes in Georgia include Tropical Storm Alberto, Hurricane Floyd, Hurricane Katrina, and more recently, Hurricane Michael occurred in 1994, 1999, 2005, and 2018, respectively. Tropical Storm Alberto brought twenty-five inches of rain, killing thirty- four people and displacing many homes, and Hurricane Floyd caused the largest evacuation effort in american history as about three million people rushed to evacuate (Georgia Disaster History, 2021). Hurricane Katrina hit western Georgia with heavy rains and winds that destroyed many buildings and took lives; there was a great economic effect as the gas price rose to $6 per gallon

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(Georgia Disaster History, 2021). Hurricane Micheal was a category five storm causing massive destruction with more than $4.5 billion worth of property damage (Reid, 2019). Because of the recency of Hurricane Michael's damages, Hurricane Micheal portrays a great example of the vulnerability of Georgia to Hurricanes. This hurricane became the first major hurricane as a Category 3+ to directly impact Georgia since the 1890s (US Department of Commerce, 2019). Hurricane Michael made landfall in Florida on the afternoon of October 10, 2018 as an extremely dangerous Category five hurricane; Georgia was also affected by Hurricane Michael on the same day, and on the morning of October 11th, the hurricane quickly exited both states as a tropical storm (US Department of Commerce, 2019). As a result of this hurricane, warning areas within Atlanta and Peachtree City County experienced winds that gusted over 70 mph in portions of central Georgia, leading to tree damage, power outages, and severe crop damage (US Department of Commerce, 2019). Because of the substantial destruction caused by the Hurricane, President Donald Trump declared Georgia as in a state of emergency. Despite the fact that the hurricane was not a landfalling hurricane in Georgia, the vulnerability of Hurricanes in Georgia is evident.

There have been several studies and efforts to increase coastal resilience, focusing on infrastructure. Most research has focused on directly impacted infrastructure, overlooking the substantial consequences of hurricanes, such as water quality and resource management. Water surges cause a drastic rise in contamination levels as hurricanes push toxins and contaminants from the soil directly into water supplies (How Hurricanes Can Impact Water Quality and Safety, 2017). The effects of these contaminated water systems can continue for years and cause health issues making it difficult to reverse and even cause death. Schafer et al. (2020) suggested that water chemistry was temporarily disturbed during hurricane Irma as saline water intruded 15 km into a freshwater river, while runoff of freshwater and dissolved organic matter (DOM) decreased salinity and dissolved oxygen but increased turbidity. There may also be more long-term ecological repercussions from these water quality changes resulting from hurricane events. It should be noted that once the ecological repercussion has occurred, it requires a long environmental recovery period to return to normal water systems.

The Savannah River runs on the border of two states, Georgia and South Carolina, and 1.4 million people in GA rely on it as a drinking water source. Unfortunately, the Savannah River has been known for unhealthy water quality, absorbing a significant amount of untreated wastes annually, threatening the quality of waterways as a recreational and drinking resource (Coleman, 2014). Therefore, monitoring the water quality of the Savannah River and proper data analysis is crucial to maintaining the river as a high-quality drinking water source and developing an appropriate long-term sustainability strategy. This study examined the impacts of heavy rain due to hurricanes and storms on the water quality of the Savannah River.

2. Materials and Methods

Water quality changes with heavy rains due to hurricanes and storms along the Savannah River were studied. Three surface water stations of the United States Geological Survey were carefully selected approximately 15 miles apart representing different environmental conditions. The locations of the selected USGS stations are shown in the figure 1 and the detailed geographical information can be found in the table 1.

The United States Geological Survey data was used to collect data on different water quality variables, including turbidity, dissolved oxygen, conductance, and salinity. This study selected three surface water stations of USGS along the Savannah River. Figure 1 shows the location of several USGS stations along the Savannah River. After each station near the river was checked for its available data, three stations were selected, each in the upper, middle, and lower parts of the river. Station A is a station located in the upper river, and the USGS station number is 02198840, which is pointed out with the red arrow. Station B is located at the mid-river, and the USGS station number is 02198920, which is pointed out with the purple arrow. Station C is a station located in the lower river, and the USGS station number is 021989773, which is pointed out by the green arrow.

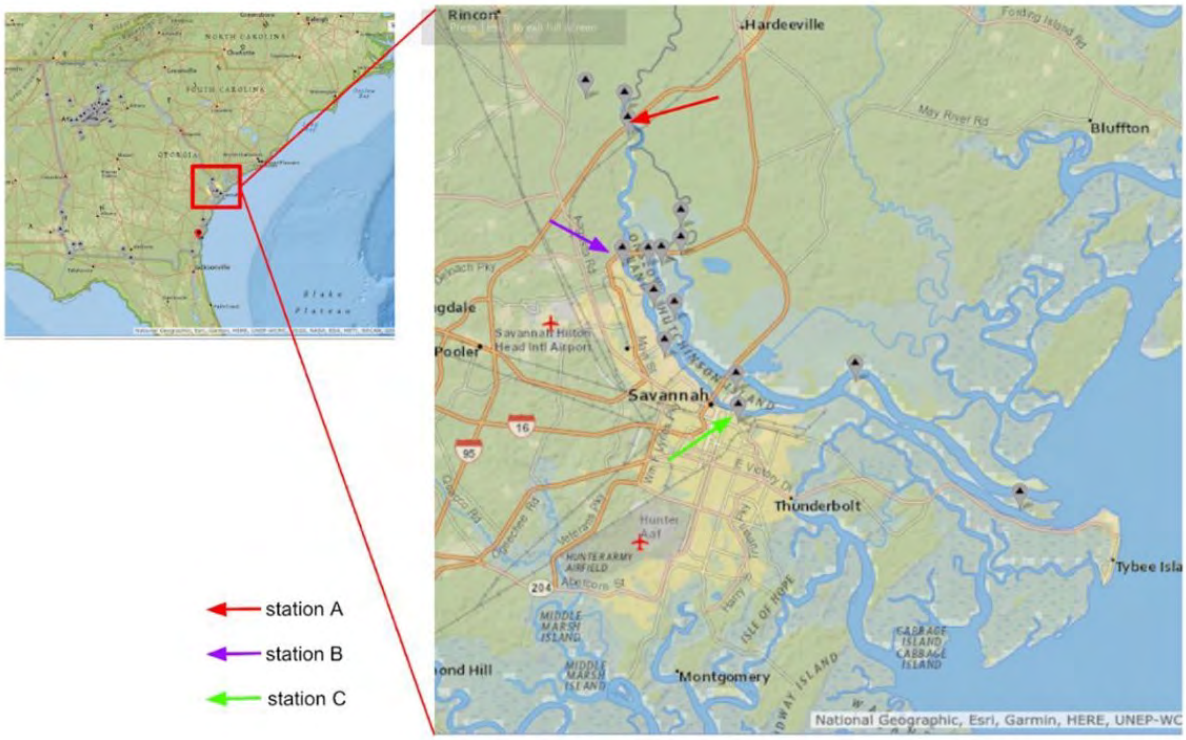

Figure 1. Map of the Stations Located on the Savannah River

Table 1. Geographical Information for the three USGS surface water stations

	Station A	Station B	Station C
USGS station ID	02198840	02198920	021989773
Longitude	-81.09039	-81.15491	-81.08121
Latitude	32.14077	32.16533	32.08105
County	Effingham	Chatham	Chatham

In October, Georgia had impacts due to Hurricane Nate (2017), Hurricane Michael (2018), and Tropical Storm Nestor (2019). On October 7, 2017, Hurricane Nate landed along the central Gulf and brought heavy rain, gusty winds, and coastal flooding. Hurricane Michael landed on October 10, 2018 and brought widespread surge and wind damage (TAE Significant Weather Events). Tropical Storm Nestor occurred around October 17-19 in 2019, and the main impacts were strong winds along coasts and storm surges. This study analyzed data collected in October of 2017, 2018 and 2019 to find the impacts of these series of hurricanes and storms on water quality in Savannah River. Graphs of the different water quality variables before and after hurricanes along the Savannah River were created based on the data collected by USGS. On all of the graphs, each line represents the data of 2017, 2018 and 2019, which are also shown on the legends of each of the graphs. The period of the hurricanes or storms is highlighted and labeled on sections of the graph that show a notable increase or decrease in the water quality variables during the period of the hurricane or storm. Then, using these highlights, the trends of each year is evaluated for each water quality variable. The different stations is also compared to find the differences of effects for the three locations (Stations A, B, and C) of the river.

3. Results and Discussion

This study presented the comparison of different water quality parameters such as turbidity, dissolved oxygen, salinity, and conductivity between pre- and post- hurricanes and storms. Graphs of the different water quality parameters along the Savannah River were created based on the data collected by USGS.

On all of the graphs, the blue lines present data from 2017, the red lines present data from 2018, and the yellow lines present data from 2019. The period of the hurricanes or storms will be highlighted and labeled in sections of the graph that show a notable increase or decrease in the water quality parameters. Then, using these highlights, the trends of each year will be found for each water quality parameter. The different stations will also be compared to find the differences of effects for the three locations (Stations A, B, and C) in the river.

Figure 2 presents comparisons of Turbidity along the Savannah River. Unfortunately, station B did not collect and monitor turbidity data during the period of Tropical Storm Nestor, but based on data collected during the periods of Hurricane Nate and Hurricane Michael, there were 100% to 250% increases in the turbidity values for all stations. In addition, the highest turbidity values were observed at station B with values reaching above 100 TNU. Station B is located at mid-river and is the deepest station, while Station A, which is located in the upper river area saw relatively low initial turbidity level, and Station C, located near the mouth of the river, which is a wide area of the river, saw initial turbidity levels higher than Station A and lower than Station B. The differences in location can explain the initial turbidity levels for the different Stations

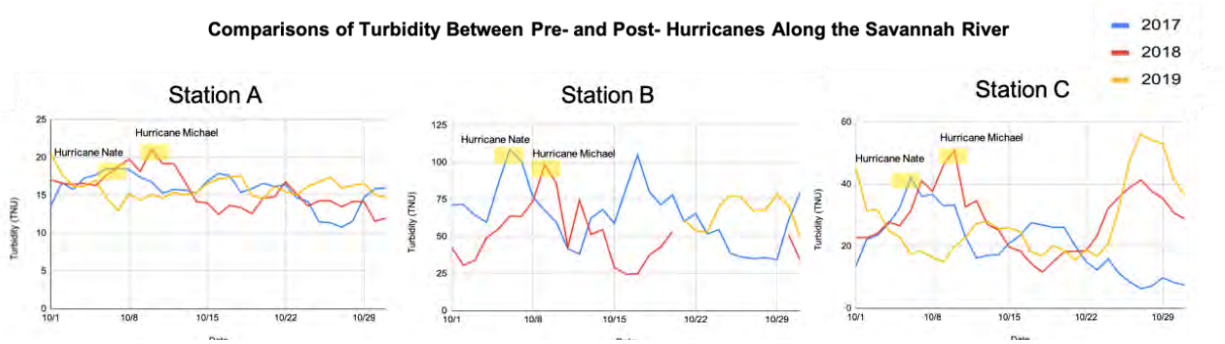

Figure 2. Comparisons of Turbidity

Figure 3 presents the comparisons in dissolved oxygen. There are 25% to 33% increases on DO levels with Tropical Storm Nestor in all stations, while Hurricane Michael only saw increases in stations B and C. It is noted that because of the hydraulic disturbance of the river during the hurricane, there is an increase of surface area contact with the air which will increase the oxygen level in the body of water. In addition, there were generally lower amounts of dissolved oxygen at Station C, which is near the ocean and the lower river, while there was an increasing amount of dissolved oxygen the further the stations were from the ocean. It can be noted that the amount of organic substance originating from the upper parts of the river reduces the DO level of the lower parts of the river. Furthermore, the increased amount of the salinity in the lower parts of the river also decreases the DO level because of the ion-molecule interaction. As shown by the highlighted parts of the graph, there are greater impacts to the DO levels during the storm when compared to the hurricanes.

Figure 4 presents comparisons of salinity along the Savannah River. There is a trend of an increase in overall salinity as the stations get closer to the ocean. In addition, for the graphs of Stations B and C, there is a 25% to 85% decrease in salinity during the periods of both Hurricane Nate and Tropical Storm Nestor, showing an increase in freshwater coming in. In station B, the values of salinity during the period of Tropical Storm Nestor are not visible but could have been similarly affected to station C. Station A had little variance in salinity, and a reason for this is the initial salinity level is too low because the station is located in the upper river.

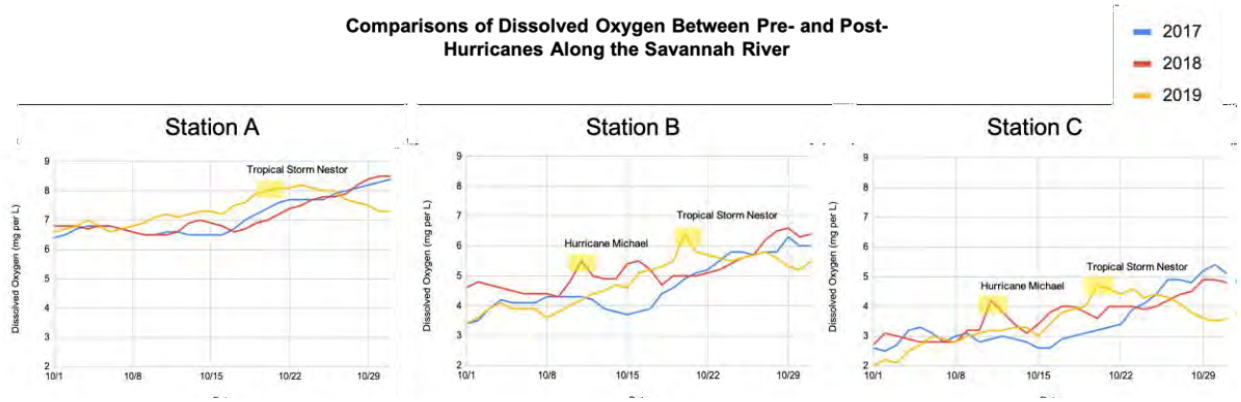

Figure 3. Comparisons in Dissolved Oxygen.

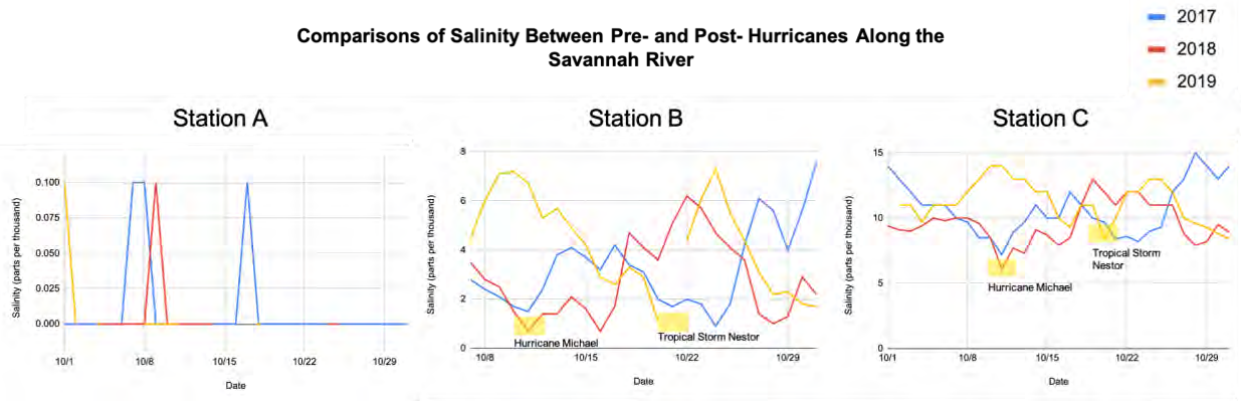

Figure 4. Comparisons in Salinity.

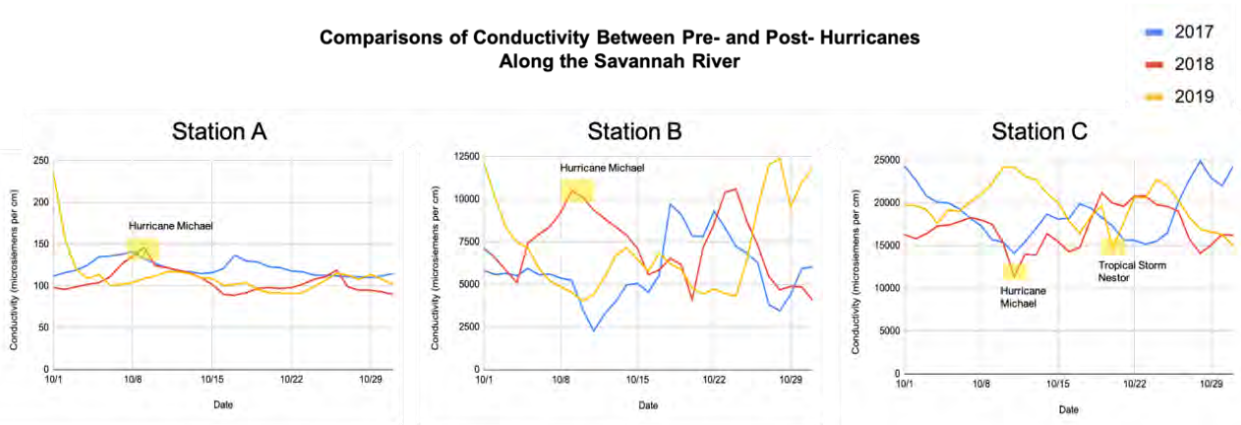

Figure 5. Comparisons in Conductivity.

Figure 5 shows the comparisons in conductivity. There seems to be a general increase in conductivity as the stations were closer to the ocean. The conductivity near the lower river stations have initial levels reaching almost 25000 µS/cm while the conductivity of the upper river station have initial values of about 150 µS/cm. These initial values are affected in different ways from the hurricanes and storms. For stations A and B, there is an increase in the conductivity of the water during Hurricane Michael. This can be explained by the hurricanes disturbing the sediment of the river, which will increase the amount of inorganic substance in the body of water. On the other hand, there are decreasing spikes in conductivity values for Hurricane Michael and Tropical Storm Nestor in

station C. This could be because during the storms, more fresh water entered the areas of station C which will reduce the conductivity of the water body.

4. Conclusions

This study found that extreme weather events such as storms and hurricanes disturb the water quality of the Savannah River region. This study observed a general increase in turbidity and dissolved oxygen as well as a decrease in salinity along the river. However, this study found both an increase and decrease of conductivity values, which were more affected by other factors such as the strength and duration of the hurricanes or storms. Therefore, this study concludes that an increased amount of freshwater inflow and wind effects during hurricanes and storms alter water quality along the river in a coastal area. Furthermore, these disturbances could be characterized depending on the location along the river.

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Did Macbeth Suffer from PTSD?

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Abstract

In this paper, the author explores PTSD-related symptoms as seen in the character Macbeth in Shakespeare's tragedy, *Macbeth* . It goes in-depth to explain the history and general overview of PTSD. Life-altering symptoms of PTSD are also explained through statistics and a list of common symptoms. The paper dives into the causes of PTSD in Macbeth as horrifying wartime experiences and his murder of King Duncan places a great deal of stress on him. Then the paper explores how Macbeth's PTSD might explain his later actions such as his apathy to his wife's untimely death and hallucinations.

Keywords: Macbeth, PTSD, Literary Analysis, Shakespeare, Tragedy

1. PTSD in the Macbeth Character

Post-Traumatic Stress Disorder (PTSD), is a condition prevalent in people who experienced or witnessed a traumatic event (Torres, 2020). Although PTSD was officially recognized in 1980, it was known as shell shock to people of the past with the first cases being reported in the 1700s (Friedman, n.d.). Originally, shell shock was known as "when a soldier was unable to function and no obvious cause could be identified." (Jones, 2012). Symptoms of shell shock were identified as "fatigue, tremor, confusion, nightmares and impaired sight and hearing" (Jones, 2012). PTSD was first brought into the spotlight following the aftermath of WWI. After fighting in the trenches with constant artillery strikes and other horrors of war, many veterans came home with changed behavior due to the trauma and stress of war. They suffered from violent flashbacks, anxiety, sleep deprivation, and aggressive behavior (Friedman, n.d.). These symptoms are identical to those described by Navy Captain Paul S. Hammer (2013) who detailed patients with PTSD as having "increased arousal that may cause hypervigilance, irritability, difficulty sleeping or an exaggerated tendency to be easily startled." This connection between the symptoms identified by research and the symptoms of experienced veterans suggests that PTSD has been around since humans first started roaming the Earth, though the specific term, along with its impact, was yet to be named.

As the play *Macbeth* by William Shakespeare progresses, Macbeth goes from a respected thane to a violent, power-hungry, false king due to the effects of PTSD. Prior to becoming a crazed tyrant, he is surrounded with death as a soldier and the combination of this and his decision to murder Duncan, the King of Scotland, fills him with trauma and guilt, eventually triggering his PTSD. Macbeth shows many signs of PTSD such as nightmares, anxiety, paranoia, and drastic changes in behavior throughout the course of the play. Macbeth's mental health spirals out of control due to PTSD, drastically altering his behavior, leading to his downfall.

As awareness for a condition called "shell shock" increased, research also began taking place. In 1980,

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after years of extensive research, the American Psychological Association included PTSD to its *Diagnostic and Statistical Manual* for mental health practitioners noting that PTSD was a diagnosable condition (Friedman, n.d.). They concluded that PTSD was caused by traumatic events, instead of an inherent individual weakness. Anyone who was exposed to a "catastrophic stressor that was outside the range of usual human experience" (Friedman, n.d.) was susceptible to developing symptoms of PTSD. Some of these unnatural experiences identified as potential causes of PTSD include: war, torture, rape, natural disasters, and human-made disasters (Mayo Clinic Staff, n.d.). However, stressors that are considered to be a natural problem in the way of life such as divorce, failure, rejection, illness, and financial reverses were not indicated as PTSD causes. The main difference between stressors that cause PTSD was that humans have the ability to cope with ordinary stressors, but the human brain was not made to handle unnatural traumatic events. When faced with a stressor outside the range of usual human experience, the brain was likely to be overwhelmed, causing PTSD (Mayo Clinic Staff, n.d.).

When looking at the situations Macbeth is in throughout the course of the play, he is in a position where he is more than capable of developing PTSD. To begin, in Act 1 Scene 2, Macbeth is revealed to be a soldier. Macbeth, "Disdaining fortune with his brandished steel / which smoked with bloody execution" (1.2.17-18) had just fought and defeated the forces of Thane of Cawdor. As a soldier, Macbeth is in a position where he is constantly exposed to unnatural traumatic events, as he has to kill others and see his comrades killed. Soldiers during war are the most common victims of PTSD as their life is surrounded by traumatic events and the case is no different for Macbeth. Like any soldier fighting in war, Macbeth is surrounded by unnatural death and, no matter how strong someone's mind is, constant exposure to death will eventually lead to PTSD. However, Macbeth doesn't show any symptoms of PTSD from his wartime experience until the murder of Duncan. Macbeth's murder of Duncan isn't typical murder as he is doing so to seize the throne from the King of Scotland. Before Macbeth murders Duncan, he justifies all of his killings as following orders. But when he decides to murder the King of Scotland, the guilt and stress over freely killing an innocent person becomes a triggering event for his PTSD. Overall, all of the death that surrounds his life due to his profession and his decision to murder Duncan cause PTSD for Macbeth.

PTSD affects people in a variety of ways and its severity depends on each individual. Some of the most prominent symptoms of PTSD include: violent flashbacks, nightmares, anxiety, sleep deprivation, bipolar behavior, and depression (Mayo Clinic Staff, n.d.). These symptoms can lead to abusing alcohol and drugs as many patients of PTSD use substances to cope with their pain. This can completely alter a person's life, as their behavior will affect their jobs, relationships, health, and enjoyment of life. Research shows that PTSD causes people to withdraw from society and constantly live inside their heads. The effects of PTSD are so overwhelming that according to the U.S. Department of Veterans Affairs (2022), studies have shown that having PTSD increases the risk that you will develop a drinking problem. In fact, "59% of people with PTSD subsequently develop substance abuse problems" and "10% of people with PTSD had attempted suicide." (Khoury, 2010). As can be seen, PTSD causes people to act in unpredictable ways and completely changes a person.

As the play progresses the effects of PTSD in Macbeth become more prevalent as evident through his sleep deprivation. The first signs of PTSD in Macbeth was shown after Macbeth says he heard a voice say "Glamis hath murdered sleep, and therefore Cawdor / Shall sleep no more. Macbeth shall sleep no more." (2.2.41-42). After this, Macbeth is haunted by this knowledge and is unable to sleep comfortably. He says "Ere we will eat our meal in fear and sleep / In the affliction of these terrible dreams / That shake us nightly." (3.2.19-21). Macbeth admits that he is having a hard time sleeping due to nightmares, which is a sign of PTSD. This lack of sleep and guilt leads to Macbeth suffering from hallucinations. During the banquet at Macbeth's castle, Macbeth sees the ghost of Banquo, after he orders his murder, and exclaims "Prithee, see there, behold, look, lo, how say you? / Why, what care I if thou canst nod, speak too." (3.4.72-73). In the first line of this quote, Macbeth is

informing his guests and Lady Macbeth that the ghost of Banquo is with them at the table. Then when he realizes no one else can see the ghost, he turns around and speaks to the ghost. These hallucinations begin due to the lack of sleep and the guilt building inside of him, giving readers an inside look into his feelings.

Just as the lives of real people go downhill due to PTSD, Macbeth starts to become very power hungry, which leads to his crazed paranoia about losing power. When he goes back to the witches and they tell him to beware of Macduff, he proceeds to kill his entire family while Macduff is away. Throughout the course of the play, Macbeth progressively becomes more violent and eventually loses control of himself. When he decides to murder Duncan, Banquo, Fleance, and Macduff's family, it doesn't matter to him that they are innocent. It comes to the point where all he cares about is his power and nothing else matters to him. This arrogance is shown when he says "Bring thou this fiend of Scotland and myself / Within my sword's length set him. If he 'scape, / Heaven forgive him too." (4.3.233-235a). This statement shows that Macbeth firmly believes he owns Scotland and anyone who dares to defy him will end up dead from his sword. Macbeth's growing disregard for anyone in order to firmly holds his power is especially shown when he completely disregards the condition and death of his wife. He doesn't show a single sign of care when the doctors came to him regarding Lady Macbeth's behavior and subsequently her death. After he is told by Seyton that the queen is dead, Macbeth simply says "She should have died hereafter; / There would have been a time for such a word." (5.5.17-18). This statement shows that he doesn't care about his wife and believes that he doesn't have time to look out for his wife, as keeping his throne is more important to him. By the end of the play, Macbeth completely changes from the beginning where he is described as being noble and a man of honor. According to the U.S. Department of Veterans Affairs (2022), those with PTSD may feel "numb" to things they typically find joy. This symptom of PTSD could explain Macbeth's seemingly sudden shift from passion to indifference regarding his wife. Her death should have devastated him but he is numb. This shows the terrifying effects PTSD can have on a person as it turns Macbeth from a noble person to a crazy tyrant, which leads to his downfall.

Throughout the course of the play, Macbeth's mental health declines due to PTSD until he becomes a power hungry maniac. He starts out as a man of chivalry, so well respected that Duncan names him the Thane of Cawdor. However, this all changes due to his environment of constant death and his decision to murder Duncan. These factors lead to Macbeth developing PTSD and he shows signs of this through nightmares, anxiety, hallucinations, and changes in behavior leading to the decline of his mental health. Macbeth's story is one of a tragic hero and serves as a cautionary tale of the dangers of PTSD, bringing attention to the seriousness of this disorder.

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Colonialism: Analyzing DDT in India: Ethical Considerations

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Abstract

The application of Dichlorodiphenyltrichloroethane (DDT) is one of the most debated global issues in the 21st century. Developed in the 1940s, it was discovered that DDT could be used as an insecticide to prevent the spread of diseases such as malaria that transmit to humans through vectors like mosquitoes (Mulliken et al., 2005). In fact, DDT was publicly lauded during the twentieth century for eradicating malaria in many developed nations and is now widely perceived as the most effective deterrent of malaria, especially in developing countries such as India (Mulliken et al., 2005). However, concerns have now risen regarding the detrimental effects of the prolonged use of DDT. Critics exemplify the aforementioned impacts of DDT within several categories including environmental, economic, health, and continued effectiveness. A comprehensive review of current research indicates that the drawbacks associated with the extensive use of DDT on these fronts outweigh its perceived effectiveness in malaria control. Moreover, research suggests that alternatives to DDT such as pyrethroids and ITN distribution show potential in replacing DDT as the primary method of vector-control in India.

Keywords: DDT, insecticide, Environment, Stockholm Convention, Health, India, ITNs, Malaria

1. Introduction

Dichlorodiphenyltrichloroethane (DDT) is an organochlorine insecticide first synthesized in 1874 (NPIC, 2000). A unique quality of DDT is that it affects the nervous system in organisms by interfering with the normal firing of neurons. Prolonged exposure to it through contact or ingestion causes nerve cells to repeatedly generate an impulse, resulting in seizures, tremors, and eventually death in less complex organisms such as insects (NPIC, 2000). This makes it an effective deterrent to malaria, a vector-borne disease transmitted to humans through insects such as mosquitoes.

According to the National Institute of Malaria Research in India, malaria assumes close to 85% of global infectious disease burden, and India alone has nearly 15 million cases with approximately 20,000 deaths annually, accounting for the majority of cases in South Asia (Kumar et al., 2007). The severity of global outbreaks of vector-borne diseases including malaria necessitated the mass production and distribution of insecticides in order to combat ever-growing case numbers. Thus, in previous decades, DDT pesticides have saved millions of lives by preventing the spread of malaria, and India has since become the largest producer and consumer of DDT in the world (Berg, 2009). However, global concerns over India's heavy reliance on DDT has engendered uncertainty over the ethicality of its continued use. This research paper is intended to benefit global discussion on DDT by providing a holistic evaluation of the ethical implications of using DDT pesticides as the primary method of combating the malaria epidemic in India and evaluate possible alternatives to DDT such as pyrethroid and ITN

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distribution.

2. Overview

2.1. Environmental Impact of Current DDT Usage

In India, DDT is an essential component of the aerosol used in indoor residual spraying (IRS), which "involves applying long-acting insecticides to [houses] to kill insects" (Rehwagen, 2006). This method is commonly perceived to be humane and cost-effective, as Dr. Asamoa-Baah states that IRS has been "one of the quickest ways to reduce [malarial] infections" (Rehwagen, 2006). Despite the apparent value of using DDT in malaria control, it is important to note that it has been banned in various countries including the US due to concerns voiced by environmentalists. Specifically, DDT has had a severe harmful impact on ecosystems. Studies have shown that the bioaccumulation and biomagnification of DDT in aquatic organisms through contamination and runoff can reach "levels many thousands of times higher than in water," harming entire ecosystems and disrupting environmental homeostasis (ATSDR, 2015). Ecologist Vladimir Turosov with the Russian Cancer Research Centre acknowledges that this is especially concerning because DDT accumulates in tissues and remains highly toxic to non-target organisms such as fish and birds for prolonged periods of time (Turusov et al., 2002). In fact, Turusov also concludes that the persistence of DDT in water has severely damaged wildlife populations around the world. This can be seen in the significant population decline of bird species, such as the osprey in India and the bald eagle in the US (Hellou et al., 2013). In response to such information, twelve chemicals including DDT were banned in 2001 by the United Nations under the Stockholm Convention because of their contribution to ecological damage (Lallas, 2001).

2.2. Economic Influence of DDT

A cost comparison of malaria control methods by the World Health Organization (WHO) found that non-DDT pesticides cost 2 to 23 times more per house than DDT (Walker, 2000). Additionally, non-DDT substances require frequent application, while DDT is sprayed just once a year and costs approximately $1.44 per house (Williams, 2004).

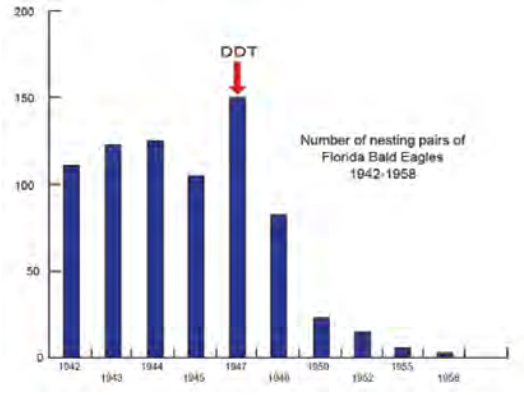

Figure 1a. Decline in the Bald Eagle population after initial mass exposure to DDT (American Eagle Foundation, n.d.)

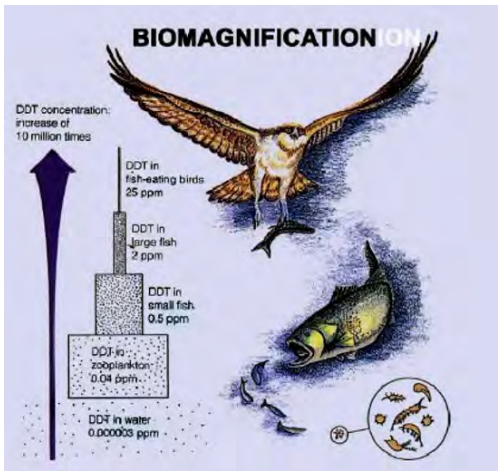

Figure 1b. How DDT accumulates in organisms through the food chain after environmental contamination (American Eagle Foundation, n.d.)

Thus, officials assume that countries with higher malaria incidence and related mortality rates receive larger net economic benefits from DDT because the potential cost of chronic conditions caused by the environmental effects of DDT may not be as significant of a concern as it is in low prevalence areas. As a result, governments in less-developed countries with high malaria prevalence are prompted to staunchly defend their use of DDT. For instance, when the global DDT ban was first proposed, at-risk populations and governments in Sub-Saharan Africa

and the Indian subcontinent defended DDT, arguing that prohibiting the use of such an effective "...anti-malaria weapon..." (Tren, n.d.) would result in an unprecedented amount of deaths and cost economies up to $480 million due to medical costs and loss of workforce members (Guimarães, 2007).

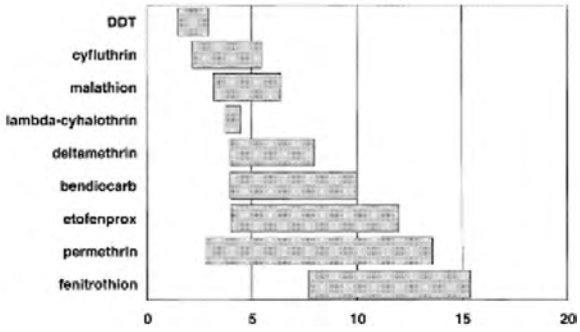

Figure 2. Average cost of insecticides in dollars per pound (Walker, 2000).

2.3. Economic Drawbacks to DDT

However, it is also important to note other studies indicate that DDT increases the economic burden on countries due to indirect costs. Although the complete eradication of malaria through DDT would "...result in a net economic benefit of 12 billion dollars…" (Mukose, 2015) annually, it would be improper to assume that IRS would result in full eradication. A study by Susmita Dasgupta analyzing the economic implications of DDT found that, "While...DDT can lead to a significant reduction in the estimated economic loss caused by malaria...it can also add more than...$28 billion a year in costs from the resulting inadvertent health effects" (Dasgupta, 2012). However, this economic loss can be reduced to $5 billion if spraying DDT is restricted to areas with the highest malaria prevalence, which would still target over 70% of the at-risk population (Dasgupta, 2012). Furthermore, although global price calculations show that DDT is currently the cheapest malaria control method, concerns over its safety have caused a decline in demand which has driven up its price.

2.4. Opposition to DDT Restriction

As stated earlier, various public health groups and governments including India oppose a complete ban on DDT because of its low cost and seemingly prominent usefulness in malaria control. For instance, despite the discouragement of DDT by the Stockholm Convention, governments in malaria-stricken countries like India have expressed outrage at the ban, and have obtained provisions from the UN to use DDT pesticides to combat malaria (Berg, 2009). The World Health Organization also supports DDT use, reasoning that the benefits of the pesticide outweigh any potential health risks (Harada et al., 2016). Other health officials disagree with this conclusion, expressing concerns over the side-effects of DDT on individuals living in highly concentrated areas. Although there is no conclusive evidence that low concentrations of DDT cause major illnesses in humans, medical experts assert that it is an endocrine inhibitor and possible carcinogen, and higher doses could harm the nervous system, liver, and reproductive organs ("DDT", 2017; Harada et al., 2016). Additionally, researcher Tom Børsen claims that despite risks of bioaccumulation, "public health agencies have incentives to use higher doses of DDT to achieve 'better' results," thereby exposing humans and wildlife to increasingly harmful concentrations (Børsen & Nielsen, 2017). Hence, the rising concentrations of DDT in the environment could potentially harm millions of Indians through food and water contamination. In fact, the Indian government even instituted a partial ban on DDT use in 2008 because of alarmingly high amounts of pesticide found in food samples (Toteja et al., 2003). However, because of the disunity between environmentalists, medical professionals, and global protocols on the morality of DDT, Indian officials have done little to enforce the ban and are able to hide behind overgeneralized regulations regarding DDT use, thus remaining disinclined to pursue a complete ban (Jayachandran).

2.5. The Decreasing Effectiveness of DDT

Regardless of ongoing global divisiveness, studies have indicated that the effectiveness of DDT in India is decreasing due to its extensive use, calling further into question the ethicality of India's continued reliance on DDT. Researchers note that "even

restricted use has led to...a dangerous rise in [resistant] mosquitoes," which will force India to use even higher concentrations of DDT, harming humans and wildlife alike (Kenney, 2013). Accredited malariologist V. P. Sharma notes several other reasons for the diminishing effectiveness of DDT in India, including inefficient administration. He reasons that because India lacks a proper oversight method and significantly undersupplies its distribution program, DDT pesticides are allocated to richer urban communities over rural areas with higher malaria prevalence, resulting in coverage rates that are too low to effectively control malaria transmission (Sharma, 2003). In other words, although DDT was previously regarded as a praiseworthy method of controlling vector-borne diseases in India, its lessening effectiveness indicates that the drawbacks of its use will soon outweigh the current benefits.

3. Discussion

3.1. A Potential Solution

One possible solution is to create evidence-based distribution systems that target malarious regions more efficiently. Although this would work temporarily, increasing insect resistance to DDT would unnecessarily expose individuals to higher amounts of pesticide and eventually render such distribution obsolete (Sharma, 2003). Instead, a cost-effective alternative to DDT pesticides are insecticide-treated nets (ITNs), which can be distributed to individuals in malaria-stricken regions. According to the WHO, ITNs have been "by far the largest contributor to the impressive drops seen in malaria incidence" since 2000 ("Malaria", n.d.). Most of these nets are treated with pyrethroids, compounds that, unlike DDT, "rapidly metabolize and do not accumulate in tissues," and are thus harmless to humans, while still retaining their effectiveness against mosquitoes (Chrustek et al., 2018).

3.2. Benefits of ITN Distribution over DDT

Initially, this solution seems costly to implement because it utilizes pyrethroids; however, this drawback would only be temporary because the price of DDT is expected to surpass the price of pyrethroids soon ("Facts", 2019). In fact, the IMARC Group, an accredited Market Research Firm, found that the global pyrethroids market is expected to grow at a compound annual growth rate of 4% in the next five years ("Pyrethroids", n.d.). This suggests that as demand increases, prices will go down, thus further narrowing the financial disparity between relying on pyrethroids and relying on DDT. While the ultimate goal of this approach would be to phase out DDT entirely, it would allow for a smooth transition towards alternative control methods while also gradually reducing malaria cases.

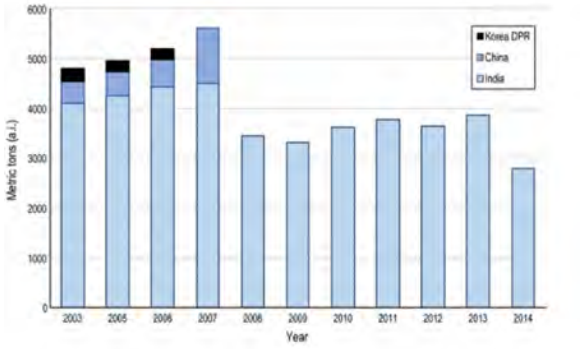

Figure 3a. shows the average use of DDT over a period of time in China, India, and DPR Korea, wherein DDT use is decreasing rapidly (Berg et al., 2017).

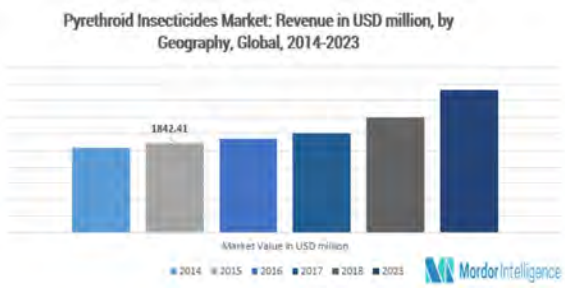

Figure 3b. shows the average global use of pyrethroids, wherein pyrethroid usage is rapidly increasing ("Pyrethroid Market", n.d.)

P. Jambulingam with the Vector-Control Research Center in India conducted a study to evaluate the effects of ITN distribution in comparison to DDT. He observed a "7.2-32.1% reduction of malaria

incidence" since using ITNs in a province where DDT pesticides were once implemented (Jambulingam et al., 2008). Jambulingam's results indicate that ITNs are becoming more effective than IRS and can be used without fear of harming human or wildlife populations. In fact, "China, the Solomon Islands, and Vietnam have begun replacing their IRS programs with ITN [distribution]" (Berg, 2009). Thus, it can be inferred that India could dramatically improve vector-control efforts by distributing ITNs to rural areas with high malaria incidence.

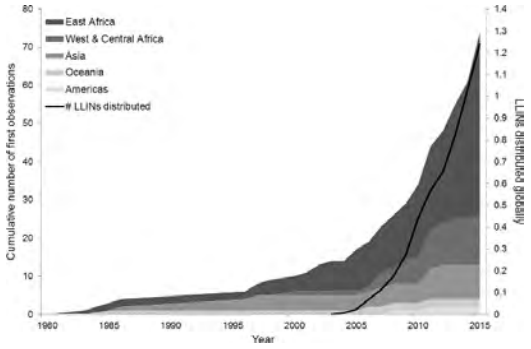

Figure 4. Global ITN distribution continues to increase rapidly (Short et al., 2018).

3.3. Limitations to Replacing DDT

There are limitations to completely replacing DDT pesticides with ITN distribution in India specifically. Since DDT is "produced by the government-controlled HIL and is [currently] cheaper than other pesticides," a total ban would be unrealistic, as officials would be unmotivated to encourage alternatives if their government would lose profit by undermining DDT production (Sharma, 2003). Additionally, without an efficient ITN distribution system, coverage may still be too low to significantly decrease malaria rates, making it necessary to have other methods of malaria control to reach as much of the Indian population as possible. To combat these limitations, researcher Kansinathan Gunasekaran suggests in his study that selling ITNs at "subsidized prices [to at-risk regions]...and ensuring the availability of nets" could improve coverage by encouraging more people to use ITNs (Gunasekaran et al., 2009). Disease experts also acknowledge that frequent insecticide rotations would help combat possible insect resistance to pyrethroids (Kranthi et al., 2001).

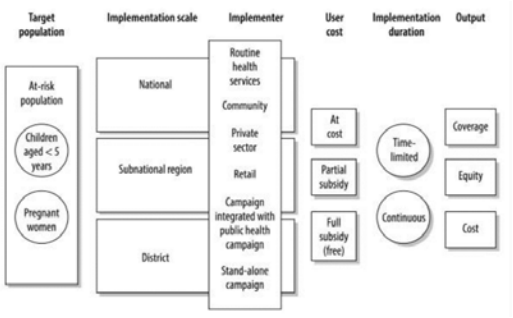

Figure 5. Diagram depicting the implementation of subsidies to improve coverage for at-risk populations (Wiley et al.)

4. Conclusion

Even globally, the controversial issue regarding DDT usage has raised "...questions about the balance between environmentalism and humanitarianism," (Querengesser, 2007) Ultimately, although there are differing conclusions on its effect on humans, data on the decreasing effectiveness of DDT coupled with overwhelming evidence regarding its ecological harm stipulate that its prolonged intensive use cannot be deemed ethical. Although further research should be conducted in order to definitively determine the physiological impacts on organisms and efficacy of DDT in comparison to ITNs, the most current studies have indicated that the best way to negate the detrimental impacts of DDT in India is to pursue less environmentally harmful alternatives of malaria control such as ITN distribution. Although limitations exist, finding another primary method of vector-control would help protect the diverse tropical ecosystems of India while effectively preserving the health of Indians for many generations.

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Effect of Artificial Nature on High School Students' Learning Experience

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Abstract

The growing accessibility of technology is creating a new avenue for incorporating nature and its visual, auditorial, and olfactory sensory details into classroom environments. Replicating nature through technology as opposed to using outdoor classrooms can reduce the barriers for teachers to expose their students to nature. The dominant benefit of exposure to nature is reducing students' mental fatigue which translates into academic and well-being benefits. A treatment including a Smart Board, speakers, laptops, and an Airwick was used to determine whether they can be used together to create a beneficial nature experience for students while reading an article and answering reading comprehension questions. Contrary to the benefits of outdoor classrooms, the findings indicate that benefits of nature to reading comprehension and well-being are not likely attained when it is artificially replicated in a classroom. Teachers and curriculum writers should look toward other tools to maximize the benefits of nature for students.

Keywords: Technology, Nature, Classrooms, Sensory Details, Wellbeing

1. Introduction

1.1 Background

An average U.S. student spends 8,884 hours over nine years in school (Sparks, 2019). Because students spend twenty-two percent of their waking hours in a classroom, one cannot deny the importance of ensuring that their physical classroom environment supports not only their academic growth but also their emotional and social wellness.

Preexisting research indicates that classrooms without windows can feel stressful and overwhelming to both students and teachers because both groups have an inherent need to affiliate with nature (Kellert and Wilson, 1993). Because students lack the ability to change the classroom environment, teachers often artificially recreate nature in classrooms without windows, taping fake windows and pictures of scenery to their walls. Not only does this make students feel more comfortable in the classroom environment (Sop Shin, 2007), but also it translates to enhanced academic ability (Benfield et al., 2015). Exposing students to nature is important for their social and emotional health; however, methods of integrating nature into classrooms remain underexplored.

Current literature shines some light on the benefits of outdoor classrooms with improving the academics and well- being of students (Dennis et al., 2014). Outdoor classrooms are especially effective for students challenged by the rigid structure of traditional classrooms. While teachers tend to positively perceive outdoor classrooms, many are concerned about integrating them into curriculums. Unpredictable weather, supervision, lack of administrator and curriculum support, and potential loss of class time are common barriers for teachers to

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implement outdoor classrooms (Ruether, 2018). Although some teachers and schools have developed curriculums that can be used during all months and seasons of the school year (Constable, 2015, Kervinen et al., 2018), they are not prevalent in education.

1.2 Student Perceptions of Nature

Because students are the subject of this study, it is important to understand how they view incorporating elements of nature into classrooms.

The Biophilia Hypothesis examined the idea of biophilia – humanity's innate affinity for the natural world. The authors asserted 'the existence of a biologically based, inherent human need to affiliate with life and lifelike processes' (Kellert and Wilson, 1993, p. 56). Therefore, *the Biophilia Hypothesis* implicates activities and institutions that act as a barrier to people's interaction with nature. Kahn (1997) expanded on Kellert and Wilson (1993) by applying the idea of biophilia to children. Kahn (1997) constructed four structural-development studies that involved 72 children from Texas and 44 children from Brazil. After analysis of the interviews with the children, Kahn (1997) concluded that 'young children (at least by the ages of 6 to 8 years) have moral commitments to nature' (p. 46). This paper supports the notion that children require exposure to nature to fulfill their biological need to affiliate with life. Given children spend a great deal of time in a classroom (Sparks, 2019), Kellert and Wilson (1993) and Kahn (1997) would agree that classrooms should provide opportunities for students to be exposed to nature.

Dr. Pia Sjöblom and Maria Svens build off the idea that students have an innate desire to interact with the natural environment by interviewing with 10–11-year-old students who participated in a nature school day. Sjöblom and Svens (2018) found students 'emphasized the different learning activities outdoors in comparison with the teaching they were used to in the classroom' (p. 307). The appreciation for the outdoor classroom is grounded in *the Biophilia Hypothesis* because it indicates that the traditional classroom may not have fulfilled students need for exposure to nature. Confirming Sjöblom and Svens (2018), Asmara et al. (2016) analyzed survey results from English learners' after participating in sixteen two-hour sessions of a trial outdoor school and determined 'all the 20 students were interested in joining the program' (p. 5). The students' agreement with the outdoor school further supports the notion that students desire to interact with nature in a classroom environment. Together, Sjöblom and Svens (2018), and Asmara et al. (2016) show that students hold a positive perception of spending more time with nature which supports the need for changes in the classroom setting.

The work by Kaplan and Kaplan establishes the foundation for the universal need for humans to interact with the natural environment. This is expanded upon by the works of Kahn (1997), Sjöblom and Svens (2018), and Asmara et al. (2016) who display scholarly agreement that students welcome increased interaction with nature.

1.3 Benefits of Viewing Nature

Viewing nature is a key component of reducing mental fatigue in students. Benefits to students' wellbeing and academic ability are often realized when their mental fatigue is reduced.

The Experience of Nature: A Psychological Perspective proposed Attention Restoration Theory which asserts that nature is a mechanism, like sleep, to reduce mental fatigue. In a classroom setting, the struggle to pay attention is 'central to what is experienced as mental fatigue. If mental fatigue is the result of an over worked capacity for directed attention, then resting this capacity would seem to be the route to recovery' (Kaplan and Kaplan, 1989, p. 182). Mental fatigue grows because of a cluttered and confusing classroom setting with no outlet for students to redirect their attention. To reduce mental fatigue, exposure to wilderness environments is 'powerful, and the experience was deeply restorative' (Kaplan and Kaplan, 1989, p. 182). Benefits to reducing mental fatigue through nature can be fulfilled through the five sensory details: touch, smell, visuals, taste, and audio.

Visual sensory details are often the most apparent component of students' interactions with nature. Elaborating on Kaplan and Kaplan (1989), Sop Shin

(2007) examined how forest views affect employee stress by studying windowed and non-windowed offices. Sop Shin (2007) found that participants 'who had opportunities to view forest scenery through windows from their workplace had less job stress' (p. 251). This benefit is applicable to students because both employees and students spend equally extended periods of time in enclosed spaces with often limited access to viewing nature. In agreement with Sop Shin (2007), Kahn et al. (2008) determined that viewing nature is beneficial for reducing student's mental fatigue; however, the study clarified that artificial nature does not appear to reduce mental fatigue. The experiment included a treatment with an empty wall and a treatment with an artificial window where participants in both treatment groups completed a series of tasks like proofreading and drawing for one hour. When participants 'looked longer out the glass window, they had greater physiological recovery; but that was not the case with the plasma window, where increased looking time yielded no greater physiological recovery' (Kahn et al., 2008, p. 198). This paper demonstrates that artificial nature does not appear to reduce student's mental fatigue; however, Kahn et al. (2008) overlooked benefits to participants' cognitive abilities. Benfield et al. (2013) explored this gap by examining students who met in classrooms with window views of a concrete wall and students in classrooms with window views of a grass field including blossoming trees. Students who had the ability to view nature 'rated the course curriculum, classroom resources, and classroom materials more positively than students with no natural view. Objective indicators of classroom attendance and course grade were not wholly supportive of natural views, but final course grades were shown to be higher in the natural window-view condition compared with the concrete view' (p. 149). Benfield et al. (2013) postulates that the natural views could be responsible for 'lowering student stress, restoring student attention, and/or enhancing the overall mood' (p. 153). Although the exact mechanism in which the benefits were realized is not clear, the relationship between natural views and higher final course grade could be further explored by research which seeks to incorporate artificial nature views.

Together, the work by Kaplan and Kaplan (1989), Sop Shin (2007), Kahn et al. (2008), and Benfield et al. (2013), demonstrate the academic and well-being benefits to students. Kaplan and Kaplan (1989) first demonstrated that interaction with nature causes students to remain attentive during classes by preventing mental fatigue. Sop Shin (2007) builds off Kaplan and Kaplan (1989) by revealing stress decreases when employees are situated near windows with forest views, while Kahn et al. (2008) demonstrated that this benefit cannot be replicated with plasma windows. Benfield et al. (2013) applies this line of research to students and shows how well-being and final course grades was higher in classrooms with nature views.

1.4 Implications of Nature Sounds and Smells

Olfactory and auditorial sensory details are often important components in students' exposure to nature. Understanding the benefits of sounds and smells associated with nature is important to narrow the gap between student's academic ability and wellbeing and their exposure to nature.

Students often read in the presence of talking, and teachers often allow students to listen to music while reading. Ylias and Heaven (2003) replicated the effect of talking by playing a television at a moderately loud volume while students read a passage and completed a questionnaire for eighty minutes. Most students reported 'being highly distracted by the operating television' (p. 1066). This paper supports the notion that television sounds, which included fluctuation in volume, is a distraction to students. In alignment with Ylias and Heaven (2003), Anderson and Fuller (2010) observed the effect of music on reading comprehension by administering reading comprehension tests to one group exposed to pop music and one group exposed to silence. The results of the study support the assumption that 'studying while listening to music detracts from the reading performance of adolescents' (p. 184). This paper demonstrates that pop music, is a distraction to students. While Ylias and Heaven (2003) and Anderson and Fuller (2010) agree that non-nature sounds like television and music can be

distracting students, no studies have explored whether nature sounds can serve as an alternative beneficial sound to students.

Incorporating nature smells into classrooms may allow for teachers to use the olfactory environment of classrooms to support academic growth and wellbeing. It must be noted there is significant variation how a nature smell is defined; however, one universal nature smell that has been known to reduce stress and anxiety is lavender. Sayorwan et al. (2012) investigated the effects of lavender oil on the central nervous system. The study concluded that inhalation of lavender oil 'significantly decreased the level of ANS arousal, namely, decreases of blood pressure, heart rate, and skin temperature' (p. 603). This paper supports the notion that lavender oil can be used to promote students' wellbeing. Expanding on Sayorwan et al. (2013), Donelli et al. (2019) examined the effect of lavender oil on anxiety. The meta- data analysis which included 13,157 participants showed 'a significant result in favor of lavender use for anxiety, either as a significant improvement from baseline within intervention groups' (p. 22). This paper demonstrates that the health benefits of lavender oil can be applied to students. Classrooms are in a unique position to attain these health benefits because of the considerable time students spend in them. While Sayorwan et al.(2013) and Donelli et al. (2019) agree that health benefits including reduction in anxiety occurs when exposed to lavender oil, both studies overlooked the effect of lavender oil on academic benefits. Current literature also remains unclear about the benefits of nature smells other than lavender oil.

The work by Ylis and Heaven (2003) demonstrated that television audio reduces reading comprehension scores in students, while Anderson and Fuller (2010) provided support that music acts as a distraction for students. For nature smells, Sayorwan et al. (2012), and Donelli et al. (2019) furthered the pool of research that lavender oil reduces anxiety.

1.5 Formulation of Research Objective

An underexplored method for fulfilling students need for nature is to integrate elements of outdoor classrooms in the traditional classroom setting through artificial nature. As seen from the work by Benfield et al. (2013) and Kahn et al. (2008), students across grades see academic benefits in terms of heightened motivation to read and increased attention to classwork. Ylias and Heaven (2003), and Anderson and Fuller (2010), demonstrated that both television sounds and music can disrupt students' ability to concentrate. Although the presented literature shows how individual nature sensory details establish academic and wellbeing benefits for students, it is unclear whether this relationship remains when these sensory details are combined or artificially replicated. This line of reasoning led to the research question: can sensory details from nature be artificially incorporated into a classroom to benefit students' reading comprehension and wellbeing?

1.6 Hypothesis

The null hypothesis is that sensory details which artificially replicate nature in a classroom has no effect on student's reading comprehension and wellbeing.

The alternative hypothesis is that sensory details which artificially replicate nature in a classroom improves student's reading comprehension and wellbeing.

2. Materials and Methods

2.1 Mixed-method Research

Quasi-experimental research and survey research worked together to test the null hypothesis. Quasi-experimental research was used to test for the academic benefits component of the hypothesis. While experimental research design would have helped to eliminate bias in the research, it was not as feasible to implement since it required the permission of more students and teachers. A survey was used to test for the benefits to wellbeing component of the hypothesis. While semi-structured interviews would be more effective at gaining additional depth, they would not be as effective at obtaining quantitative results.

2.2 Quasi-experimental Research

Quasi-experimental research design is a valuable tool because it is more feasible to conduct the current study with a smaller participant pool. Quasi-experimental research tests the null hypothesis by introducing a treatment to non- randomly divided participants. Kahn et al. (2008) exemplifies the use of quasi-experimental research as they non- randomly divided participants into baseline and treatment groups to determine the effect of artificial windows on wellbeing. The method by Kahn et al. applicable to this study because both studies aim to examine the possible effects of a treatment on a small population.

Following consent by an eleventh-grade English teacher, the experiment was planned to occur in one English period for one school week. The experiment consisted of two baseline trials and two treatment trials in the following order: baseline in classroom, baseline in media center, treatment in classroom, treatment in media center. There was a gap day between the baseline in classroom and baseline in media center because the class did not meet. No informed consent was needed for this component of the quasi-experimental research because the classwork was integrated into the curriculum. The media center is included in the experimental design to test whether a change in the classroom setting produces any academic or well-being benefits. The classroom used in the experiment was the same classroom used by the students for their entire school year.

The treatment aimed to replicate three sensory details of nature: visuals, sounds, and smells. A nature video (https://www.youtube.com/watch?v=xNN7i TA57jM) was selected to replicate the visual and sound sensory details of nature. This specific video was chosen because of the subtle variation in volume and the visual was deemed to be non- distracting. A Smart Board was used to project the video while speakers were used to project the audio of the video in the classroom and media center. The Fresh Waters Scented Oil Airwick was chosen to replicate the olfactory sensory detail of nature. It was deemed to be a non- overwhelming natural smell and its similarity to the Lavender Oil Airwick which is known to reduce anxiety. It was plugged into the wall of the classroom and media center. Reading comprehension was measured by using an online platform named NewsELA. This platform distributed articles for students to read and annotate on their school-provided laptops, and when finished students answered multiple choice questions and free-response questions. The multiple-choice grading was done by NewsELA and the open-ended was graded by the teacher. NewsELA was chosen because students were familiar with using the platform from previous classwork.

2.3 Survey Research

Surveys are a valuable tool for testing the hypothesis because it gives insight into the benefits to student's wellbeing and perception of the treatment. This method directly tests the wellbeing component of the research hypothesis because it allows students to self-report wellbeing, which is the best way to measure unobservable components of wellbeing like emotions. Benfield et al. (2013) exemplifies the use of surveys when testing the impact of classrooms with window views to nature. Following the completion of a course, participants took a survey which gauged their opinions about having access to a view of nature. This is applicable to the current study because both surveys are given at the end of a treatment period to young students in a school environment.

An institutional review board authorized the survey and participants were made aware of a survey the class period following the completion of the experiment. An informed consent letter was provided to the participants which they took home and got signed by a guardian. Students were offered a participation grade as an incentive for completing the survey. Over the course of a week, students brought the informed consent letter to the teacher and then completed the survey. The purpose of the survey was to gauge student interest for incorporating artificial nature sensory details into classrooms and whether they witnessed any benefits to their wellbeing. The Microsoft Forms online survey was used because it was easier to tabulate results and ensure the uniqueness of each data point.

2.4 Replicability

For this method to be replicable, three crucial conditions must be met. The first condition is that high school language arts classes, specifically upperclassman, must be the participants. The current study does not account for variation in age. The second condition is that the setting of the participants must be a traditional classroom with windows on one wall and LED lighting. This condition is important because students whose settings often change may react differently to the introduction of nature sensory details. The third condition is that any classwork or tests provided to students must be given online. A key component of student's routines in this English class was using their computers to complete classwork. There can be variation in how students react to the introduction of nature sensory details based on what medium they complete classwork.

3. Results

Data was omitted when students were unable to participate in both the pre-treatment and post-treatment assignments in either the classroom or the library.

A dependent samples t-test, which compares the mean (*M*) scores between the pre-treatment and post-treatment, was used to determine whether a change occurred when applying the treatment. Standard deviation (*SD*) represents the variation in scores, and the P-value describes the probability that the results are by chance.

3.1 Quiz Scores

To test the null hypothesis that pre-treatment (M = 86.538, SD = 14.544) quiz scores were the same post-treatment (M = 87.5, SD = 20.31) scores in the classroom, and pre-treatment (M = 79.63, SD = 27.767) quiz scores were the same as post-treatment (M = 87.963, SD = 26.285) scores in the media center, a dependent samples t-test was performed. Table 1 depicts the results of the dependent samples t-test when applied to the change in quiz scores.

Table 1. Treatment does not change quiz scores.

	Sample Mean (*M*)	***SD***	**T-score**	**Alternate Hypothesis**	**P-value**	**Statistically Significant**	**Margin of Error**
Classroom (n=26)	0.962	20.592	0.24	$M > 0$	0.4068	No	1.931
Media Center (n=27)	8.333	41.603	1.04	$M > 0$	0.1538	No	16.657

α=.05

As seen by Table 1, the null hypothesis failed to be rejected in the classroom, $t(25) = .24$, $\alpha < .05$, and failed to be rejected in the media center, $t(26) = 1.04$, $\alpha < .05$. Thus, the change in quiz scores were not statistically significant in either the classroom or media center.

3.2 Annotations

To test the null hypothesis that the pre-treatment (M = 17.962, SD = 10.278) number of annotations was the same as the post-treatment (M = 20.231, SD = 9.275) in the classroom, and pre-treatment number of annotations (M = 10, SD = 4.923) was the same as the post-treatment (M = 7.852, SD = 4.785) in the media center, a dependent samples t- test was performed. Table 2 depicts the results of the dependent samples t-test when applied to the change in the number of annotations in the classroom and media center.

Table 2. Treatment may change number of annotations

	Sample Mean (*M*)	***SD***	**T-score**	**Alternate Hypothesis**	**P-value**	**Statistically Significant**	**Margin of Error**
Classroom (n=26)	2.269	8.398	1.38	$M > 0$	0.0903	No	4.542
Media Center (n=27)	-1.778	2.94	-3.14	$M < 0$	0.0021	Yes	3.555

α=.05

As seen by Table 2, the null hypothesis failed to be rejected in the classroom, $t(25) = 1.38$, $\alpha < .05$. The null hypothesis was rejected in the media center, $t(26) = -3.14$, $\alpha < .05$, but since there was a decrease in annotations, the alternative hypothesis was also rejected. Thus, the change in the number of annotations was not statistically significant in the classroom while the post-treatment was statistically significantly lower than pre-treatment in the media center

3.3 Writing Scores

To test the null hypothesis that the pre-treatment ($M = 2.846$, $SD = 1.156$) writing scores was the same as post- treatment ($M = 3.308$, $SD = 0.838$) in the classroom, and pre-treatment writing scores ($M = 2.667$, $SD = 1.109$) was the same post-treatment ($M = 2.111$, $SD = 0.934$) in the media center, a dependent samples t-test was performed. Table 3 depicts the results of the test when applied to the change in writing scores in the classroom and the media center.

Table 3. Treatment changes writing scores

	Sample Mean (*M*)	***SD***	**T-score**	**Alternate Hypothesis**	**P-value**	**Statistically Significant**	**Margin of Error**
Classroom (n=26)	0.462	1.208	1.95	M > 0	0.0312	Yes	0.924
Media Center (n=27)	-0.556	1.251	-2.31	M < 0	0.0146	Yes	1.112

α=.05

As seen by Table 3, the null hypothesis was both rejected in the classroom, $t(25) = 1.95$, $\alpha < .05$, and in the media center, $t(26) = -2.31$, $\alpha < .05$. The alternative hypothesis was accepted in the classroom. The null hypothesis and the alternative hypothesis were both rejected in the media center because writing scores significantly decreased. Thus, the writing score was statistically significantly higher post-treatment in the classroom than pre-treatment, while statistically significantly lower post-treatment in the media center than pre-treatment.

3.4 Wellbeing

Sixteen students completed the survey. Table 4 details the results of the first four questions which gauged student's preferences of the treatment components.

Table 4. Student preferences of treatment components

Stimulus	**Prefers**	**Does not Prefer**
Forest Sounds	2	14
Forest Video	2	14
Airwick	6	10
Classroom	6	10
Media Center	10	6

Table 4 presents the finding that most students do not prefer forest sounds and forest video while they are reading. Table 4 also indicates that while some students prefer the Airwick while reading, most students do not prefer it.

There was one open-ended question to gauge what would make students feel most comfortable while reading. One response was omitted because it was unrelated to the survey. Seven out of the fifteen responses discuss music while six discuss no sounds or some semblance of quietness. Unique responses included exposure to sunlight, not having pressure to read, comfortable temperature, different chairs, and using paper instead of a laptop.

4. Discussion

4.1 New Understandings

Based on the quasi-experimental research, it is now understood that it is unlikely students' reading comprehension is improved when exposed to a treatment which artificially replicates nature sensory details. Table 1 indicates that student's quiz scores does not change in either the classroom or the media when exposed to the treatment. Table 2 indicates that student's annotations do not change in the classroom and decreases when in the media center. While Table 3 shows writing scores increased for students in the classroom, writing scores in the media center

decreased when exposed to the treatment.

Based on the survey research, it is now understood that it is unlikely that students' wellbeing improves when exposed to the treatment. Although more students preferred reading in the media center over the classroom, Table 4 indicates that most students did not prefer the treatment. Responses to the open-ended question add that students often feel most comfortable when exposed to either music or no sound as opposed to any artificially replicated nature sensory detail.

4.2 Fulfillment of Gaps in Research

While Benfield et al. (2013) and Sop Shin (2007) both analyze the effect of nature views on study participant's well-being and academic ability, neither consider the effect of artificial nature views. Moreover, although Kahn et al. (2008) considers the effect of artificial nature views on participant's well-being, their study is not targeted toward students. This study fills the gap by focusing only on students and by specifically addressing artificial nature views, which has been shown does not likely benefit students' reading comprehension or wellbeing.

No studies have been conducted on the relationship between artificial nature sounds and students. Although Ylias and Heaven (2003), and Anderson and Fuller (2010) showed different ways sounds can distract students, neither focuses specifically on artificial nature sounds. This study fills this gap by incorporating artificial nature sounds and showing how it is unlikely they benefit students' reading comprehension or wellbeing.

Although Sayorwan et al. (2012). and Donelli et al. (2019) agree that health benefits occur when exposed to lavender oil, no literature has applied lavender oil or other similar substances to the classroom environment and examined their impacts on students. This study fills this gap by implementing the Airwick in the treatment and by showing it does not likely have a benefit on students' reading comprehension or wellbeing.

4.3 Limitations

On the quasi-experimental research method, while this study was originally designed to include lavender oil, which the literature review had outlined benefits for student's wellbeing, logistical barriers prevented its implementation and Airwick already used by the teacher was used instead. Although the Airwick was deemed to be similar enough to a lavender oil smell, it may not have maximized wellbeing benefits for students.

On the findings, while the reading-level and the subject remained constant among the four articles, variation in the difficulty of the quiz and open-ended questions may have skewed the findings. It is also unclear whether cofounding factors like hours slept, sickness, or stress levels caused variation in the results between the four trial days. While it is difficult to account for all cofounding factors that may cause variation in test results, it is important to recognize that the test results between trials may not have been directly comparable to one another. Moreover, the non-random selection of the English class and the small sample size limits the generalizations this study can make. The non-random selection of the English class means it is difficult to recognize how well the study represents the total student population. Because the null hypothesis was tested only by examining high school students, this study may not be representative of students across age groups. Cofounding variables, non-random selection, and a small sample size means teachers and curriculum writers should view the findings of this study cautiously.

5. Conclusion

5.1 Implications

Teachers should reconsider replicating nature in the classroom through projectors, speakers, and Airwicks if their goal is to improve reading comprehension and wellbeing for students. This study concluded that there was no significant increase in reading comprehension as it was measured through quiz scores, writing scores, and number of annotations. It also found that student wellbeing did not improve as most students disliked the changes to the classroom environment according to the survey. Although it should be noted that students seemed to

prefer the media center over their traditional classroom, teachers should weigh whether the possible increase in wellbeing is worth the possible decrease in reading comprehension.

In alignment with Anderson and Fuller (2010), this study calls into question the role of music in student reading comprehension and wellbeing. Because students were able to listen to music during the baseline trials and unable to listen during the treatment trials, it is probable that the absence of music is a factor that increased reading comprehension.

For teachers and curriculum writers who are deciding how to expose students to nature, it is recommended that they look toward natural ways of exposing students to nature like holding outdoor classes and increasing exposure to windows as opposed to replicating nature artificially in the classroom.

5.2 Areas of Future Research

The quasi-experimental method used by this study does not account for variation for age of students, their academic track (b level, a level, or honors), or time slept. Future research should focus on collecting data on these cofounding factors to explore whether there is variation in the effects of the treatment on students. Future researchers should also expand upon this study by implanting experimental research design so their study can be representative of the student population.

As indicated by the responses to the open-ended survey question, future research should also focus on the sound of rain, silence, and their effect on improving reading comprehension and wellbeing. If students indicated that they prefer reading under those conditions, then it is likely there could be an increase in wellbeing.

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Colonialism: Colonization's Impact on Indigenous Family Life

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Abstract

Assimilation was required by Indigenous North Americans and Africans in response to European colonization, serving the needs of the colonizers but irreparably disrupting Indigenous family life like increased parental stress, changes to the underlying family structure, and family division. This research paper provides supportive underlying assertions with references to Achebe's *Things Fall Apart* and four journal articles. The author contends that only through decolonization and reconciliation can Indigenous peoples reverse some of these negative consequences. Indigenous people can reclaim their cultural and psychological freedoms through decolonization to obtain their sovereignty, like self-manage their land, culture, customs, and political systems.

Keywords: Colonization, Indigenous Family Life, Boarding Schools, Parental Stress, Family Unit, Religious Conversion

1. Introduction

Viewed as uncivilized savages and persistent obstacles to expansion efforts by their European colonizers, Indigenous North Americans and Africans were forced to assimilate into their colonizer's culture to become "productive assets." However, the consequences of assimilation for Indigenous peoples went well beyond the original intention. How did colonization specifically impact family life, central to Indigenous livelihood? This paper argues that colonization disrupted the strength of Indigenous family relationships by exacerbating parental stress and instability, fundamentally redefining their culture's family structure for future generations, and creating unnecessary division within the family.

2. Adding Parental Stress and Instability

Colonization fundamentally damaged relationships among family members by creating heightened mental stress felt by parents, in addition to the removal and subsequent reteaching of Indigenous children. First, colonization placed undue stress and burden on fathers by altering their family roles in nontraditional ways and undermining their ability to showcase their masculinity. We can see this change in Chinua Achebe's novel *Things Fall Apart*. Prior to the arrival of white missionaries, the confidence of Igbo male leaders was comparatively higher. However, the presence of European missionaries provoked a feeling of emasculation in Igbo men due to the removal of their power by outside forces, resulting in increased domestic violence within families. Although some may argue that conflict is a natural element of family life, others argue that any level of domestic violence is mentally harmful to the victim and children, normalizing these behaviors and creates family insecurities, tensions, and immediate fear. When these colonial values contrast with the critical role mothers played within Indigenous families, parental identity and balance are

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sacrificed, and any semblance of stability may be compromised. For example, in *Things Fall Apart:*

> *Okonkwo encouraged the boys to sit with him in his obi, and he told them stories of the land-masculine stories of violence and bloodshed. Nwoye knew that it was right to be masculine and be violent, but somehow he still preferred the stories that his mother used to tell... (Achebe, 2009)*

Like other colonized Indigenous people, Nwoye was conflicted as he needed to make the binary choice between his father and mother, masculinity and femininity, and expectations and desires, making it challenging to forge his own sense of identity, happiness, and independence. The repercussions of adhering to unfamiliar colonial expectations that conflict with prior life experiences can lead to parental mental health issues and substance abuse. These issues are supported by interviews with Indigenous women, who attribute these factors to historical experiences of oppression (Burnette, 2016, p. 364).

3. Redefining the Family Unit

Indigenous family structures were disrupted and redefined by colonization, causing foundational uncertainty regarding family member roles and responsibilities. Missionaries and colonizers imposed a model of what constitutes an acceptable family on cultures whose own model might differ wildly from the paternally headed nuclear family-oriented system seen in Europe. The "full reversal of the matrilineal and female-centered values that structured many [pre-colonial] indigenous communities" and subsequent increase in destructive behaviors by male partners created additional family responsibilities and ongoing stress for Indigenous women (Burnette, 2016, p. 365). Women were measured and judged by their ability to adhere to unfamiliar colonizer-centric standards regarding home keeping, family life, and morality. As noted by Dunstan et al. (2020), legal policies favoring this family model have "repeatedly called attention to the 'gaps' between the ideal family and Indigenous ways of doing family life and sought to disrupt and reshape Indigenous family life, mothering and caring for children towards ideals of nuclear family structures and intensive parenting" (p. 339). Changing the underlying structure of the family unit to be more insular and self-contained opened the possibility of family members feeling alone, isolated, and unsupported. Although one could argue that a nuclear family creates benefits like "good citizenship and access to welfare" (Dunstan et al., 2020, p. 330), for some Indigenous cultures, a nuclear-style family unit shifted against historical concepts of Indigenous kinships and communities that support family well-being. Kinship is an essential support mechanism to address the needs of Indigenous families, often by providing help with child-rearing. For instance, another case study reveals that within Indigenous communities

> *It was common and desirable for extended family members, especially grandparents, to take in and raise their kin… and therefore if an Indian woman did have a child that she could not care for, "there is often a willingness on the part of grandparents or other relatives to take the child." (Jacobs, 2014)*

Kinship ties spread across an extended family network fosters a sense of community and enables broader support for children's well-being and emotional needs by "encouraging a more multi-levelled idea of family that overlies nuclear relationships" (Dunstan et al., 2020, pp. 324-325).

4. Moving Children to Boarding Schools

Family structures and communities were further eroded when colonizers removed Indigenous children from their families and forced them to attend special boarding schools. These schools, which are now perceived as educational failures, existed across North America and had the primary goal of assimilating Indigenous students into Anglo culture by breaking their allegiance and closeness to their families, ancestry, heritage, and customs (Feir, 2016, p. 133). Many would argue that the permanence and continuity of stable family life provide a child with the support, encouragement, and mentorship that fosters learning and thriving in their activities and emotional and intellectual development. Children removed from their homes and subjected to new cultural and social norms must cope with massive

changes few can withstand, potentially resulting in low self-esteem, insecurity, and isolation. The colonial mindset behind Indigenous boarding schools can be seen in the character of Mr. Brown in *Things Fall Apart*, who "learned a good deal about the religion of the clan and he came to the conclusion that a frontal attack would not succeed. And so he built a school and a little hospital in Umuofia" (Achebe, 2009, p. 155). Like colonial governments in North America, Mr. Brown recognizes the difficulty of changing Indigenous behavior and beliefs and decides to build a school where he can indirectly affect cultural and religious change. Within a school environment, children learn academic skills and are also socialized to follow cultural rules, behaviors, and protocols. When these rules contrast with one's family life or upbringing, this may cause confusion, inferiority, and inadequacy in the child. In 1926, the Institute for Government Research authorized a commission to survey the conditions of Indigenous people on nearly all reservations throughout the United States. The subsequent report, published in 1928, was highly critical of Indigenous boarding schools, deeming their provisions for the care of Indigenous children as "grossly inadequate" and noting that child removal "largely disintegrates the family and interferes with developing normal family life" (Jacobs, 2014, Prologue).

Some scholars argue the benefits of boarding school, claiming "residential schools generated a culturally-connected and educated elite that spent their careers fighting for Indigenous rights" (Feir, 2016, 435). Although it may be true that a small percentage of Indigenous students attending boarding school may have succeeded in this regard, one may also want to consider how the majority of Indigenous students fared. It should also be noted that the existence of boarding school alumni with positive experiences does not compensate for the overall detrimental effects these schools had on Indigenous children and their families. Ultimately, we must consider whether the benefits outweighed the costs in the long term.

5. Changing Core Beliefs

Colonization can also alter core belief systems like religion and cultural practices, thereby creating a divide within the family and making it difficult for family members to maintain the conviction of their heritage, customs, and traditions. This division may have lasting implications for future generations. Children during the initial colonization might not gain enough cultural knowledge to teach their future children, resulting in a legacy of fractured and adulterated interpretations that deviate irreparably within and among families. With the support of colonial governments, Christian missionaries worked relentlessly to convert Indigenous people by preaching, building churches, and providing services and other benefits. Indigenous families and communities were further divided when members subscribed to differing religious beliefs. For example, from *Things Fall Apart*, Nwoye converts from his native religion, Chukwu, to Christianity, unlike the rest of his family. This change would presumably influence his cultural and heritage viewpoints and affect what religious and other core beliefs he and his future family would have. Nwoye's spirituality following his conversion is profound:

> *It was not the mad logic of the Trinity that captivated him. He did not understand it. It was the poetry of the new religion, something felt in the marrow… He felt a relief within as the hymn poured into his parched soul. (Achebe, 2009)*

Regardless of the sincerity of a conversion, when family members have deep yet divergent religious beliefs, everyday decisions and actions made by individual family members may create conflict within the family. This change has more significant implications when aggregated and applied at the community level. It may make it difficult for the community to have shared values and interests that bind and allow for positive progress. By introducing and encouraging a new religion alongside reinforcing governmental laws and rules, Indigenous parents and children may lose a level of familiarity and closeness. This loss is seen in *Things Fall Apart* when Okonkwo's close friend Obierika notes

> *Our own men and our sons have joined the ranks of the stranger. They have joined his religion and they help to uphold his government. If we should try to drive out the white men in Umuofia we should find it easy… But what of our own people*

who are following their way and have been given power? They would go to Umuru and bring the soldiers, and we would be like Abame. (Achebe, 2009)

Abame was a village destroyed by British colonizers and local collaborators following the murder of a white man, and Obierika fears the same fate will befall them if they try to drive out the colonizers in their own village.

6. Conclusion

The impacts colonization had on familial relationships and mental health were immediate and felt by future generations. By challenging Indigenous core belief systems, colonization confused and disrupted traditions regarding parental identity, parent-children intimacy and separation, divergent core beliefs. It may have instigated a fundamental redefinition of what was considered a sufficient family unit structure. It appears that only through decolonization and reconciliation can Indigenous peoples reverse some of these negative consequences. Indigenous people can potentially reclaim their cultural and psychological freedoms through decolonization to obtain their sovereignty, like self-manage their land, culture, customs, and political systems. It seems that it ought to be the responsibility of colonizer governments to allow Indigenous people to reclaim what they have lost so that their cultures don't disappear, and family relationships and structures are strengthened, taking ful responsibility for these challenges and repercussions. Will they allow for the decolonization of and provide support to Indigenous peoples and future generations so that healing can occur? Perhaps as a first step, colonizing governments can return Indigenous lands so that Indigenous families can return and live with complete autonomy. Further exploration is recommended on the practical steps of decolonization, what programs would best support these steps, and what additional factors ought to be considered for each Indigenous group.

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Assessing the Influences of Social Media on Youth Civic Engagement

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Abstract

Social media is a Web 2.0 platform that has become a permanent influence on the daily lives of adolescents, becoming one the key influencers in crafting the thought processes, values, and beliefs of youth. One of the biggest influences social media plays on youth is guiding their level of civic engagement and their political values. This paper analyzed the current research published surrounding the topic of social media and youth civic engagement and examined the multitude of factors in which social media constituted either a positive or negative influence on youth civic engagement. Some major findings which highlight the positive effects of social media include increased civic engagement, voter turnout, and education in socio-political issues. Conversely, negative influences of social media on youth civic engagement include exposure to echo chambers which can deepen political polarization, proliferation of fake news, and increased feelings of stress and depression when encountering political media. Aside from the influences, the paper also presents solutions and suggestions to mitigate the issues of social media and brings to light multiple gaps and limitations within the research. By understanding how social media can shape youth's sense of political standings and obligations as a society we will be able to harness the positive connections to direct towards ensuring social media is an accessible and empowering tool for civic engagement simultaneously working to mitigate and subdue the negative aspects of technology on civic involvement to significantly improve civic participation.

Keywords: Social Media, Youth Civic Engagement, Positive Influences, Negative Influences, Web 2.0

1. Introduction

For a long time, the decline in voter turnout for youth was a key issue that worried not just political and social scientists, but also the general population. Youth were long accused of being politically apathetic and failing in their duty as a citizen to uphold democratic values. Research showed that young people were less likely to participate in politics than older people, with youth voting at a 25% lower frequency than the US population ages 65 and up. But emerging research has uncovered that this trend of insufficient youth civic engagement has long taken a turn. For example, the 2018 congressional elections created headlines due to historic numbers of youth showing up to vote in the midterm elections (Table 1). Statistics show that youth voter turnout was the highest in four decades, with Minnesota and Montana having the highest voter percentage increase of 20.7% and 24.5% increase respectively, breaking records in many states (Ginsberg et.al, 2021). This trend in increased youth civic engagement was already beginning to grow prior to 2018, and since then has successfully sustained itself with continued high rates of young people showing up at voting polls and exercising their democratic rights in each election. So, then the question is, just what is contributing to this historical increase in youth civic

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engagement?

Research shows that in today's day and age, youth are increasingly tapping into the power of new digital tools and social networks to merge their cultural interests to politics, express their perspective, and protest and influence issues of public concern (Chapman, 2019). The most popular digital technology utilized by youth (classified in our study as members of the population ages 13-24) to engage in civics and politics is social media. Social media is a Web 2.0 form of technology exclusively defined as interactive digital channels which facilitate the creation and sharing of information, ideas, interests, and other forms of expression through virtual communities and networks ("Social Media Overview", n.d.). The term Web 2.0 defines second generation web applications which facilitate interactive information, sharing, interoperability, user-centered design, and collaboration on the World Wide Web (Kenton, 2022). Under this definition, social media encompasses social networking sites (e.g., Instagram, Snapchat, Facebook, TikTok), messaging apps (e.g., WhatsApp, WeChat, Kakao Talk, etc), social gaming tools, YouTube, and more. Approximately 97% of youth use at least one platform of social media with the most popular sites currently being YouTube (85% frequency usage amongst teens), Instagram (72% frequency usage amongst teens), and Snapchat (69% frequency usage amongst teens). It's also important to note that emerging platforms are frequently being introduced, with some (i.e., TikTok) quickly gaining worldwide traction among youth. For adolescents growing up today, exposure to screens begins early in life. US children under the age of two spend an average of 42 minutes per day with screen media. By the time youth reach adolescence, most are fully immersed in the world of technology. The latest national representative statistics suggest that 95% of adolescents ages 13-18 have access to a smartphone and 88% have access to a desktop or laptop at home. In 2018, a measure of 45% of adolescents reported that they were "almost constantly" online, a large percentage increase from just 24 per cent only three years prior (Nesi, 2020).

Table 1: During the 2018 Congressional Elections a record amount of youth turned up to the polls to vote ("2018 Youth", 2019).

	State	2018 Youth Turnout Rate	2014 Youth Turnout Rate	Percentage Point Increase	Youth Turnout Increase Higher than All-Ages Turnout Increase?
1	Minnesota	43.7%	23.1%	20.7 pts	Yes
2	Montana	42.1%	17.6%	24.5 pts	Yes
3	Colorado	40.8%	27.6%	13.1 pts	Yes
4	Oregon	39.2%	27.4%	11.8 pts	Yes
5	Maine	36.4%	30.5%	5.8 pts	Yes
6	Washington	35.0%	16.4%	18.6 pts	Yes
7	Iowa	34.7%	22.1%	12.6 pts	Yes
8	Virginia	33.4%	13.1%	20.2 pts	Yes
9	Massachusetts *See notes below*	33.3%	16.0%	17.3 pts	Yes
10	Georgia	33.0%	13.3%	19.7 pts	Yes
11	New Jersey	32.8%	11.1%	21.8 pts	Yes
12	Michigan	32.7%	15.3%	17.4 pts	Yes
13	Florida	31.5%	18.3%	13.2 pts	Yes
14	Connecticut	30.6%	15.3%	15.4 pts	Yes
15	California	30.3%	10.3%	20.0 pts	Yes

On the other hand, civic engagement is broadly defined as participation in activities and discussions related to policy and politics. Oftentimes civic engagement is cited as an indication and attention toward improving the community; this effort may include electoral political acts— such as voting or contacting elected officials—but also fewer formal acts such as following politics (Middaugh et.al, 2019). However, in looking at civic engagement in youth today, it is not enough to simply assess youth's civic engagement using traditional measurement scales. Rather, it is important to differentiate between traditional civic engagement and an emerging variant of civic engagement: digital civic engagement. Scholars have found that young people may be abandoning traditional forms of so-called 'dutiful' citizen participation (such as neighborhood policy meetings, party membership, newspaper reading, etc.), in favor of a more personalized politics of self-actualization and expressive engagement with greater emphasis on non-traditional modes of engagement such as digital networking, volunteering, and consumer activism (Kahne et.al, 2016). To address this gap in literature, I analyzed the civic engagement activity of youth mostly under the scope and context of the new variant of civic engagement, digital civic engagement but also keeping in mind traditional forms of civic engagement as well.

In order to create a stable foundation for cultivating the next generation's civic actors, it is important to assess civic engagement and the prevalence of the topic amongst youth. Education and exposure to civic issues and topics from an early age is paramount for creating a generation of civic minded individuals. With increasing research pointing to social media as being a major source of this early education and exposure to civics, the aim of this study is to assess the overall influence of social media on youth, taking into consideration all positive and negative effects, present solutions and suggestions on how to mitigate the negative effects, and point out the gaps and limitations that need to be addressed.

2. Results and Discussion

Social media proves to have mixed results in literature with regards to impact on youth civic engagement; there are several aspects of social media which showcase the beneficiaries of social media on youth political exposure and participation, but there are also aspects of social media in which a negative effect is also imminent. Through my literature review, I have compiled a descriptive list of the prominent aspects of social media that multiple researchers have repeatedly cited as effects of social media usage on youth civic engagement. In this review, the aspects are organized into two definitive categories: positive and negative consequences of social media usage on youth civic engagement. Using these two categories I evaluate the true effects of digital media upon youth civic involvement.

2.1 Positive consequences of social media usage on youth civic engagement

Social Media engages youth civic engagement

Multiple scientific studies show that social media activity promotes heightened participation in youth civic engagement (Cho et.al, n.d.; Kahne et.al, 2016; Middaugh et.al, 2017). It is believed that social media has become the most accessible hub of information available to youth, thus becoming a critical repertoire due to its ability to allow youth to find, discuss, and mobilize around political issues. To prove this statement, researchers have conducted multiple systematic analysis on a few different study pools to investigate just how thorough the effects of social media is on the frequency and distribution of participatory politics. Using the 2013 Youth and Participatory Politics (YPP) Survey, one study used the data's representative sample of 2,343 youth respondents (ages 15-27) and measured the conceptual understandings of youth civic engagement and how it was emerging with digital media. The study also supplemented the analysis with data for the Pew Internet and American Life Project Survey, which included 2,251 respondents, of which 125 were between ages 18-24, and 2,253 respondents, of which 232 were ages 18-24. The overall reports indicated that 67% of youth (ages 18-24) vs 39% of adults, were recorded having engaged in civic and political activities using social networking sites. The 2014 YPP Survey also found that 36% of youth in

between the ages of 15-18 engaged in at least one act of digital participatory politics within the previous year, with 6% choosing to work on an election campaign and 4% donating money (Kahne et.al, 2016). This indicates that social media is the main form in which youth connect to politics, and as social media usage grows so does the percentage of youth involved in civics. With the systematic analysis indicating just how powerful the influence of social media is upon youth civic engagement, it is easy to credit this heightened interest of civic engagement to increased proliferation of civic content online. However, it has been found that online youth participation, even when it is not explicitly political in nature, can correlate to higher political engagement in both online and offline circumstances. This is because youth digital participation is peer-centered, interest-driven spaces. For example, young people who connect over shared non-political interests such as fandom spaces and other 'affinity networks' are directly correlated to higher political engagement, online and off. In fact, a Swedish study of youth ages 13-17 discovered that participation in creating user-generated content were strong predictors of political participation (Cho et.al, n.d.). Humor, memes, satire, and other engaging pop culture practices are used by youth for digital civic engagement, facilitating mass participation in civics online. In fact, figure 1 highlights the main core practices of participatory politics which youth engage in to be more active on political society.

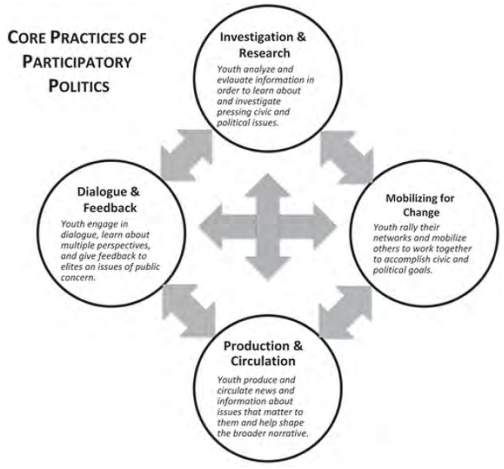

Figure 1. Core practices of participatory politics utilized by youth to increase civic engagement (Kahne et.al, 2016).

Social Media serves to rally youth together

For global scale movements of political protest to take place, such as the Black Lives Matter Movement (BLM), social media plays a crucial role in galvanizing youth together to affect these movements and grow them into world-wide events. In the first large-scale quantitative survey of adolescents' exposure to BLM demonstrations, 4,970 youth across the country (mean age of 12.88) indicated that they were highly engaged in the social media movement of BLM. Social media was used 30% of the time to engage with the BLM movement, particularly during covid-19 when many people could not physically attend protests and social media became an indispensable tool to continue to hold people accountable. From July 2013 to March 2016, youth used 13.3 million tweets in total to show solidarity and involve themselves with the BLM movement. It is evident that social media has played a massive role in creating global participation of youth in political movements. It should be also noted that this massive collectivization does not go unnoticed by legislators and lawmakers. Groundbreaking legislative changes have been created to combat the issues that these massive political movements seek to address. For example, the shooting of Michael Brown, an unarmed 18-year-old in Ferguson, Missouri, elicited a wave of protests which were tweeted about in the US more than any other major event in 2014. The result was forty policing laws in 24 states changing in the year following Michael Brown's death (Tupper, 2014). Another example can be seen in the February 2018 institution of the #NeverAgain movement, where social media was used to organize and create the March for Our Lives in cities across the United States. Research shows that when it comes to developing a strong connection for youth to civics, it's important to allow youth members to see that the challenges they face are collective problems (Middaugh, 2019). This is because when youth experience how they are not alone in the issues they face their participation in online public discourses and discussions serve the goal of democracy as they are able to find information and perspectives beyond what is deemed important by elites. This personalization of politics helps create an authentic interest in civics amongst youth, providing an

increased chance of them participating in civics for a prolonged period. Research articles have also illuminated how when individuals speak up and combine their voices with those who have similar outlooks and thoughts, elected officials are pressured to be more responsive (Bennett & Segerberg, 2012; Ginwright et.al, 2006; Middaugh, 2019). When expressing concerns and perspectives in a collective manner, it can help for developing civic skills for future citizenship, influence public policy, and enhance one's own civic confidence and interest. This leads to more general positive developmental outcomes, especially amongst marginalized youth. As seen in previous examples, in both movements' youth used social media to circulate information and perspectives, mobilize others to get involved, apply pressure to elected officials, and change the conversation about fundamental societal issues. Social media has truly become an indispensable tool used to congregate people together to support political issues on a world stage.

Social Media can allow youth in developing countries to organize for mass protests and call for change

Building on the topic of social media allowing youth to rally together is the fact that, for youth in emerging countries, social media has provided a means for people to organize nationwide to conduct protests or fight against oppression. Countries such as Egypt, Iran, Tunisia, and Hong Kong have had research documenting the effectiveness of the usage of social media to discreetly fight against the government. The infamous 2011 Egyptian Arab Springs, or otherwise known as the January 25, 2011, revolutions provide plentiful research on the influence of social media on an actual nationwide protest. One study on the Egyptian Arab Springs found that in 2009, only half of the population in the Middle East and North Africa supported the fundamental democratic freedoms such as speech, assembly and religion, however in just two years' time there were emergences of mass uprisings against Egypt's authoritarian regimes that were calling for freedom of speech and religion that quickly became known as the Arab Springs. It was found that social media such as Facebook, Twitter, and YouTube played important roles in transforming organized groups and informal networks, establishing external linkages, developing a sense of modernity and community, while simultaneously drawing global attention. The study also supplemented their understanding of social media relative to other factors facilitating the participation in the Arab Springs by analyzing data from the March-April 2011 Gallup poll of a representative sample of Egyptians over the age of 14. Results found that information sources such as the internet and social media were considered "New media sources of information" and they were favored by demonstrators more than by sympathetic onlookers, with 18% of demonstrators favoring text messages, 16 % favoring news websites, and 12% favoring Facebook/ Twitter. A sample of 800 social media posts were also uncovered over the period of January 25 - February 12 which emphasized the suffering and rage that were motivating the people to collectivize and rebel. As far as the popularity of which social media platform was used the most frequently by youth during the Arab Springs, Facebook and Twitter were the most popular, with 23.2% frequency usage rate and 13.4% usage rate respectively, and YouTube was the third leading popular platform with 11.2% usage (Brym et,al, 2014). Aside from the Arab Springs, similar trends can be seen in mass political protests galvanized in youth in other countries as well. The 2019 Hong Kong protests were grown largely by the galvanization of Hong Kong's youth population and spread globally by usage of social media. However, in Hong Kong, the emerging social media platforms were most notably Telegram and LIHKG, not Facebook or Twitter (Middaugh et.al, 2017). But aside from what social media platform was used, it is clear to see that social media is a powerful means for youth to fight against oppression in developing countries due to its ability to discreetly unite the oppressed together, fuel the beliefs of the demonstrators, and gain world-wide support and recognition.

For Youth who have been historically marginalized, social media allows for the resistance of oppression and injustice

Another subsection of how social media allows youth to rally together is the observation of how

those who are historically marginalized can be defined as groups of people who have been regulated to the lower or peripheral edge of society. Many groups are and continue to be denied full participation and representation in mainstream cultural, social, political, and economic activities ("Researching Historically", n.d.). Social Media has become a useful tool for these groups, an inexpensive mechanism used to amplify their voices and highlight their historical narratives to build awareness of structural oppression and injustice. Roughly 80% of black survey participants in a study stated that social media highlights important issues that otherwise would not be as recognized and gives voice to gravely underrepresented groups and in 2016, African American youth were the most frequent youth group on social media, constituting about 68% of users, when compared to White and Hispanic groups. Research shows that black social media users are more likely than white users to view social media as partially or substantially important to them. 54% of black youth say that social media allows them to share their views about important issues, 52% say that social media allows them to get involved in issues which are important to them, and 53% of black youth say that social media is a venue to express their political opinions. Disaggregating this data upon the lines of gender reveal similar statistics in disparities. White college-aged women maintained higher rates of social media use ,72% usage rating, than their male peers, 66% usage rating. It's also been found that black women regularly out consume their Black male peers by at least one hour of popular media intake a day. For civic agency and visibility, users from marginalized backgrounds overwhelmingly describe social media as being an invaluable political tool. Many global wide campaign movements, such as the Black Lives Matter movement which focused on racial justice and equity, DACA (Deferred Action for Childhood Arrivals policy) which focused on immigrant reform, and the Me-Too movement which focused on fighting sexual abuse where mostly advocated by marginalized youth as they were directly affected. These marginalized groups utilize hashtags and search-bombing, a strategy of continued searching of a topic to allow it to trend on search engines and social media sites, in order to raise awareness about any issue. For example, through the dynamic, user-generated hashtags such as #SayHerName, #TimesUp, #Justice4Nia, young black women were able to bring intersectional issues to the top of search engine results and trending topic lists on social media platforms like Twitter that otherwise would have been overlooked by mainstream media (Tanksley, 2020). All in all, it is evident that marginalized youth harness the power of social media to engage in civic action and discourse, challenge dominant narratives, and participate in intergroup dialogue in creative and subversive ways.

Social Media enables youth to gain a lasting socio-political education

For many low-income and racial minority communities, there is a lack of proper education on civics and politics. In communities which do provide or require a socio-political education for youth, oftentimes the education is disengaging and fails to institute excitement or interest in participating in politics amongst youth. Social media engages youth in civics in a way that can deepen participants' understanding of issues and ways to bring about change in areas of interest (Kahne et.al, 2016). One study conducted a cross-sectional survey method involving 508 undergraduate students in a distance learning program at a university in Indonesia. The purpose of the study was to examine the role of social media in facilitating political knowledge and through what means it can do this. Results showed that 32.25% of surveyed students did receive political information from politicians or parties via social media. But when analyzing the relationship between social media and political knowledge, the chi-square value result showed that the relation was not significant. Rather, the relationship with a chi square value that was significant was between social media and a phenomenon called online political talk (Figure 1). Political talk is any form of conversion online that is related to politics and policy. The study found that online political talk functions as a mediator variable between social media usage and student's political knowledge (Intyaswati et.al, 2021). Therefore, social media can facilitate socio-political education through an indirect means of fostering interpersonal communication on social media networks.

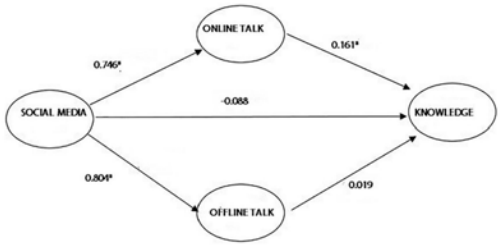

Figure 2. The relationship between Social Media and Political Knowledge does not have a significant value, however it is shown that the use of social media affects online political talk, which then directly results in increased political knowledge (Intyaswati et.al, 2021).

Social media influences youth to vote and get involved in elections

In terms of elections, social media has created a high-level impact in influencing the decisions of youth to participate in voting. One study conducted a survey asking youth participants who were eligible to vote the question: to what extent did the opportunity to participate and gain information through digital media, including mobile technology and Web 2.0, influence your decision to engage in the [2010 Calgary] elections? The participants could offer an answer on a Likert scale with 5 meaning "significant influence", and 1 indicating "little influence". The results indicated that 93 respondents answered the question with a 4 or a 5, meaning that digital opportunities were influential in their decision to exercising their democratic rights. Only about 19 respondents indicated that digital media carried little influence in their desire to engage (Munir, 2018). The reason as to why social media usage can lead to heightened civic engagement participation can be tied to the fact that the information available to youth online could lead to campaign knowledge and feeling of power in guiding decisions through voting. What's even more is that not only does social media encourage youth to vote in elections, but social media also encourages youth to become involved in volunteering for election campaigns, such as volunteering in social media departments on campaign teams. The 2020 Democratic presidential primaries showcased the full scale of youth participation in political campaigns. Survey polls found that prior to the Iowa caucuses, it was found that 44% of youth in Iowa knew of another young person working on a campaign. And it was estimated that more than 2 million youth volunteered for a campaign in the past two years ("Youth Volunteering", n.d.). With youth increasing their presence at polls and showing up in millions to volunteer at campaigns, social media can now be linked as a potential explanation to this phenomenon.

Table 2. A comprehensive list of the positive influences of social media on youth civic engagement

Positives
● Social media promotes heightened activity in civic engagement
● Social media serves to rally youth together ○ For Youth who have been historically marginalized, social media allows for the resistance of oppression and injustice ○ Social Media can allow youth in developing countries to organize for mass protests and call for change
● Social media enables youth to gain a lasting socio-political education
● Social media influences youth to vote and get involved in elections

2.2 Negative consequences of social media usage on youth civic engagement

Social media may not sustain youth civic engagement

There is emerging research narrating the phenomenon of decreased youth civic engagement after a certain political event that had garnered a lot of media attention "blows over ". For example, the Black Lives Matter movement was a global movement which involved mass scales of youth in support right after the killings of George Floyd and Breanna Taylor. However, reports show that after a lapse of several months the majority of BLM support had decreased to 55% in September of 2020 from 67% in June of 2020, and those who shared that they were strongly in support of the movement stood at 29 %, down from 38% three months prior (Horowitz &

Thomas, 2020). While the reason for this decrease in support cannot be directly attributed to social media, it cannot be ignored that social media did fail to prolong the engagement in the BLM movement. One study specifically aiming to understand social media's ability to sustain activity conducted a survey asking youth voters what tools they used during the 2010 election to stay civically engaged and what they have since used to stay engaged. The goal of the research was to see that if successful in initiating engagement for civics amongst those aged 18-30, to what degree would the engagement be sustained? Survey participants indicated using tools such as social media, websites, smartphone applications, and other technological advances to keep up with the 2010 elections. The survey also asked what kind of civic engagement activities participants involved themselves in due to the influence of social media. Respondents could select from opportunities such as volunteering, attending or participating in council meetings, attending open houses or information sessions, etc. The results of the survey showed that since the end of the 2010 election, slightly more than 50% of the respondents indicated not engaging in civics online or in person despite still using the tools they used in the 2010 election to stay civically engaged. 86% of the respondents of the survey indicated that digital engagement opportunities would encourage them to sustain engagement, however with over half of respondents showing that they had disengaged from civic activity, there appears to be an incongruity to that statement in reality (Penney, 2019). These results show that while social media seems like a great tool to captivate and grow support for civic matters, it cannot seem to hold that interest and engagement for long. This is concerning as in order to have a strong democracy citizens must continuously engage themselves in civic matters but it appears that social media cannot fulfill that requirement.

Social Media is biased

Politicians and political groups are known to experiment with strong language which is designed to catch attention and encourage shares and retweets. Therefore, oftentimes the media which is being proliferated on social media is user-generated or accompanied by user commentary and bias (Middaugh, 2019). However, research has noted that it isn't entirely the politician or user's fault for spreading biasness and user-commentary posts. The design layout of social media and how it allows for like-minded people to congregate together, while simultaneously excluding all those who disagree with their point of view, seems to fuel the political bias running rampant on social media. In Facebook for example, users are allowed to create Facebook groups with regulations on who can join based on the discretion of the creator of the group. This can result in what researchers call "echo-chambers" which are groups of like-minded users framing and reinforcing a shared narrative without any exposure to any difference of opinions. In truth, social media echo chambers are a consequence of platforms' ideological sorting of users. To maximize engagement, platforms such as Facebook, tend to show their users content which aligns with their existing beliefs. And once these recommendation algorithms suggest a new group or a new video to watch, this often leads to progressively more extreme versions of these existing beliefs (Daskalopoulos et.al, 2021). One study specifically investigated the main social media platforms and how they are likely to influence information spreading and echo chambers' formation. They performed comparative analysis of more than 100 million pieces of content concerning several controversial topics (such as gun control, abortion, etc.) from Facebook, Twitter, Gab, and Reddit. They also quantified their definition of echo chambers over social media by two main ingredients: 1) homophily in the interaction networks and 2) bias in the information diffusion toward like-minded peers. Results of the study showed that for topics such as vaccines and abortion, Facebook and Twitter showed a strong correlation between the leaning of a user and the average leaning of their nearest neighbors. This meant that like-minded people on Facebook and Twitter tended to congregate together, resulting in two polarized groups clustered at the ends of each spectrum (Figure 2). Conversely, Reddit and Gab showed a different trend, users of those platforms did not split into groups with opposite learning but formed a single community that were not at polarized ends of the spectrum but more centered and thus

moderate with their views (Figure 2). This shows that for social media platforms, there is a much higher prevalence of like-minded people associating with each other, whereas in website discussion platforms like Reddit, there is more conversation with those of different opinions which contributes to less extreme biasness. Furthermore, the presence of homophilic interactions can be confirmed by the community structure of the interaction networks. The study calculated each community's average learning, determined as the average of individual leanings of its members. As shown in the provided figure number 3, the study arranged the communities for each social medium, presented by increasing average leaning on the x-axis (color coded from blue to red), with the y-axis informing the size of the community. Within the social media platforms Facebook and Twitter, it was shown that communities tended to spread across the whole spectrum of possible leanings, however users with similar leanings form each community. For Facebook especially, it seems that there are communities which have a robust average leaning. The results of Facebook and twitter are directly in accordance with the observation of homophilic interactions, but the communities in Reddit and Gab don't cover the whole spectrum and in contrast to Facebook and Twitter only show similar average leanings (Cinelli et.al, 2021). The two main ingredients for echo chambers are first homophilic interactions and bias in information diffusion. Analyzing the data shown above it seems social media platforms such as Facebook and Twitter show indicators of the two ingredients which make up the echo chambers, while open group discussion websites such as Reddit and Gab do not have those ingredients. This goes to show that social media is a strong breeding ground for echo-chambers which can facilitate extreme left or right political biasness in the information proliferated on that platform that is often left unchecked. One of the most dangerous connections echo chambers have towards civic engagement is its ability to increase political polarization amongst youth which can lead to voting behaviors characterized by extreme ideologies. One study analyzed data from the Swiss Election Study Selects 2019 to decipher whether echo-chambers affected people's political interests and how that may play out come the 2019 Swiss Election. The study characterized political polarization through observing how many people choose to split their votes across political parties. In Switzerland, voters have the opportunity when voting to spread their votes across different political parties which indicates they have more open-mildness and less feelings of animosity towards the other party. Thus vote-splitting can be considered a proxy for political open-mindedness.

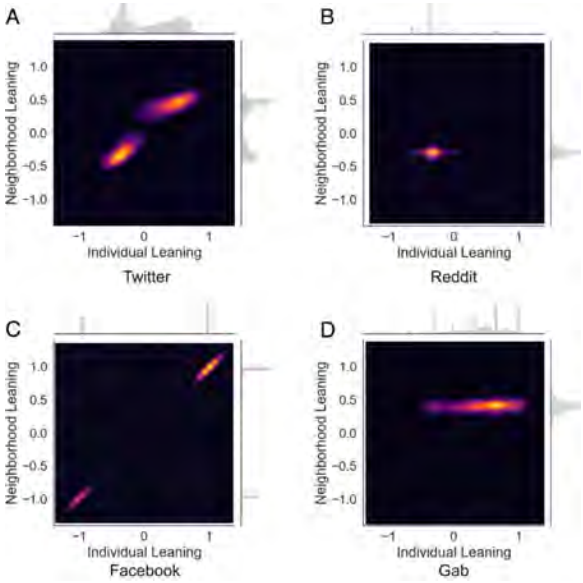

Figure 3. For Twitter and Facebook, there are stronger leanings towards the leaning of a user and the average leaning of their neighbor, meaning likeminded people tend to gravitate together on social media platforms. However, for platforms such as Gap and Reddit, users don't split into groups with opposite leanings but form communities (Cinelli et.al, 2021).

The study compared the likelihood of people being exposed to civics online and their tendency to split their votes versus those who did not engage in political online activities. For those who did not engage in political media activities, the likelihood to split their vote was around 40% and this was regardless of whether they were civically engaged. However, for social media users there was a discrepancy between those who had a level of political interest and those who did not. For users who were civically engaged the likelihood to split votes was significantly higher than those who were not civically engaged, 42% for rather politically

interested and 45% for very politically interested. But for social media users who were not civically engaged, they only had about a 26 % probability of splitting their votes. The study found that these individuals were more likely to find themselves in echo chambers providing them with one-sided information which thus decreases their likelihood to split votes among candidates from different parties. When compared to other political factors, the study also found that none other than political interest significantly moderated the patterns of online activities and vote splitting than political interest which indicates that the exposure to echo-chambers can have an unique effect that not much other influences can have on people's voter behavior (Figure 4) (Ackermann et.al, 2022).

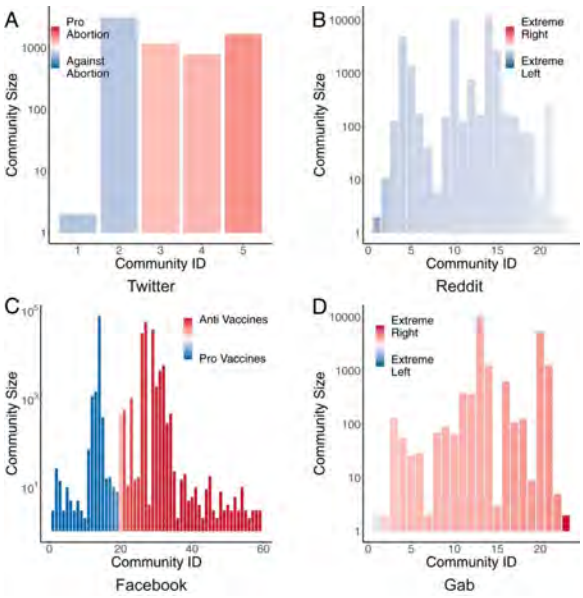

Figure 4. Facebook shows high levels of extreme positions on sensitive political topics versus online platforms which mostly show a very light shade with more spread out results (Cinelli et.al, 2021).

Social media inflames political polarization

Research shows that Republicans and Democrats are more divided along ideological lines - and partisan antipathy is growing deeper and more extensive- than ever before. A 2014 study of 10,000 people nationwide compared the political standpoints of Americans then to the political leanings of those prior to the digital age (around the late 1990s to early 2000s). Over the two decades that lapsed, survey results showed that the overall share of Americans who expressed consistently conservative or liberal opinions had doubled, jumping from 10% to 21%. As a result, the ideological overlap amongst the two parties greatly diminished, with 92% of Republicans to the right of the median Democrat, and 94% of Democrats to the left of the median Republican ("Political Polarization", 2014). Contrary to social media platform's contentions, a range of experts have pointed to the use of social media as a major contribution to the growing partisan animosity in the U.S, even going as far as calling social media a "key facilitator" to the highly politically polarized climate of today. The US federal government has also begun investigating the role social media had in creating one of modern history's most violent displays of political animosity: the January 6th insurrection at the U.S capitol.

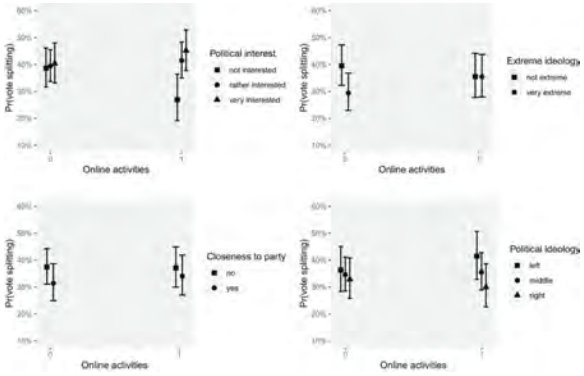

Figure 5. Political Interest indicates the highest discrepancy in likelihood to split votes, showing the large and unique impact echo-chambers may have on voting behavior (Ackerman et.al, 2022).

The House Select Committee has requested a wide range of social media and telecommunications companies to preserve records related to the investigation, specifically looking at how the false claims about the results of the 2020 election spread on platforms such as Facebook and Twitter, and how algorithms could have contributed to the promotion of disinformation and extremism (Barret et,al, 2021). However, the key concern that must addressed is how youth's exposure to such political tensions can influence their political leanings and civic ideologies.

Increasingly, youth are gravitating towards media that uses incivility or extreme language, and research shows that exposure to this type of outrage language is associated with less-open mindless and extreme positions (Middaugh, 2019). As youth are constantly being exposed to this type of media, social media then becomes a brewing ground for further hatred and antagonism for the opposing political party amongst the next generation's civic leaders.

Social media exposes youth to fake news

It's no secret that false information has become a defining feature of social media. With open access to express one's thoughts and minimal checks on accuracy of statements, false accusations and conspiracy theories have proliferated to stoke division. What's more is that research has also found that youth are more likely to share and be interested in news that is eye-catching or emotionally resonant rather than factually accurate. One study asked youth participants what they look for when choosing media sources to share with others to raise awareness or explain an issue, and it was found that the participant's main concerns tended to focus on whether the information was eye-catching or emotionally resonate (Middaugh, 2019). It was striking how little the youth participants factored in credibility of information or factual accuracy when considering what information to share. According to a 2018 study, it was found that falsehoods are 70% more likely to be retweeted on Twitter versus the truth, and these types of posts often reach their first 1,500 people approximately six times faster (Brown, 2020). When youth encounter media which is eye-catching and emotionally provocative, such as media postings with outrageous language, sharing it with others has the potential for spreading misinformation and impacting the tone of public discourse. One of the biggest concerns on how fake news can impact civic engagement today is through how fake news can destabilize political institutions and delegitimize media organizations through decreasing public trust in key social institutions. One study specifically investigated this phenomenon and reported how misinformation can alter people's trust. Through combining two-wave survey data with records of online political behavior they examined the role of misinformation exposure as a predictor of trust in the media and political system. The findings found were split amongst political ideological groups. Fake news overall was associated with a general decrease in media trust. Misinformation exposure whilst the one-month period around the 2018 election predicted a 5% decrease in media trust among participants. Consuming fake news was also associated with lower mainstream media trust amongst all levels of political ideology. But in contrast to the negative association between news exposure and media trust, it was found that consuming misinformation was associated with an increase in political trust for those with far-right ideology. Fake news consumption was associated with a 4% increase in political trust and an 8% increase in trust for Congress for far-right leaners. This phenomenon can be explained through the fact that most fake news sources identified by scholars and fact-checking organizations produced content applicable to far-right ideology. And in late 2018, Republicans were in power in the Executive, Legislative, and Judicial branches of government. With all branches of government under Republican control, it wasn't surprising that the predominately right-leaning content would bolster confidence in political institutions. However, the same did not hold true for those of liberal ideology. Those of liberal ideology when exposed to fake news reported less governmental trust this showing a linkage between fake news consumption and institutional trust (Ogyanova et.al, 2020). But fake news does more than just divide people's trusts in their government, research also shows that fake news corresponds with abilities to alter election results. One study conducted following the 2016 presidential election surveyed respondents 281 questions which included three fake news statements. Two of which were negative statements about Hillary Clinton and one being a positive endorsement involving Donald Trump. Results indicated that beliefs in the fake news stories were strongly linked to defection from the Democratic ticket. Among those who did not believe a single one of the three fake news statements, 89% cast ballots for Clinton; 61% of those who believed one news item voted for Clinton; but for those who believed two or three of the news statements resulted

in only 17% casting ballots for Clinton (Gunther et.al, 2018). Both studies indicate that the growing body of fake news can have large repercussions on civic events by both affecting the outcomes of national elections and growing either distrust or falsified confidence in key social institutions.

Political content on social media can become a source of fear, stress, and annoyance for youth

In a survey conducted to highlight the negative effects of social media interactions amongst an era of widespread polarization and partisan antipathy, it was found that for many social media users the influx of political content is a source of frustration and annoyance. A substantial population of youth users were found to be worn out by the tone and volume of political material in which they encountered upon social media platforms and viewed social media as an "inherently angry and disrespectful medium in comparison to other venues for discussing politics". And though not the majority just yet, an expanding group of social media users express resignation versus excitement over the volume of political content in social media feeds. It was reported that by a roughly two-to-one margin, social media users express resignation over excitement on the volume of political content in their social feeds. One-in-five social media users (20%) indicated that they enjoyed seeing lots of posts about politics on social media, however nearly twice (37%) described themselves as feeling worn out by the exposure to political posts and discussions on social media. This feeling of being worn out or tired of political content can detach youth from being fully engaged or interested in civics, drawing them away from civic engagement. What's more is that the survey also found evidence that political discussions and arguments on social media can be stressful to many people in ways that in-person arguments are not. The survey found that 59% of social media users indicated that they found it stressful and frustrating to discuss politics in social media with people they disagree with, while just 35% say that these discussions are generally interesting and informative. In addition to the weariness and stress that social media may inflict upon youth, an emerging body of youth are beginning to see social media as a place to also refrain from speaking their minds about political issues for fear of criticism or losing friends: 64% of social media users feel as if that description of social media platforms describes them either very (14%) or somewhat (50%) well (Duggan & Smith, 2016). Though these viewpoints may not be the dominant opinions just yet, it's clear to see that emerging research is suggesting that increase exposure to civic media on social media platforms, especially the type of media which espouses outrage language and extreme positions, is increasingly becoming a source of discomfort, fear, and stress for youth. Because of that, youth could be deterred from actively engaging in civics come their adulthood due to social media.

Table 3. A comprehensive list of the negative influences of social media on youth civic engagement

Negatives
● Social Media may not sustain youth civic engagement
● Social Media is biased
● Social Media inflames political polarization
● Social media exposes youth to fake news
● Political content on social media can become a source of fear, stress, and annoyance for youth

Gaps/inconsistencies in knowledge

To have an even better understanding of the influence of social media on youth civic engagement, it's important to address the multiple gaps and inconsistencies in the literature that regard the connection and influences of social media on youth civic engagement. Mentioned earlier in the paper was the issue on how social media had the inability of prolonging youth civic engagement, however there is a gap in research to explain just why there is lower than anticipated sustained engagement levels (Dayton, 2012). One possible explanation could be that after a certain political goal has been achieved, i.e., the conclusion of an election, the political urgency that once engaged youth to using social media to participate in civics evaporates,

disentwining youth to their civic duties and their sense of interest. Another possible explanation could be that youth, being influenced by their peers to engage in sharing information and participating in digital space discussions on political phenomena, would lose their obligation to be engaged in these advocacy movements once they see their peers are no longer involved. In order to get to the bottom of just what the presiding reason is for the inconsistency in expression of continued civic engagement, both quantitative and qualitative research must be undertaken to uncover the reason behind this issue. Another thing that must consistently be considered and researched upon is the emerging ways in which young people express their political expressions on social media and the consequences of these emerging techniques. New social media platforms and digital spaces are being produced and released on the market every day. The rise of TikTok came during the unprecedented time of the global pandemic, quickly rising to become one the world's leading social media platforms with more than 3 million people per day downloading this video-sharing app (Walker, 2020). With apps and new social media emerging, consistent research needs to be done to explore any possible changes these social media platforms may create in impacting youth civic engagement and subsequently provide new directions for future scholarly inquiry in digital political practices. Another gap which is prevalent in the research is looking into certain political expressions indicating civic engagement online and seeing the effects of them. For example, while sharing information has been discussed as an act of political expression indicating civic engagement, there has been little discussion about how the acts of circulation may harm or help the goals of representation and productive discourse. More research needs to be done to assess the small acts of political engagement on social media and what harms and benefits they specifically invest in youth civic engagement. Another topic of social media that researchers have investigated but have not reached a defined answer about is whether social media has the power to soften traditional patterns of inequality. Some journals have pointed to the open accessibility and free news services social media provides to people, thus helping to bridge the inequity in engagement in politics, either it be based on socioeconomic status or other dimensions such as race or ethnicity. Social media use could result in direct 'counter stratification' effects by elevating political engagement among the previously uninvolved to levels that are much closer to those exhibited by the more involved. Another possibility is that the direct influence of widespread social media use upon political engagement could serve to broaden the overall pool of young people engaged in politics and thus creating a softening of political inequality patterns over time that can be carried through generations. However, these possibilities have not been confirmed by any empirical analysis or in-depth studies, so subsequent research needs to be conducted to see if social media truly does have the power to soften traditional patterns of inequality amongst youth. Upon reviewing the literature, it must also be mentioned that there are multiple limitations that can also be associated with the study. First and foremost, one of the leading limitations upon reviewing the literature was a finding that there were too many mixed results. Several factors can explain the elusiveness of clear patterns of findings within the emerging literature on social media and youth political engagement. First, many of the existing studies have been relatively limited in empirical scope. Many study samples rely on college students, which are collected with varying degrees of sophistication. Others have used nationally representative samples of samples of youth of varying sizes and the majority of studies are also only centered in a particular focusing event, such as elections or Caucasus (Xenos et.al, 2013). Another limitation to the information gathered in this study is that many studies assessing digital media and youth civic engagement are only representative of wealthy democratic countries. The literature of youth civic engagement is heavily concentrated upon wealthy democracies only and the fact that the narrative turns towards a politics of 'self-actualization' is not necessarily applicable to other countries. For example, researchers in Mexico had recently found that a history of extreme disenfranchisement from government, with a ranking at the bottom of 18 Latin American countries in terms of citizens' satisfaction with democracy, led to almost 87% of youth

conveying that they would never engage in political discussions on social media and only 36.4% reporting that they intentionally follow the news. On the contrary, researchers found that Egyptian youth's extreme disenfranchisement during Hosni Mubarak's authoritarian rule spurred the creation of robust, collective, youth-led alternative civic engagement organizations (Cho et.al, n.d). With the contradiction in results for developing countries, clearly there must be a more global perspective in research to flesh out the true narrative. Lastly, to be better understand the implications behind fake news and youth civic engagement, research needs to be conducted to fill in the missing literature regarding how disinformation versus misinformation can have of political society today. By filling this gap, it can better be understood how the types of fake news can impact the civic knowledge and standings of not just our current society, but the future generations as well.

Solutions/Suggestions

As technology continues to advance and humanity develops an ever-increasing dependency on digital media, it's important that we find ways to ensure that technology is used responsibly and effectively. We must find ways to mitigate the negative effects of digital media on youth civic engagement as much as possible while simultaneously actively growing the positive impacts. One of the first ways we can do this is by having youth educational facilities integrate digital media into the civic education curriculum. Examples can be drawn from the Educating for Democracy in the Digital Age (EDDA) project, which was a district-wide approach to re-envisioning civic education during the digital age characterized by creating professional learning communities at various school sites that worked together to integrate digital civic learning opportunities into the high school curriculum. Similar examples include the Black Youth Project's (BYP) New Media Research Program and the Media, Activism, and Participatory Politics (MAPP) Project partners at USC (Kahne et.al, 2016). Expanding more on having educational facilities introduce the effects of social media on youth civic engagement is having teacher-facilitated online peer-to-peer deliberation in the classrooms to identify public matters which may be of concern to students, and negotiate the validity of and diverse perspectives upon related knowledge in digital spaces. This can give students formal and informal learning experiences in the creation and articulation of online public issues while simultaneously realizing the unpredictable nature of such publics. Teachers and educational facilities should also promote not just the creation and sharing of user-generated knowledge upon interest-driven social justice issues, but also the means to thoughtfully and purposefully act on such knowledge via online networked publics. This includes exploring the nascent yet ever changing social norms in online networked publics, remaining sensitive not just to the challenges of online interactions, but to the vitality of expressing and operationalizing the privileges and rights of young people in democratic and commercial digital places. Moving aside from considering what can be done in youth educational spaces to ensure social media has a positive impact on youth civic engagement is also looking into what can be done in technological platforms. To alleviate the stressors political discussion on social media can have on political polarization, one large thing that can be done is looking into these social media companies' ideological algorithms and altering them. Having come under hard public and governmental scrutiny in the past couple of years, social media companies such as Facebook and Twitter have already started making changes to their algorithms and news feeds. For example, in April 2021, Twitter announced its "Responsible Machines Learning Initiative", an enterprise that worked to scrutinize not only the algorithms which drive content recommendations but also the other ways in which algorithms contribute to bias and political polarization (Daskalopoulos, et.al. 2021). However, it remains to see whether these changes or heightened attention on the algorithms will actually enact any change or result in any tangible results in dismantling political polarization. Tech companies have generally withheld information in their algorithms despite multiple research findings pointing to these algorithms being the root cause of the polarization of users. Whether it is the role of the government and US lawmakers to force these tech companies to be transparent with their algorithms, or the agreement can be reached through negotiation,

one major step forward in ensuring the effects if social media on youth civic engagement is letting the algorithms of tech companies be made accessible to the public and altered to block ideological groupings together and less exposure to extreme political positions and topics. Lastly, the overall suggestion that must be considered as society evolves deeper into the world of social media and digital spaces, is to consistently assess the risks and negatives of social media on youth civic engagement.

3. Conclusion

Social media is an ever-growing phenomenon that increasingly has a strong prominence on the political culture and climate today. As the emerging generation steps up to continue the civic duties of upholding their countries' democracies or political regimes, it's important to assess the major influences present that are impacting youth's decisions. While there are a multitude of positive attributes of social media that point to a bright future of large-scale political engagement amongst youth and the improvement of human and social rights, there are also negative influences of social media that seem to be inflaming political polarization, hostility, and biases. Considerations must be taken to look at how youth can harness the power of social media effectively and use it to advance more engagement in politics while simultaneously not creating further divide and reproach amongst the political culture. Educating the public and youth as well as holding tech companies responsible for their algorithms should be enacted, while constant updates research must be conducted to fill gaps and mitigate limitations. Social media is an inevitably permanent part of life that will continue to make drastic changes to the political landscape of our society. It is up to use to ensure that social media is a positive and empowering influence for youth civic engagement so that each upcoming generation can continue to uphold the values of freedom, equality, and justice in their country.

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Effects of Empathetic Ability on Multicultural Acceptance in Korean Teenagers and Their Parents

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Abstract

Teenagers from multicultural families living in Korea are suffering from invisible discrimination and cannot fit well in with Koreans having traditional values due to their different appearance and cultures. This study attempted to elucidate the effect of empathetic ability on multicultural acceptance in Korean teenagers and their parents in order to evaluate the perception against teenagers from multicultural families. Korean middle and high school students and their parents were asked to fill out a standardized self-reported questionnaires. Empathetic ability and multicultural acceptance of Korean teenagers and their parents, and correlation between empathetic ability and multicultural acceptance, and effect of empathetic ability on multicultural acceptance were analyzed. Seventy teenagers and seventy parents were participated in the study. With regard to empathetic ability, the teenagers scored significantly higher in taking a view, imagining, and empathetic awakening than their parents. When it comes to multicultural acceptance, the parents scored significantly higher in in multicultural relationship formation, multicultural awareness, multicultural openness, and multicultural empathy than teenagers. Empathetic ability except empathetic interest was significantly correlated with multicultural acceptance. Teenagers' empathetic ability had a significant effect on multicultural acceptance. However, the effect of parents' empathetic ability on multicultural acceptance was not statistically significant. Since Korean teenagers have higher empathetic ability than their parents and have a great impact on multicultural acceptance, in order to enhance the understanding on multicultural society, education improving empathetic ability as well as education promoting multicultural acceptance should be complemented.

Keywords: Empathetic Ability, Multicultural Acceptance, Teenagers, Parents

1. Introduction

In the era of globalization, multiculturalism became a natural social phenomenon as cultural mobility and population movement accelerated. Korea, which has long been proud of itself as a single cultural nation, is also becoming a multicultural society for various reasons such as international marriage and employment of foreign workers (Lee and Song, 2021; Park and Yu, 2017). In fact, the number of multicultural families in Korea due to international marriages is 16,177 as of 2020, accounting for 7.6% of the total number of marriages in Korea. As of 2020, the total number of babies born in Korea is 272,337, of which 16,410 are multicultural ones, accounting for 6% of the total (Statistics Korea, 2021). The school-age population itself is continuously decreasing, but the number of students from multicultural families is steadily increasing. Along with this, various problems related to students from multicultural families have been reported.

Teenagers from multicultural families living in Korea are suffering from invisible discrimination and

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cannot fit well in with Koreans having traditional values due to their different appearance and culture (Kim, 2020). In addition, there are many difficulties in adapting to middle and high school life which leads to relatively low academic achievement and the college entrance rate. And more students from multicultural families in Korea tend to suffer from depression, low self-esteem, and psychological atrophy than Korean students, which may negatively affect their life satisfaction in the future. Therefore, helping students from multicultural families grow up properly, adapt well to school life, and enjoy fair opportunities is important in terms of social integration.

It has been reported that Korean's perception against multi-racial/multi-cultural society is relatively negative (Chung, et al., 2017). In terms of social integration, Koreans' negative perception against multiculturalism will be a critical problem in Korea's development. Therefore, in order for Korean students to positively accept such a multicultural society, it is important to cultivate multicultural acceptance that supports the social value of coexistence of various races and ethnic groups.

Multicultural acceptance is an attitude that recognizes different races or cultures equally with one's own culture without any prejudice and cooperates with them for harmonious coexistence (Ahn et al., 2015). An open attitude toward multiculturalism is essential to embrace cultural diversity and live in harmony with migrants from various cultural backgrounds amid rapidly changing modern society. Therefore, multicultural acceptance is recognized as a major variable in multicultural society (Hughes and Hood, 2007). While studies so far have mainly targeted adults, it is necessary to study the multicultural acceptance of adolescents, main players of future society. This is because positive attitudes toward other ethnic groups or cultures formed in youth are very important to coexist and live in harmony in the future.

Among variables related to multicultural acceptance, empathetic ability is very important as a key element of efficient communication in acknowledging differences from other cultures. Empathetic ability is to have an emotional state that is more appropriate for the situation the other person is in than his or her own situation. Empathetic ability is to understand the other person's point of view, induce altruistic behavior, and further help social adaptation by improving pro-social and interpersonal relationships (Jo and Lee, 2010; Chung, 2010). Therefore, empathetic ability plays a positive role in open multicultural attitudes (Lee, 2017). Since empathetic ability affects interpersonal or social skills, it can be assumed to affect multicultural acceptance. It will be meaningful to understand Korean youths' current awareness toward multicultural society and to examine their empathetic ability as a psychological variable.

Parents are the most intimate blood relationship to humans and provide parenting and education to their children. In this process, they influence each other. The parent-child relationship is the most basic, intimate, and the basis for learning human behavior patterns (Kim, et al., 2018). Consequently, teenagers' empathetic ability and multicultural acceptance can be affected by the relationship with their parents. Therefore, by comparing empathetic ability and multicultural acceptance of teenagers with their parents', we will be able to evaluate the need for appropriate education at home.

In order to properly respond to multicultural society, an open attitude of acknowledging and accepting cultural differences is required. As for 2 critical factors, empathetic ability and multicultural acceptance, there are not many studies on the relationship between them so far. Thus I would like to identify a relationship between empathetic ability and multicultural acceptance.

This study attempted to examine Korean teenagers and their parents' perception against teenagers from multicultural families and to find out whether there is a correlation between Korean teenagers and their parents. In addition, this study tried to find out how empathetic ability affects on multicultural acceptance.

2. Materials and Methods

2.1. Study design

This study is a descriptive survey study to understand an effect of empathetic ability on

multicultural acceptance of Korean teenagers and their parents by identifying the degree of empathetic ability and multicultural acceptance and analyzing the relationship between them.

2.2. Study population

From September 2021 to March 2022, an online survey was conducted on middle and high school students and their parents living in Seoul, Incheon, Gyeonggi-do, Gangwon-do, and Gyeongsang-do. They were asked to fill out a standardized self-reported questionnaires. Prior to the survey, the researcher explained the purpose of the study, the survey method, response tips, and precautions, and distributed the Google questionnaire online for them to fill it out. A turnaround time to complete questionnaires was 10-15 minutes, and the survey was conducted anonymously to protect personal information.

2.3. Measurement Tools

The measurement tool of this study consists of a measure of empathetic ability and a measure of multicultural acceptance, and details are as follows;

Empathetic Ability Scale

In this study, two test tools were used to measure empathetic ability: Davis's Interpersocal reactivity index (IRI) scale (taking a view, imagining, empathic interest) (Davis, 1980) and Bryant's emotional empathy scale (empathetic awakening) (Bryant, 1982). The questionnaire consisted of a total of 30 questions, which were composed of cognitive empathy and emotional empathy. Cognitive empathy included taking a view (5 questions) and imagining (5 questions), and emotional empathy included empathic awakening (15 questions) and empathic interest (5 questions). For each question, a 5-point Likert scale was used, with 5 points for 'very yes', 4 points for 'yes', 3 points for 'normal', 2 points for 'no' and 1 point for 'not at all'. It is interpreted that the higher the score, the higher the empathetic ability.

Multicultural acceptance scale

In this study, the multicultural acceptance scale for teenagers by Kim et al. (Kim and Jung, 2010) was used to measure multicultural acceptance. The composition of this scale consists of a total of 33 questions, four categories of multicultural relationship formation (15 questions), multicultural awareness (6 questions), multicultural openness (8 questions), and multicultural empathy (4 questions). Each question is a 6-point Likert scale from one point for 'not at all' to six points for 'very much'. Negative questions were evaluated in reverse order. The higher the score, the higher the multicultural acceptance.

2.4. Data processing and analysis methods

In this study, the collected data were analyzed using the SPSS 26 statistical program (IBM Corp., Armonk, NY, USA) to evaluate the relationship between teenagers and their parents' empathetic ability and multicultural acceptance. The analysis method specifically used in this study is as follows; The average and standard deviation of empathetic ability and multicultural acceptance were calculated in teenagers and their parents. The student t test was used to compare the empathetic ability and multicultural acceptance of teenagers and their parents. Pearson product-moment correlation analysis was conducted to find out the correlation between empathetic ability and multicultural acceptance in teenagers and their parents. Linear regression analysis was conducted to find out the effect of empathetic ability on multicultural acceptance in teenagers and their parents. The significance level of statistical analysis was set to 0.05, and it was evaluated to be significant when the p value was less than 0.05.

3. Results

3.1. Characteristics of subjects

Of the total 142 collected questionnaires, 140 copies (70 copies of middle and high school students and 70 copies of parents) were used for analysis, excluding 2 copies of the questionnaire (1 middle and 1 high school students) that responded insincerely. The characteristics of the subjects is shown in Table 1 and 2.

Teenagers who participated in the study were 39 male students (55.7%) and 31 female students (44.3%). They were 19 middle school students (27.1%), 50 high school students (71.5%), and 1 international school student (1.4%). There were 43 (61.4%) students living in urban areas and 27 (38.6%) students living in rural areas. The parents who participated in the study were 35 men (50%) and 35 women (50%). There were 53 parents (75.7%) in their 40s. Fifty six parents (80%) lived in Seoul.

Table 1. Characteristics of participating teenagers (N=70)

Variable		Number	%
Sex	Male	39	55.7
	Female	31	44.3
School	High school	50	71.5
	Middle school	19	27.1
	International school	1	1.4
Residence	Seoul	35	50.0
	Metropolitan	8	11.4
	Others	27	38.6

Table 2. Characteristics of participating parents (N=70)

Variable		Number	%
Sex	Male	35	50.0
	Female	35	50.0
Age	30s	2	2.9
	40s	53	75.7
	50s	15	21.4
Residence	Seoul	56	80.0
	Metropolitan	4	5.7
	Others	10	14.3

3.2. Empathetic ability and Multicultural acceptance in teenagers

As shown in Table 3 and 4, the average score of empathetic ability was 3.52 and the average score of multicultural acceptance was 3.26, thus empathetic ability was higher than multicultural acceptance. Among categories of empathetic ability, imagining was the highest at 3.64, and empathetic interest was the lowest at 3.25. Among categories of multicultural acceptance, multicultural empathy was the highest at 3.89, and multicultural relationship formation was the lowest at 2.94.

Table 3. Empathetic ability by category in teenagers (N=70)

Category	Related question	Mean	Standard deviation
Taking a view	16, *19, 22, 25, 28	3.51	0.58
Imagining	17, 20, *23, 26, 29	3.64	0.78
Cognitive empathy		3.57	0.58
Empathetic awakening	1, *2, 3, 4, 5, 6, 7, 8, 9, 10, *11, *12, *13, *14, 15	3.58	0.51
Empathetic interest	18, 21, 24, 27, 30	3.25	0.44
Emotional empathy		3.50	0.39
Empathetic ability		3.52	0.41

*Reverse grading question

Table 4. Multicultural acceptance by category in teenagers (N=70)

Category	Related question	Mean	Standard deviation
Multicultural relationship formation	1, 2, 4, 7, 8, 9, 11, 15, 16, 19, 21, 29, 30, 32, 33	2.94	0.60
Multicultural awareness	3, 6, 10, 13, 23, 31	3.66	0.66
Multicultural openness	5, 12, 14, 18, 20, 26, 27, 28	3.23	0.98
Multicultural empathy	17, 22, 24, 25	3.89	0.75
Multicultural acceptance		3.26	0.63

3.3. Empathetic ability and Multicultural acceptance in parents

Table 5 and 6 showed that all the scores of each category were more than 3 points, and it suggested that parents perceived empathetic ability and multicultural acceptance above average. The average score of empathetic ability was 3.53 and the average score of multicultural acceptance was 3.55, thus multicultural acceptance was slightly higher than empathetic ability. Among categories of empathetic ability, empathetic awakening was the highest at 3.76, and empathetic interest was the lowest at 3.04.

Among categories of multicultural acceptance, multicultural empathy was the highest at 4.23, and multicultural relationship formation was the lowest at 3.17.

Table 5. Empathetic ability by category in parents (N=70)

Category	Related question	Mean	Standard deviation
Taking a view	16, *19, 22, 25, 28	3.49	0.39
Imagining	17, 20, *23, 26, 29	3.35	0.54
Cognitive empathy		3.42	0.37
Empathetic awakening	1, *2, 3, 4, 5, 6, 7, 8, 9, 10, *11, *12, *13, *14, 15	3.76	0.32
Empathetic interest	18, 21, 24, 27, 30	3.04	0.27
Emotional empathy		3.58	0.26
Empathetic ability		3.53	0.25

*Reverse grading question

Table 6. Multicultural acceptance by category in parents (N=70)

Category	Related question	Mean	Standard deviation
Multicultural relationship formation	1, 2, 4, 7, 8, 9, 11, 15, 16, 19, 21, 29, 30, 32, 33	3.17	0.57
Multicultural awareness	3, 6, 10, 13, 23, 31	3.89	0.68
Multicultural openness	5, 12, 14, 18, 20, 26, 27, 28	3.66	0.85
Multicultural empathy	17, 22, 24, 25	4.23	0.64
Multicultural acceptance		3.55	0.59

3.4. Empathetic ability and Multicultural acceptance between teenagers and their parents

With regard to empathetic ability, the teenagers scored significantly higher in imagining (3.64±0.78 vs. 3.35±0.54, p=0.012), empathetic awakening (3.58±0.51 vs. 3.76±0.32, p=0.016), and empathetic interest (3.25±0.44 vs. 3.04±0.27, p=0.001) than their parents (Table 7).

Table 7. Comparison of empathetic ability between teenagers and their parents

Category	Teenagers		Parents		p-value
	Mean	S.D.	Mean	S.D.	
Taking a view	3.51	0.58	3.49	0.39	0.812
Imagining	3.64	0.78	3.35	0.54	0.012
Cognitive empathy	3.57	0.58	3.42	0.37	0.067
Empathetic awakening	3.58	0.51	3.76	0.32	0.016
Empathetic interest	3.25	0.44	3.04	0.27	0.001
Emotional empathy	3.50	0.39	3.58	0.26	0.153
Empathetic ability	3.52	0.41	3.53	0.25	0.961

*S.D. standard deviation

When it comes to multicultural acceptance, the parents scored significantly higher in multicultural relationship formation (2.94±0.60 vs. 3.17±0.57, p=0.024), multicultural awareness (3.66±0.66 vs. 3.89±0.68, p=0.039), multicultural openness (3.23±0.98 vs. 3.66±0.85, p=0.007) multicultural empathy (3.89±0.75 vs 4.23±0.64, p=0.004), multicultural acceptance (3.26±0.63 vs 3.55±0.59, p=0.006) than teenagers (Table 8).

Table 8. Comparison of multicultural acceptance between teenagers and their parents

Category	Teenagers		Parents		p-value
	Mean	S.D.	Mean	S.D.	
Multicultural relationship formation	2.94	0.60	3.17	0.57	0.024
Multicultural awareness	3.66	0.66	3.89	0.68	0.039
Multicultural openness	3.23	0.98	3.66	0.85	0.007
Multicultural empathy	3.89	0.75	4.23	0.64	0.004
Multicultural acceptance	3.26	0.63	3.55	0.59	0.006

*S.D. standard deviation

3.5. Correlation between Empathetic ability and Multicultural acceptance in teenagers and their parents

In this study, the Pearson proper correlation analysis between empathetic ability, multicultural acceptance, and their categories was conducted. The correlation between the categories of empathetic ability and multicultural acceptance in teenagers is shown in Table 9. Taking a view had positive correlation with multicultural relationship formation (r=.252, p<0.05), multicultural awareness (r=.267, p<0.01), multicultural openness (r=.358, p<0.01), and multicultural empathy (r=.372, p<0.01), respectively. Overall, taking a view had positive correlations with multicultural acceptance (r=.346, p<0.01). Imagining had positive correlation with multicultural awareness (r=.304, p<0.01), multicultural openness (r=.311, p<0.01), and multicultural empathy (r=.242, p<0.01), respectively. However, it had no significant correlation with multicultural relationship formation (r=.215, p>0.05). Overall, imagining had positive correlations with multicultural acceptance (r=.301, p<0.01). Cognitive empathy had positive correlation with multicultural relationship formation (r=.266, p<0.05), multicultural awareness (r=.333, p<0.01), multicultural openness (r=.382, p<0.01), and multicultural empathy (r=.344, p<0.01), respectively. Overall, cognitive empathy had positive correlations with multicultural acceptance (r=.370, p<0.01). Empathetic awakening had positive correlation with multicultural relationship formation (r=.311, p<0.05), multicultural openness (r=.456, p<0.01), and multicultural empathy (r=.455, p<0.01), respectively. However, it had no significant correlation with multicultural awareness (r=.231, p>0.05). Overall, empathetic awakening had positive correlations with multicultural acceptance (r=.413, p<0.01). However, empathetic interest had no significant correlations with multicultural relationship formation (r=.099, p>0.05), multicultural awareness (r=.094, p>0.05), multicultural openness (r=.016, p>0.05), and multicultural empathy (r=.061, p>0.05), respectively. Overall, empathetic interest had no significant correlation with multicultural acceptance (r=.075, p>0.05). Emotional empathy had positive correlation with multicultural relationship formation (r=.334, p<0.05), multicultural awareness (r=.254, p<0.05), multicultural openness (r=.453, p<0.01), and multicultural empathy (r=.465, p<0.01), respectively. Overall, emotional empathy had positive correlations with multicultural acceptance (r=.428, p<0.01). Empathetic ability had positive correlation with multicultural relationship formation (r=.336, p<0.01), multicultural awareness (r=.316, p<0.01), multicultural openness (r=.466, p<0.01), and multicultural empathy (r=.455, p<0.01), respectively. Overall, empathetic ability had positive correlations with multicultural acceptance (r=.443, p<0.01). Therefore, it suggests that the higher the empathetic ability, the higher the multicultural acceptance.

The correlation between the categories of empathetic ability and multicultural acceptance in parents is shown in Table 10. Taking a view had no significant correlations with multicultural relationship formation (r=.107, p>0.05), multicultural awareness (r=.284, p<0.05), multicultural openness (r=.157, p>0.05), and multicultural empathy (r=.103, p>0.05), respectively. Overall, taking a view had no significant correlation with multicultural acceptance (r=0.174, p>0.05). Imagining had no significant correlations with multicultural relationship formation (r=.056, p>0.05), multicultural awareness (r=.107, p>0.05), multicultural openness (r=.018, p>0.05), and multicultural empathy (r=.119, p>0.05), respectively. Overall, imagining had no significant correlation with multicultural acceptance (r=.057, p>0.05). Cognitive empathy had no significant correlations with multicultural relationship formation (r=.098, p>0.05), multicultural awareness (r=.228, p>0.05), multicultural openness (r=.070, p>0.05), and multicultural empathy (r=.141, p>0.05), respectively. Overall, cognitive empathy had no significant correlation with multicultural acceptance (r=.134, p>0.05). Empathetic awakening had no significant correlation with multicultural relationship formation (r=.162, p>0.05), multicultural awareness (r=.209, p>0.05), and multicultural openness (r=.225, p>0.05), respectively. However, it had positive correlation with multicultural empathy (r=.345, p<0.01). Overall, empathetic awakening had positive correlation with multicultural acceptance (r=.238, p<0.05). Empathetic interest had no significant correlation with multicultural relationship formation (r=.266,

p<0.05), multicultural awareness (r=.051, p>0.05), multicultural openness (r=.135, p>0.05), and multicultural empathy (r=.047, p>0.05), respectively. Overall, empathetic interest no significant correlations with multicultural acceptance (r=.180, p>0.05). Emotional empathy had positive correlation with multicultural relationship formation (r=.080, p>0.05), multicultural awareness (r=.180, p>0.05), and multicultural openness (r=.172, p>0.05), respectively. However, it had positive correlation with multicultural empathy (r=.305, p<0.05). Overall, emotional empathy had no significant correlation with multicultural acceptance (r=.173, p>0.05). Empathetic ability had positive correlation with multicultural relationship formation (r=.102, p>0.05), multicultural awareness (r=.233, p>0.05), and multicultural openness (r=.151, p>0.05), respectively. However, it had positive correlation with multicultural empathy (r=.275, p<0.05). Overall, in parents, empathetic ability had no significant correlation with multicultural acceptance (r=.182, p>0.05).

Table 9. Correlation between empathetic ability and multicultural acceptance for each category in teenagers

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	.491**	1										
3	.820**	.902**	1									
4	.522**	.539**	.613**	1								
5	.234	.044	.145	.086	1							
6	.579**	.543**	.644**	.960**	.195	1						
7	.750**	.766**	.876**	.894**	.191	.933**	1					
8	.252*	.215	.266*	.311*	.099	.334*	.336**	1				
9	.267**	.304**	.333**	. 231	.094	.254*	.316**	.705**	1			
10	.358**	.311**	.382**	.456**	.016	.453**	.466**	.785**	.653**	1		
11	.372**	.242**	.344**	.455**	.061	.465**	.455**	.665**	.617**	.634**	1	
12	.346**	.301**	.370**	.413**	.075	.428**	.443**	.941**	.944**	.918**	.725**	1

P<0.05*, p<0.01**

1. Taking a view, 2. Imagining, 3. Cognitive empathy, 4. Empathic awakening, 5. Empathic interest, 6. Emotional empathy, 7. Empathetic ability, 8. Multicultural relationship formation, 9. Multicultural awareness, 10. Multicultural openness, 11. Multicultural empathy, 12. Multicultural acceptance

Table 10. Correlation between empathy and multicultural acceptance for each category in parents

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	.249*	1										
3	.711**	.858**	1									
4	.419**	.314**	.450**	1								
5	.094	.191	.188	.186	1							
6	.410**	.338**	.463**	.968**	.427**	1						
7	.624**	.647**	.800**	.874**	.381**	.902**	1					
8	.107	.056	.098	.162	.266*	.080	.102	1				
9	.284*	.107	.228	.209	.051	.180	.233	.713**	1			
10	.157	.018	.070	.225	.135	.172	.151	.732**	.671**	1		
11	.103	.119	.141	.345**	.047	.305*	.275*	.692**	.576**	.678**	1	
12	.174	.057	.134	.238*	.180	.173	.182	.934**	.831**	.899**	.791**	1

P<0.05*, p<0.01**

1. Taking a view, 2. Imagining, 3. Cognitive empathy, 4. Empathic awakening, 5. Empathic interest, 6. Emotional empathy, 7. Empathetic ability, 8. Multicultural relationship formation, 9. Multicultural awareness, 10. Multicultural openness, 11. Multicultural empathy, 12. Multicultural acceptance

3.6. Effect of Empathetic ability on Multicultural acceptance in teenagers and their parents

A linear regression analysis revealed that teenagers' empathetic ability had a significant effect on multicultural acceptance (R^2=0.185, β=-0.443, p<0.001) (Table 11). However, the effect of parents' empathetic ability on multicultural acceptance was not statistically significant (R^2=0.019, β=-0.182, p=0.132) (Table 12).

Table 11. The Effect of Empathetic ability on Multicultural Acceptance in teenagers (N=70)

Independent variable	Non-standardization coefficient		Standardization coefficient	t	R^2	*F*	p-value
	B	*SE B*	*β*		(Corrected R^2)		
Empathetic ability	-0.680	0.167	-0.443	-4.079	0.197 (0.185)	16.636	<0.001

Table 12. The Effect of Empathetic ability on Multicultural Acceptance in parents (N=70)

Independent variable	Non-standardization coefficient		Standardization coefficient	t	R^2	*F*	p-value
	B	*SE B*	*β*		(Corrected R^2)		
Empathetic ability	-0.425	0.279	-0.182	-1.525	0.033 (0.019)	2.327	0.132

4. Discussion

The study idea was emerged from my personal experience of participating in medical volunteer activities for multicultural families. Multicultural families in Korea are experiencing poor educational environments as well as health problems. Thus Koreans need to improve their awareness of multicultural societies. For modern people living in the era of globalization, multicultural acceptance that can respect the other's culture is essential for harmony and peace of mankind.

This study examined the role of empathetic ability among the factors affecting multicultural acceptance. In particular, the following problems were examined in this study. First, what is the current level of the empathetic ability and multicultural acceptance of Korean teenagers and their parents? Second, is there a difference in empathetic ability and multicultural acceptance between Korean teenagers and their parents? Third, does empathetic ability correlate with multicultural acceptance of Korean teenagers and their parents? Lastly, what is the effect of empathetic ability on multicultural acceptance of Korean teenagers and their parents? As a result, it was found that empathetic ability had a significant correlation with multicultural acceptance of both Korean teenagers and their parents. In addition, it was found that empathetic ability has a significant effect on multicultural acceptance of Korean teenagers.

Korea has already entered a multicultural society, but the Korean people's awareness on a multicultural society is still low. According to the National Multicultural Acceptance Index (KMAI) conducted by the Korea Women's Policy Institute, Korea had 51.17 points, which was lower compared to the average of 70.89 points for the top 20% countries of multicultural acceptance (Korea Women's Policy Institute, 2012). This finding indicates that continuous efforts is needed for Korean to increase their level of multicultural acceptance. Furthermore, discrimination against multicultural families still remains, leading to the overall atmosphere of Korean society.

Previous studies have emphasized the concept of empathetic ability as a mind that understands, cares for, and accepts heterogeneous cultures without prejudice, and emphasizes the importance of empathetic ability for people from other cultures to promote cultural sensitivity (Kim and Sung, 2014). As such, empathetic ability is the ability to feel others' emotions and understand others' point of view (Lee, 2013). Hence, empathetic ability can be a good solution to promote multicultural acceptance. This study is valuable in that teenagers and their parents were surveyed at the same time, focusing on

the relationship between them. Furthermore, it is meaningful that the difference in perception against multicultural society was examined by comparing empathetic ability and multicultural acceptance between teenagers and their parents.

In this study, it was found that although Korean teenagers had lower multicultural acceptance than their parents, their empathetic ability had a significant effect on multicultural acceptance. Multicultural acceptance is the adaptability necessary to a member of a multicultural society. The high acceptance of multiculturalism means high probability on cultural diversity and integration of the community. Therefore, it is thought that the empathetic ability of Korean teenagers can have a positive effect on the attitude of appropriately responding to and accepting various situations and the adaptability necessary to members of a multicultural society.

This study has some limitations. Although this study conducted a survey of middle and high school students and their parents nationwide, it is difficult to generalize to all teenagers and their parents due to the small number. Therefore, it is necessary to conduct a survey on a larger number nationwide in future studies. Furthermore, this study presented only empathetic ability as a variable related to the multicultural acceptance in Korean teenagers, but it is necessary to use it as basic data to develop other cultural understanding and empathy programs for teenagers by presenting more diverse variables and revealing their effects. Nevertheless, it is clearly meaningful to confirm that empathetic ability has an effect as a psychological factor affecting multicultural acceptance through this study.

5. Conclusion

Through this study, the following conclusions were made.

This study showed that there was a significant correlation between the empathetic ability and multicultural acceptance in Korean teenagers. This suggests that Korean teenagers' empathetic ability is expressed as altruistic behavior or pro-social behavior and forming friendly relationships with others by understanding their situations. Furthermore, the higher the empathetic ability, the higher the multicultural acceptance in Korean teenagers, indicating that multicultural acceptance can be increased with encouraging empathetic ability.

Therefore, in order to establish a harmonious relationship with teenagers from multicultural families, education programs for adolescents should be introduced in school. In addition, empathetic ability is basically formed based on positive interrelationships with parents, so it is necessary to prepare educational programs for parents as well as students.

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The Effects of Sports Injuries on Mental Health in High School Female Athletes

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Abstract

Sports injuries have become increasingly common in female high school athletes, ranging from ankle or wrist sprains to ACL tears. Despite this, the mental health effects resulting from these injuries have not been investigated. By utilizing a mixed method approach and incorporating survey quantitative data in conjunction with interview qualitative data, the various mental health effects of sports injuries in high school female athletes were examined. It became evident that young female athletes who have experienced injuries deal with major anxiety, mood drops, lack of motivation, lack of confidence, and diminished physical performance. Moreover, positive correlations were established between injury severity and mental struggles. While analyzing prior research and new information from the interviews conducted, a vicious cycle was confirmed regarding stress and re-injury. Overall, this research is significant because it allows female athletes dealing with mental health issues due to sports injuries to understand that they are not alone and to help find healthy ways to address these struggles.

Keywords: Injury, Sports, Athlete, Mental Health, Female

1. Introduction

Female participation in high school sports has increased dramatically since the late 1900s. Specifically, when Title IX passed in 1972, females were given the ability to receive equal opportunities in sports and thus participate in more high school sports. Since Title IX, injuries in female high school athletes have increased significantly, yet the mental toll of these injuries has not been fully explored. Investigation of these mental effects would allow coaches and parents to better understand and help female high school athletes suffering mentally after an injury. The gap in research regarding this psychological toll leads to the question: To what extent do sports injuries affect mental health in female high school athletes?

In order to understand how the collected data help to determine the extent to which sports injuries impact the mental health of young female athletes, it is important to first look at the existing research on the subject. There are currently a few studies analyzing how females' mental health can be impacted by injury risk as well as rehabilitation after a sports-related injury (Herrero, 2020). Dr. Herrero, an orthopedic surgeon at NYU, begins by explaining how resilience, sleep, and mindfulness are related to an athlete's performance and injury risk. Furthermore, she asserts that anxiety, depression, and burnout can impair recovery after a sports-related injury. Specifically, Dr. Herrero includes eating disorders as an effect of injury, which is highly prevalent in female athletes. Dr. Herrero also acknowledges that many female athletes' source of identity relates to their body image and athletic build (Herrero, 2020). For this reason, injuries that cause a

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change to the body may have the potential to trigger depression and eating disorders. From this study, the additional aspect of eating disorders can be examined further as an effect of sports injuries. Because eating disorders can impair both physical and emotional well-being, effects of eating disorders can be linked to both performance and confidence upon returning to sports. It is important to acknowledge however that this study is somewhat limited because as a meta-analysis, it only has four reference sources.

While it is important to recognize the effects of sports injury on mental health, it is also important to understand the ways in which mental health issues can impact sports injuries. A research study in the *British Journal of Sports Medicine* by Dr. Margot Putukian, chief medical officer for major league soccer, was conducted to explore the influence of stress on injury rate. In her paper, Dr. Putukian begins by noting that stress increases muscle tension, which in turn can increase the risk of injury. Additionally, she concludes that physical injury can cause depression, which also increases the likelihood of re-injury and can have a negative impact on performance when returning to a sport (Putukian, 2016). This study brings light to a potential trend amongst female athletes: the cycle of stress and sports injuries. Stress itself can lead to injury, and once injured, one can become depressed thereby heightening the chances of re-injury. From this study, it will be possible to further examine this cycle by asking interview questions regarding the possible effects of stress on injury rate. In addition to stress, Dr. Putukian explains why many athletes avoid seeking help with their mental health after an injury, and connects this to factors of stigma, denial, and fear. In her study of elite athletes aged 16-23, Dr. Putukian found that "stigma was the most important perceived barrier to seeking help" (Putukian, 2016). She concluded that this stigma surrounds the fact that many athletes view seeking therapy as a weakness and are accustomed to working through pain. Furthermore, Dr. Putukian suggests that athletes may have not developed a healthy coping mechanism outside of their sport, and therefore struggle to appreciate the benefits of seeking help (Putukian, 2016). It is important to understand that this study is slightly limited in that it did not differentiate between specific populations within the athletic community, such as specific genders or sports. Dr. Putukian could have more successfully illustrated the distinguishing characteristics between different groups of athletes and injury-related mental health challenges.

In another study published in The Journal for Medicine & Science in Sports & Exercise, the authors dive deeper into the psychological reactions accompanying athletic injury as well as the psychological issues related to athletic injury rehabilitation. Dr. Herring and supporting authors, who are doctors in sports medicine, comment that along with disordered eating and lack of motivation, depression is an extremely problematic response to a sport-related injury and it can even magnify other negative responses to injury. Specifically, when summarizing emotional responses of athletic injury related to rehabilitation, the authors note that rehabilitation can be negatively affected by loss of identity, fear and anxiety, and a loss of confidence. Additionally, the authors illustrate that many of the problematic effects of sport-related injuries can also decrease the success of rehabilitation, so it is important to seek strategies to avoid worsening these effects (Herring et al., 2006). This study relates back to the cycle of injuries and stress discussed earlier. Losing confidence during rehabilitation due to stress can increase the risk of re-injury, which only causes more stress for an athlete.

In order to deepen our understanding of the effects of sports injuries on mental health, it is also important to analyze a realistic progression of mental health before, after, and during an injury. In a study surrounding four female division 1 athletes, "coping behavior, psychological response, and rehabilitation adherence" were studied over the progression of an injury. In the *Journal of Clinical Sport Psychology*, authors Leilani Madrigal and Diane L. Gill identified many common stressors that resulted from sports injury. They found that "feeling isolated from the team, loss of control, and pressure to prove self and abilities were evident as athletes reflected over the course of their rehabilitation experience" (Madrigal and Gill, 2014). Furthermore, the authors included that "playing through injury was reflected in many statements by athletes who adopted a play-through anything mentality" (Madrigal and Gill, 2014). Being

off the field and away from teammates as a result of a sports injury can be extremely difficult. These stressors contribute to more detrimental choices, like choosing to play through an injury. Although this choice may appear as the most desired option at the time, players are simply putting themselves at an even greater risk for re-injury when making this decision. While this article successfully portrayed mental health effects of female athletes, it was limited in that it only included four participants. For this reason, it is not possible to generalize the findings and make definitive conclusions.

Several studies have successfully demonstrated that sports injuries in high school athletes have become more common over time. According to a study from 2006, "participation in high school sports resulted in an estimated 1.4 million injuries at a rate of 2.4 injuries per 1,000 athlete exposures" (Comstock et al., 2006). Sports injuries in high school span from simple wrist and ankle sprains, to severe concussions, fractures and ligament tears. While physical rehabilitation is the primary response to healing a sports injury, the mental effects of these injuries are often overlooked. In female high school athletes in particular, studies are lacking on the emotional and psychological impact of sports injuries. Mental health effects are not prioritized, in part, due to the athletes' mindset as well as pressure from coaches. Coaches rely on their athletes to win games and bring their teams success, yet the physical aspects of returning to sports after injury are oftentimes emphasized over the mental aspects. Similarly, athletes themselves often refrain from displaying signs of mental issues for fear of being viewed as weak or quitters by teammates and coaches (Keane, 2021). Because of the significant lack of attention to the psychological aspects surrounding sports injuries, a gap in research has developed regarding the extent to which sports injuries actually impact mental health in athletes. This gap is even wider in female athletes and is the focus of my research.

There are several components of mental health that may be impacted by experiencing a sports injury. The effects on confidence, anxiety, depression, and mood are some of the emotional aspects of sports injuries that will be analyzed. Confidence and perceived performance will specifically relate to mental health upon returning to sports, while anxiety, depression, and mood will likely correlate to the direct effect of the injury before returning to sports. Additionally, it is important to take into account the type of injury, the duration and severity of the injury, as well as the sport that caused the injury. Severe long-term injuries will likely have a more significant impact on mental health compared to minor short-term injuries. Furthermore, by spending more time in the recovery process after an injury, it is likely that an athlete's mental health will improve and they will experience less issues with confidence, anxiety, and mood. By collecting both quantitative and qualitative data in survey and interview formats, it will be possible to analyze the ultimate effect of sports injuries on mental health in high school female athletes.

2. Methodology

To investigate the proposed research question, this study uses a Likert Style survey to gather respondent data regarding various effects of sports injuries on mental health. Survey analysis attempts to categorize similar responses and relate them to the severity and type of sports injury in a quantitative manner. Quantitative analysis works cohesively with this research inquiry because it allows for a broad range of mental health effects caused by sports injuries to be classified and compared in an organized fashion.

In addition, an interview method was used to gather more detailed information surrounding these mental health effects. While quantitative data can gather fact-based numbers regarding various aspects of mental health, it lacks the ability to capture true emotions which are essential components of mental health. In a semi-structured interview setting, it was possible to create questions related to the responses of the interviewees in order to expand upon the information collection. In the Practical Research Methods Guide, Dr. Dawson notes that semi-structured interviews allow the "interview to remain flexible so that other important information can still arise" (Dawson, 2002). Upon comparing the interview data, it is possible to develop repeated themes and topics of discussion to support the overall

analysis.

The mixed-method approach of combining both quantitative and qualitative research is supported by the idea of triangulation. Specifically, according to Denzin, methodological triangulation "involves using more than one option to gather data, such as interviews, observations, questionnaires, and documents" (Denzin, 1973). In using method triangulation, it will be possible to "deepen and widen one's understanding" regarding sports injuries and mental health by minimizing overall bias and further enriching the study (Denzin, 1973).

The quantitative aspect of the Likert survey was produced using Google Forms software. According to Jan Losby, PhD from the CDC, "Likert scales may meet your needs when you have attitude, belief, or behavior items" (Losby 2012). Effects including overall mental health, confidence, and anxiety were inserted into the form along with severity and type of injury. On the Likert scale, 1 represented minor injuries as well no negative mental health effects, whereas 5 represented severe injuries and the experience of negative mental health effects "quite often". By comparing similar numbers on the survey, it is possible to connect severity with overall mental health effects.

Regarding the data analysis process for quantitative results, both Chi-Square Tests of Independence and Pearson correlation techniques were utilized to build relationships between the data collected. Moreover, to analyze the data for the qualitative research, interviews were recorded, transcribed, and then put through a complex coding method in which the important themes collectively discussed in the interviews were identified. After completion of the coding process, a thematic analysis chart was created to clearly view the common mental health effects of sports injury in a chart format.

3. Results: Quantitative

A variety of mental health effects due to sports injury were analyzed in the survey. First, actual versus expected data were collected regarding various mental health effects to display the overall significance of the data found. In a set of data regarding mental health effects, it is expected that the same amount of participants experience minor effects versus severe effects, yet this was not the case in the research found. As seen in Figure 1 which represents actual versus expected anxiety rates related to injury, the majority of participants experienced extreme anxiety. With a total of 40 female athletes answering this question, it is expected that 20 respondents would have minor anxiety and 20 respondents would have severe anxiety. Respondents answered on a scale of 1 to 5, with 1 representing minor anxiety and 5 representing extreme anxiety. Those who answered with 1s and 2s were shown in the figure as having "minor anxiety", whereas those who answered with 4s and 5s were shown in the figure as having "severe anxiety". A Chi-Square Test of Independence was used to evaluate actual versus expected amounts of participants with certain mental health effects. All 3s were disregarded from data analysis because as a "middle" or "average" rating, the 3s would effectively weaken the correlations being studied. As portrayed in the figure, 33 respondents had severe anxiety due to injury while 7 respondents had minor anxiety. The findings for those who experienced anxiety from sports injury fell outside of the expected range of responses, (N=40), p=.000039. Any p value less than .05 represents a statistically significant finding.

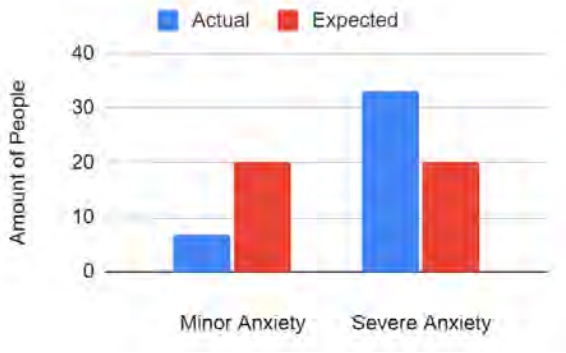

Figure 1: Actual Versus Expected Anxiety Rates due to Sports Injury

Similar to anxiety, drops in mood were also significant effects of sports injury. Figure 2 illustrates actual versus expected mood drop rates. Mood drops were analyzed on the same 1 to 5 scale as anxiety (omitting any 3s), and it was ultimately found that 32 respondents had severe mood drops due to injury

while only 7 had only minor mood drops. The findings for those who experienced mood drops from sports injury fell outside of the expected range of responses, (N=39), p=.000062.

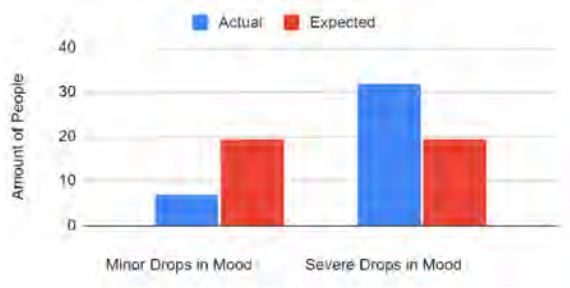

Figure 2: Actual Versus Expected Mood Drop Rates due to Sports Injury

Actual versus expected rates of lack of motivation due to injury were also found using the same process as the previous figures. Figure 3 indicates that 28 respondents experienced severe lack of motivation, whereas 11 respondents had minor lack of motivation. The findings for those who experienced a lack of motivation from sports injury fell outside of the expected range of responses, (N=39), p=.0065.

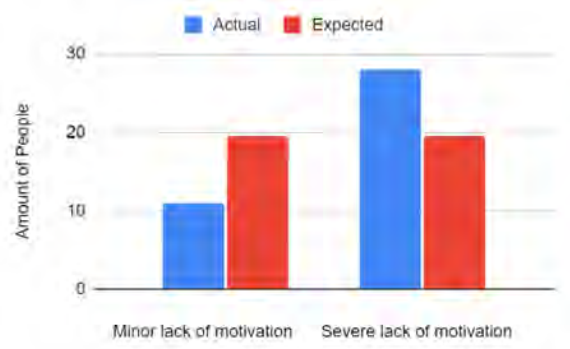

Figure 3: Actual Versus Expected Lack of Motivation due to Sports Injury

Figure 4 had a slightly different scale than the previous figures. The survey choices were on a scale of 1 to 5, where 1 represented high confidence and 5 represented low confidence. Respondents who selected a 1 or 2 are presented in the figure as having excellent confidence, while those who selected a 4 or 5 are presented in the figure as having very poor confidence. The 3s were not included in the data analysis. As seen below, 27 participants had very poor confidence and 7 participants had excellent confidence after a sports injury. The findings for those who experienced a lack of confidence from sports injury fell outside of the expected range of responses, (N=34), p=.000054.

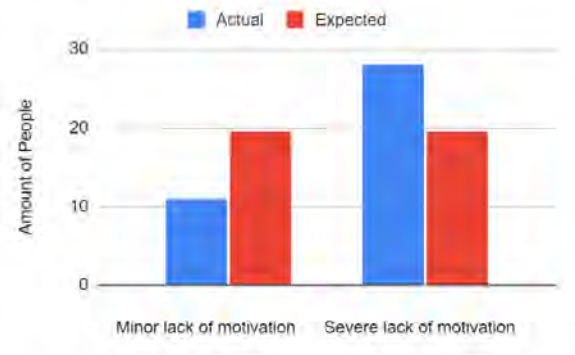

Figure 4: Actual Versus Expected Confidence Levels after Sports Injury

Figure 5 shows actual versus expected physical performance after injury and it has the same scale as figure 4. A total of 36 respondents had very poor physical performances after injury and 11 respondents had excellent performances after sports injury. The findings for those who experienced a lack of performance from sports injury fell outside of the expected range of responses, (N=47), p=.00027.

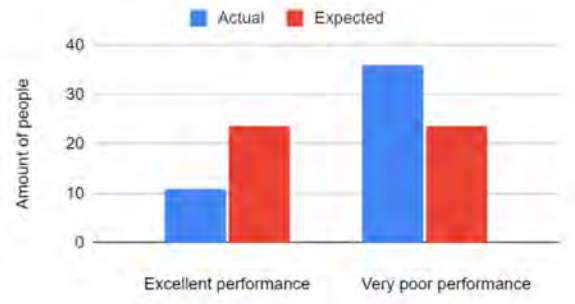

Figure 5: Actual Versus Expected Physical Performances after Sports Injury

Figures 6 and 7 are very similar in that they both analyze overall mental health. Figure 6 illustrates actual versus expected overall mental health immediately after injury, while figure 7 represents overall mental health after having returned to sports once recovered. Figure 6 displays that immediately after injury, 24 female athletes had very poor mental

health whereas 8 female athletes had excellent mental health. The findings for those who experienced an overall drop in mental health immediately after injury fell outside of the expected range of responses, (N=32), p=.046. Figure 7 presents that once returning to sports, 3 people had very poor mental health and 33 people had excellent mental health. The findings for those who experienced an overall rise in mental health after returning to sports fell outside of the expected range of responses, (N=40), p=.000039.

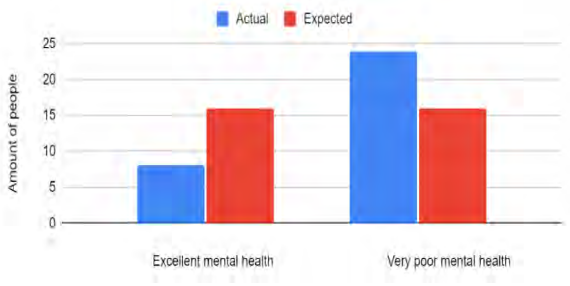

Figure 6: Actual Versus Expected Overall Mental Health Immediately After Injury

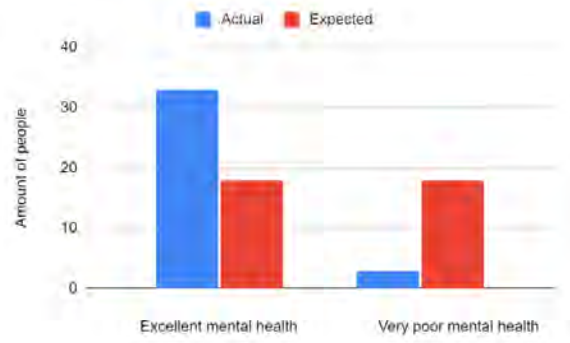

Figure 7: Actual Versus Expected Overall Mental Health after Returning to Sports

The following results do not represent actual versus expected effects, but rather correlations between two different variables using the Pearson correlation method. To develop these results, a tabulated method was utilized in which specific correlations could then be extracted as well as an r value. A high r value and steep slope indicates a very strong positive correlation. Specifically, in the figure below, the correlation between mental health effects and injury severity is displayed. For example, figure 8 presents the correlation between severity of injury and depression. Ultimately, there was a weak positive correlation between injury severity and depression rates, in which r = 0.21. A weak positive relationship indicates that as severity of injury increases, the response of depression slightly increases. The strength of correlations is determined by the r value, on a range from weak to strong.

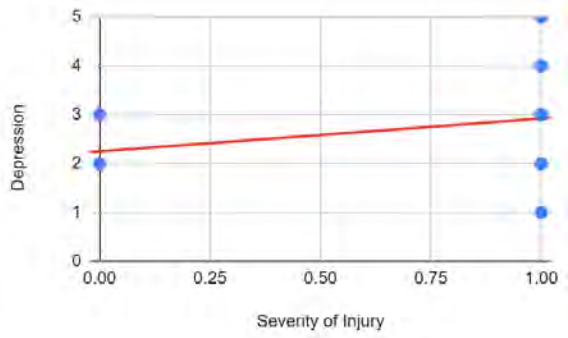

Figure 8: Correlation of Injury Severity to Depression Rates

Figure 9 presents the correlation between injury severity and drops in mood. There was a moderate positive correlation between injury severity and mood drop rates, in which r = 0.31. A moderate positive relationship indicates that as severity of injury increases, the response of mood drop increases to a medium extent.

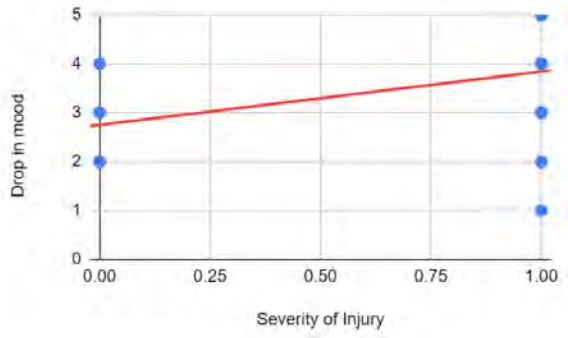

Figure 9: Correlation of Injury Severity to Mood Drop Rates

Figure 10 presents the correlation between injury severity and lack of motivation. There was a strong positive correlation between injury severity and lack of motivation, in which r = 0.47. A strong positive relationship indicates that as severity of injury increases, lack of motivation increases to a great extent.

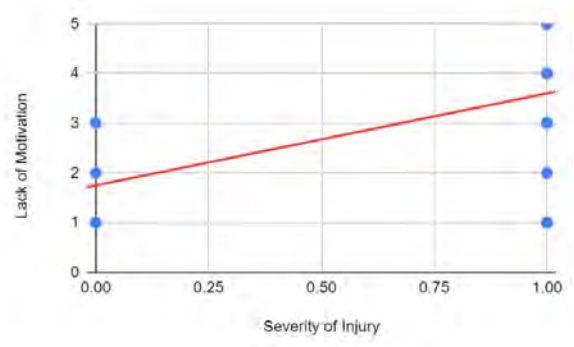

Figure 10: Correlation of Injury Severity to Lack of Motivation

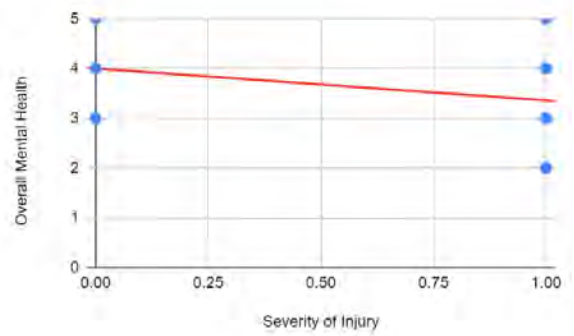

Figure 11: Correlation of Injury Severity to Overall Mental Health Immediately After Injury

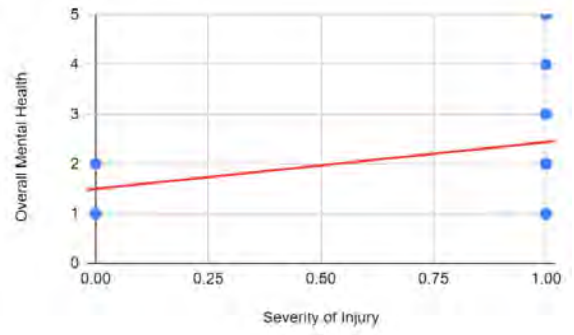

Figure 12: Correlation of Injury Severity to Overall Mental Health After Returning to Sports

Figures 11 and 12 present severity of injury correlated to overall mental health immediately after injury and after returning to sports. There was a weak negative correlation between injury severity and overall mental health immediately after injury, in which r = -0.27. A weak negative relationship represents that as injury severity increases, overall mental health slightly decreases. Figure 12 illustrates that after returning to sports, there was a moderate positive correlation between injury severity and overall mental health, in which r = 0.33. Thus, after returning to sports, many athletes' mental health increased to a great extent.

4. Results: Qualitative

At the beginning of the study, data from four interviews were thematically analyzed. In a thematic analysis, researchers can determine broad themes in a given data set. From these themes, it is then possible to determine more inclusive themes that generalize certain ideas. This method of analysis was used to evaluate the extent to which certain athletes encountered similar mental effects as a result of sports injuries. The interviews were voice-recorded anonymously and then translated onto a document.

The thematic analysis was carried out in multiple steps. First, each of the four interviews were conducted, recorded, and transcribed. Interview recordings were listened to multiple times to identify arising themes from the interviewee responses. Next, a coding method was used to connect similar experiences between the athletes in an attempt to recognize common mental effects athletes endured as a result of sports injury. Once similar experiences were identified, the various themes were sorted into a list of multiple broad categories that fit all themes well. From here, the number of times each broad theme occurred in all the interviews was counted to display a more direct view of shared mental health experiences.

After applying the thematic analysis to the interviews and primary sources, six different themes emerged regarding mental effects as well as approaches to addressing the mental effects of sports injuries. However, four themes were repeated more frequently. These four themes were: (1) Loss of an Outlet, (2) Feeling Rushed to Return to Sport, (3) Performance Anxiety, and (4) Strong Relationships Boost Recovery. Below, each theme is defined and the number of times it was referred to during the interview process is listed. Furthermore, below is also a list of the questions asked during the interviews that allowed the different themes to emerge.

Table 1: Thematic Analysis Themes and Definitions

Theme	Definition	Number of times this theme occurred in interviews
Loss of an Outlet	Sports injuries lead to a loss of a psychological outlet outside of everyday life.	8
Feeling Rushed to Return to Sport	After sports injuries, athletes feel rushed to return to their sport before fully recovering.	7
Performance Anxiety	As a result of sports injuries, athletes are nervous regarding performing at their original potential. They are also nervous about the risk of re-injury.	6
Strong Relationships Boost Recovery	Athletes have found that speaking with friends and loved ones helped them mentally recover after injury	5

Questions asked during semi-structured interviews:

1. What was your injury? What was the severity of your injury? How long was your recovery?
2. Do you believe that your mental health was impacted by your injury? Explain.
3. How did you/did you not deal with or cope with any mental health effects from your injury?
4. How do you think your performance and confidence changed once returning to sports after your injury?
5. Do you believe that you were mentally prepared upon returning to your sport after your injury?
6. If you could give others who are suffering sport-related injuries one piece of advice, what would it be?
7. Did you feel that your coach/club/parents did enough to support you mentally?
8. Did you get outside help? Why/why not? Were you afraid to seek support?
9. Did you feel rushed to return to your sport?
10. Many athletes have mentioned that a loss of a physical outlet becomes very difficult when an athlete is injured. Do you relate to this?

5. Discussion and Limitations

As predicted in this research study, sports injuries have a significant impact on mental health in female athletes in high school. Not surprisingly, those who have more severe injuries tend to have more extreme mental health effects. In reference to Dr. Putukian and her theory that stress increases re-injury rates, it is evident that athletes who were participants in the interview can relate to this idea. As discussed in the qualitative section of the paper, many athletes experienced anxiety and stress when preparing to return to their sport after recovering. As a result of this stress, which as noted by Dr. Putukian can increase muscle tension, many athletes claimed that they suffered re-injuries due to rushing to return to their sport. Relating back to the cycle of stress leading to re-injury discussed earlier, many athletes experience this unfortunate cycle because of sports injury.

Looking at the quantitative Chi-Test of Independence results, certain mental health effects stood out as more prominent than others. For example, most athletes that responded to the survey ended up having severe anxiety, severe drops in mood, and severe lack of motivation compared to expected values. Furthermore, most athletes who experienced injuries had very poor confidence and physical performance after injury. Herring suggested that rehabilitation can be negatively affected by loss of identity, fear and anxiety, and a loss of confidence. It can be concluded that the unfortunate mental health effects many athletes experience can slow down their rehabilitation process, underscoring why it is extremely important to recognize and understand the psychological impact of sports injuries.

In addition to analyzing expected versus actual mental health results, correlation graphs between severity of injury and certain mental health effects were constructed. As an example, there was a positive correlation between injury severity in relation to depression, mood drop, and lack of motivation. There was a weak negative correlation between injury severity and overall mental health immediately after injury, indicating that as severity of injury increased, overall mental health slightly decreased after injury for many athletes. On the other hand, there was a moderate positive correlation between injury severity and overall mental health after returning to sports, indicating that once athletes with severe injuries returned to sports, their overall mental health increased more significantly. These results suggest that those with more severe injuries

tend to have even better mental health than prior to their injury once returning to sports. In this case, athletes finally can return to their outlet, and are likely more appreciative and grateful for their ability to take part in sports. In the end, both the quantitative and qualitative data collected helped to narrow the current gap in research regarding female athletes and mental health effects due to injury.

As discussed in the literature review, it was anticipated that eating disorders would be an effect of sports injury. However, eating disorders actually were not a significant mental health effect compared to others based on the survey results, and therefore were omitted form the results section. Surprisingly, depression rates were also low in comparison to other mental health effects. Part of the reason many athletes reported they did not have major depression or eating disorders because of injury relates to the stigma specifically attached these two issues. Dr. Putukian concluded that there are also stigmas around weakness for athletes and behind seeking therapy for issues like depression. It is possible that because of these stigmas, many athletes did not select that they had depression or eating disorders to avoid appearing weak.

The two bar charts illustrating Actual versus Expected Overall Mental Health Immediately After Injury and Actual versus Expected Overall Mental Health After Returning to Sports demonstrate the importance of utilizing sports as an outlet. Immediately after injury most athletes had very poor mental health. However, after returning to sports, the majority of athletes had excellent mental health, and few had very poor mental health. This relationship implies that the true reason athletes suffer mentally following injury is because of a loss of their physical and emotional outlet. As soon as athletes returned to their sport, their overall mental health rapidly improved. As expressed in the qualitative interviews, athletes still suffer through stressors even after returning to sports, specifically regarding the anxieties of re-injury. However, because they have returned to their sport, mental health improves significantly, illustrating the gravity of the outlet that sports provide for athletes.

Significant limitations arose from collecting the quantitative and qualitative data in this research. In the quantitative study, athletes had to rate the severity of their own injury. This approach was inherently subjective, as some athletes ranked more severe and less severe injuries at the same severity rate in my survey. For example, a sprained ankle is typically not as severe as an ACL injury, however some athletes may have ranked these injuries as the same severity depending on their own experiences. Injury severity correlations were a key aspect of the quantitative data, therefore this limitation likely skewed some of the results. In addition, had the quantitative data been collected on a 1 to 4 scale instead of on a 1 to 5 scale and then omitting the 3s from the analysis, all responses would have been included. It is possible that this would have made the results more significant. Furthermore, data was only collected from 50 athletes for the quantitative results, and more athletes could have further broadened the scope of the data. Additionally, most participants were soccer players, slightly limiting the type of injuries and injury severities included in the data. Moreover, although the qualitative results were crucial for the research, only four students were interviewed. By interviewing more students, additional significant themes may have become evident, thereby enhancing the qualitative section of the research.

6. Conclusion and Implications

There are critical implications that have arisen from the results of this research. There has been a lack of attention to mental health issues associated with sports injuries in female athletes in high school. This research can help doctors, coaches, and athletes to further appreciate the severity of mental health issues in female athletes resulting from sports injury. Simply understanding the mental health effects themselves is a critical first step in eventually creating a solution. However, more research is needed to investigate different tools and strategies to screen for and address the psychological suffering of female athletes. By providing better support for their athletes, coaches can have a more impactful role in helping their athletes recover mentally. Finally, the most important implication of this research is that female athletes struggling with mental health issues after sports injuries can now realize that they are not

alone. Female high school athletes suffer similar psychological issues following sports injuries, and hopefully this study will encourage athletes to acknowledge and prioritize mental health after injury.

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Responsibilities of Healthcare Professionals during Natural Disasters and Mass Casualty Incidents

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Abstract

Disasters and emergencies can strike at any time without leaving any time to prepare. Severe storms, hurricanes, wildfires, tornadoes, and floods are some of the natural disasters that frequently strike Georgia, USA. Many factors influence a community's exposure and vulnerability to disasters, including natural, artificial, and technological dangers. Floods, storms, droughts, and heatwaves are becoming more frequent and intense in Georgia. Climate-related natural disasters are becoming more frequent, as examined in this study, in light of three major disaster risk factors: expanding population exposure, increased population vulnerability, and increasing climate-related hazards. This study addresses the responsibilities of medical doctors with regard to natural disasters and mass casualty incidents.

Keywords: Natural Disaster, Public Health, Health Care, Mass Casualty Incidents

1. Introduction

1.1 History

The state of Georgia in the United States is prone to a wide range of natural catastrophes including hurricanes, tornadoes, severe thunderstorms, wildfires, and floods. Georgians, and Americans in general, are at risk of disease epidemics (such as pandemic outbreaks) and man-made catastrophes (such as transportation accidents and terrorist attacks involving dangerous chemicals) (USGS, 2017). Disasters and emergencies can strike at any time and there is no time to prepare (Phillips et al., 2015). As a result, being well-prepared is critical at all times.

Throughout Georgia, thunderstorms are the most common form of natural catastrophe. These storms are capable of wreaking havoc and destroying entire towns and cities. Several northern Georgia counties were affected by the 500-year flood in September 2009. The flood caused $150 million worth of damage and ten fatalities, including 20,000 homes, businesses, and other structures in 23 counties. As a result of this flood, 46 Georgia counties were declared federal disaster areas (Gotvald, 2010).

Hurricanes can strike Georgia from the Atlantic or the Gulf of Mexico, making it vulnerable to storms and hurricanes. Hurricane Katrina landed in Georgia on August 29, 2005, and heavy rain and damaging winds swept across the state's west (Gotvald, 2010). At least two people were killed and scores of homes and businesses were damaged when Katrina's ashes moved across the state. The price of gasoline shot up to $6 per gallon after oil pumps in the Gulf of Mexico were disrupted, causing panic among consumers (Georgia Disaster History, 2019). As a result of Hurricane Katrina, Georgia received more than 100,000 Gulf Coast evacuees (Georgia Disaster History, 2019).

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1.2 Potential Causes of Natural Disasters in Georgia

Disruptions to a community's ability to function beyond its capacity to handle disasters on its own are known as disasters. Many factors influence a community's exposure to and vulnerability to disasters, including natural, artificial, and technological dangers. Floods, storms, droughts, and heatwaves are becoming more frequent and intense in Georgia. Temperatures are becoming more volatile and intense as a result of the growing levels of greenhouse gases in the atmosphere (Environmental Protection Agency, 2017). Rainfall has also become increasingly erratic and intense. Increasing hydrometeorological and climate phenomena worldwide suggest a possible relationship with human-caused climate change.

This research examines several natural disasters linked to climate change occurring with increasing frequency, in light of three major disaster risk factors: expanding population exposure, increased population vulnerability, and increasing climate-related hazards. Disaster risk models from 1971 to 2013 show that people's socioeconomic vulnerability and population exposure to catastrophes are linked to the frequency of these intense disasters (Environmental Protection Agency, 2017). Precipitation deviations are favorably linked to hydrometeorological events, whereas temperature and precipitation deviations are negatively linked to climatological events. According to this study, global climate change indices show substantial progress in addition to these positive consequences.

As the planet warms, so does our climate. Since the late 1700s, human activity has resulted in a 40 percent increase in atmospheric carbon dioxide concentrations. Increases in other heat-trapping greenhouse gases are also occuring. Gases such as these have warmed the Earth's surface and lowered its atmosphere by about a degree Fahrenheit (F) over the past 50 years (Environmental Protection Agency, 2017). In many places, increased evaporation and humidity and rainfall are benefits of global warming, but in others, it is a cause of drought.

Oceans and ice cover are also being affected by greenhouse gas emissions. Increasing ocean acidity has been linked to increased carbon dioxide-water reactions, which produce carbonic acid. A one-degree increase in ocean surface temperature has occurred over the past 80 years. Warming hastens the spring thaw and forces mountain glaciers to recede. Even the massive ice sheets of Greenland and Antarctica are receding (Banholzer et al., 2014). Therefore, sea levels are rising at a faster rate because the terrain is sinking, and Georgia's sea level is increasing faster than other shores. Along the Georgian coast, sea levels are expected to increase by one to four feet over the next century if the oceans and atmosphere keep warming.

Wetlands and dry lands are getting submerged by rising sea levels, eroding coastlines, and increasing coastal floods. In the last two decades, hurricanes and tropical storms have become increasingly powerful. Scientists are not sure if the recent strengthening of these storms is a long-term trend despite rising waters. Nevertheless, as climate warms, hurricane winds and rainfall rates are anticipated to increase. It does not matter if the intensity of storms increases; as sea levels rise and storm surges increase, coastal houses and infrastructure are more likely to be flooded. When the water level rises, the frequency of storms can increase, resulting in an increase in the economic burden of house maintenance expenses, including home insurance. The consequence of rising water levels could be more significant along the shore, such as in the Savannah and Brunswick regions.

2. Infrastructure Damage and Human Fatalities Caused by Three Major Natural Disaster in Georgia

The most destructive tornadoes form from supercell thunderstorms, which are massive and strong storm systems. Supercells form about once every 1,000 storms and about every fifth or sixth supercell produces a tornado (National Weather Service, 2020). The late afternoon and evening are the most common times when tornadoes originate. Thunderstorms can form now that the sun has sufficiently warmed the land and atmosphere (National Geographic, 2019). Tornadoes arise when humid, warm air meets drier, cold air. A tornado can strike at any time of the year, but it is more likely to

occur in specific seasons or periods within an area. As the jet stream moves northward, the number of tornadoes increases (National Geographic, 2019). While May is the month with the most tornadoes, ferocious twisters in April are not uncommon. Later in summer, tornadoes are more likely in the north.

A whopping $400 million in damage and 70 deaths are caused annually by tornadoes in the United States (National Geographic, 2019). Mighty winds demolish buildings and homes. A riverbed can be drained of its water by strong winds, which can also demolish bridges, flip trains, send automobiles and trucks flying, and peel the bark off trees. People can be thrown from great heights or killed due to being tossed around by strong winds. Flying shingles, shards of glass, doors, and metal rods strike the majority of individuals killed or injured in a tornado. The average number of deaths per year in the United States was higher before improved forecasting and warning measures were adopted.

Natural catastrophes harm millions of individuals globally annually. At least 100 individuals must be affected for a disaster to qualify as a disaster in the eyes of the International Federation of Red Cross and Red Crescent Societies. Advancements in technology have enabled more people to move to disaster-prone areas. Southern California's change from an agrarian lifestyle has led to population concentration in metropolitan hubs (Thomas et al., 2016). Disasters are predicted to cause greater damage in the future. Disasters deplete the resources of the areas in which they occur. Non-industrialized governments are less prepared to deal with large-scale disasters as they lack financial resources. Hurricane Katrina and other recent events serve as a sobering reminder that even developed countries, such as the United States, are not exempt from natural disasters.

In Georgia, there are usually six days a year when tornadoes are reported. This season is the most likely time for tornadoes to occur, with the peak occurring around April. Mid-afternoon to early evening is when tornadoes are most likely to form, but they can strike at any time or night (National Weather Service, 2022). Tornadoes that are powerful or violent (EF2 or higher on the Enhanced Fujita Scale) account for 37% of all tornadoes, with April being the month most likely to see these storms (National Weather Service, 2022). Few EF-4 tornadoes have been documented in Georgia, but no EF-5 tornadoes have ever been recorded in the state. Tornadoes in Georgia are typically difficult to observe because of the rain and hail surrounding them, and the mountainous terrain can also hamper a tornado's visibility.

3. Post-Disaster Health Problems in Survivors

Civilization cannot function when a natural disaster occurs. Calamity has ramifications beyond the physical, affecting people psychologically and socially. Many natural disasters occur rapidly and inflict significant damage (Bonanno et al., 2010). Unfortunately, the psychological effects of disasters have proven incredibly difficult to quantify owing to their unplanned and chaotic nature.

The psychological toll of a disaster on survivors has been frequently overestimated in published reports. These reports indicate that many, if not most, survivors would suffer from posttraumatic stress disorder (PTSD). They also underestimate the disasters' more significant impact in other areas. Only a tiny percentage of people exposed to disasters suffer from significant psychological damage (Bonanno et al., 2010). Suicidal ideation, substance abuse, and stress-related health costs are just a few of the many problems associated with poor mental health that disaster survivors experience (Pourhosseini et al., 2016). Only a small percentage of those exposed to high levels of these disorders may have severe symptoms.

Psychological resilience can be observed in the aftermath of a disaster. In addition to chronic dysfunction, there are expected catastrophic outcomes. It can take a few months or more for survivors to regain mental equilibrium (Pourhosseini et al., 2016). More than half of those exposed merely experience brief symptoms of discomfort and continue to maintain a good course of functioning or resilience (Bonanno et al., 2010). Studies employing various strategies, including latent growth mixture modeling and other relatively advanced data analytic tools, have shown that resilient outcomes can be achieved.

4. Health Care Solutions to Support Public Health after Natural Disasters

Healthcare is one of the most critical aspects of disaster management. Disaster management has a direct impact on the health of disaster victims as well as on the performance of numerous sectors. To enhance and implement reforms in the health care system, it is vital to evaluate programs and highlight their shortcomings. Public health aims to guarantee that individuals live in conditions they need to be healthy (Philipsborn et al., 2020). The three fundamental activities of the public health sector—assessment, policy development, and assurance—are the foundation of a community's ability to respond to human needs, particularly those connected to catastrophes (Ghebreyesus, 2019). It is the responsibility of public health to lead an interdisciplinary and team-based approach to the continuing assessment of the health condition and needs of the public, develop and prioritize plans to address those needs, and assure access to essential health services throughout disaster recovery. The committee's recommendations and report are intertwined because the components of the public health recovery mission cut across all other sectors. Therefore, this study identifies the specific responsibilities of the public health sector.

Health systems have been strengthened, the International Human Rights Code (IHR) has been implemented, and multi-hazard disaster risk management techniques have been developed to better manage health hazards associated with hazardous occurrences. A risk-management approach should be used to develop emergency and disaster preparedness policies and programs (Ghebreyesus, 2019). There is a continuum of measures in which the focus is not just on responding to an incident or crisis, but also on enhancing the resilience of communities and countries against future emergencies and disasters.

Reducing risks, exposure, and vulnerabilities, as well as building the capacity to prevent or mitigate the effects of potentially emergency triggering events, are all tasks that health systems may and should help with. These include disease surveillance, mass casualty management, primary care, pre-hospital treatment, chemical and radiation safety, mental health, and risk communication (Ghebreyesus, 2019). Emergency preparedness plans, specialized emergency health teams, infrastructure requirements, emergency response plans, and simulation exercises are additional capabilities that health systems have to manage non-routine or emergency hazards.

More healthcare personnel are required to treat patients who have been harmed by disasters in an unlimited variety of ways. Physicians must also know about local hazards, which necessitates the recruitment of extra doctors when a particular talent is needed to deal with calamity. The doctors' responsibility is to be disaster-ready on their own (Pourhosseini et al., 2016), and this involves preparing for the safety of the physician's family.

For disaster recovery to be successful, we will need more highly trained healthcare professionals so that they can care for their loved ones and patients. Survival packs, meeting places, and backup communication lines are only a few examples. Every so often, checking these is a good idea (Pourhosseini et al., 2016). In the case of calamity, physicians should stock their offices with the required supplies. International volunteers should check their travel documents and immunization records and take preventive drugs such as malaria pills and tetracycline.

5. Conclusion

Disasters and catastrophes can strike at any moment, leaving no time for preparedness. Natural disasters, such as hurricanes, tornadoes, severe storms, wildfires, and floods, are common in Georgia. Furthermore, community exposure and vulnerability to disasters are influenced by several factors, including natural and man-made disasters as well as technological threats. Consequently, disaster management requires a thorough examination of all facets of healthcare in the event of a catastrophe. Additionally, the healthcare department needs potentiality and relationships with other departments before a disaster occurs, which will result in fewer disaster challenges, particularly during the response phase. Therefore, data obtained from the experience and knowledge of disaster managers can be of great

significance during operational planning in disaster healthcare services.

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Deep Transformer based Intent Classifier (DTIC)

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Abstract

With the large-scale data availability and increasing popularity of digital service platforms, more and more users have begun reading reviews of listed items before deciding to perform a transaction. To determine the intention of these reviews, we will use a type of machine learning technique called sentiment analysis or intent mining to analyze the texts. A vital task of using Natural Language Processing (NLP) is to classify the opinion or sentiment from text into different sentiment categories. In this work, we propose to use a deep, fine-tuned BERT (bidirectional encoder representations from transformers) intent classifier model to analyze the texts. A xgboost classifier and a classical logistic regression model are used as baselines to compare with the BERT based model. These models are applied to one category of the open public Amazon book review data (Amazon book review data) to perform intent mining and survey the results. From our experiments, we observed the deep learning BERT model showed a higher performance than the other two baseline models. The accuracy of using a deep learning model can be boosted by up to 20%.

Keywords: BERT Language Model, Classification, Natural Language Processing

1. Introduction

As online retailers attempt to reign the digital market by satisfying customer needs, they rely on customer reviews and communication channels for a rating on their products. These reviews not only help retailers but also for customers to gauge the quality of their products. Reading reviews about an item gives users an idea of quality from other customers. By analyzing the reviews, businesses can survey the customers' opinions. To leverage public opinion, companies can build recommendation systems or better-targeted marketing campaigns. These recommendation systems can have distinct classifications: negative, positive or neutral. This process is called sentiment analysis or intent mining in the machine learning domain. Sentiment analysis uses techniques like natural language processing (NLP) and computational linguistics to identify subjective information.

In this paper, we create a TF-IDF (term frequency-inverse document frequency) feature vector (Cox, 1958) for traditional xgboost classifier and logistic regression models. We also use pre-trained BERT (Pedregosa, et al., 2011) to generate encoded vectors for fine-tuning classification. These classifiers are used to classify book reviews into multi-class intent categories in our experiments. The main objective of our work is to present a comparative study on different classifiers based on confusion matrix and accuracy while analyzing the features correlated to sentiment categories to identify the most efficient model in the text domain.

Through study, we expect to see that the latest fine-tuned BERT model should outperform classical logistic regression and xgboost classifier. Moreover, xgboost classifier should have better performance

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than logistic regression. The reason behind this is logistic regression and xgboost classifier cannot handle large numbers of sparse and high-dimensional features. The BERT-pretrained model which was pre-trained on a big corpus and the fine-tuned deep learning architecture can learn non-linearity and high-dimensional vectors very well without overfitting. Furthermore, xgboost classifier will perform better than logistic regression since it can learn not only linear boundaries, but also complex non-linear features. Our experiments validate these reasoning and our insights are derived by analyzing the results. On the other hand, although BERT-pretained plus fine-tuning models demonstrate its superiority over the rest traditional models, the large number of model parameters and large size of model is still a bottleneck for small-scale applications. We plan to investigate a distilled model to reduce the complexity of the BERT model and have the similar performance as what we have in our current study. We provide our summary and future work at the end.

1.1 Feature Engineering

TF-IDF feature vector

TF-IDF stands for term frequency-inverse document frequency and it is a measure to quantify the importance or relevance of string representations (words, phrases, lemmas, etc.) in a document amongst a collection of documents (also known as a corpus). TF-IDF is composed of two parts: TF (term frequency) and IDF (inverse document frequency). Term frequency refers to the frequency of a given term relative to the total terms occurrence in the document. Inverse document frequency (IDF) measures how common (or uncommon) a word/term is amongst the corpus. IDF is calculated below where t is the term (word) frequency measuring the commonness of, and N is the number of documents (d) in the corpus (D). The denominator is the number of documents in which the term (t) appears in.

$$idf(t, D) = log(\frac{N}{count(d \in D : t \in d)})$$

In our data, all the words in review text are used as corpus and each review text is treated as a document. For our baseline models, logistic regression and xgboost classifier model, we use TF-IDF as input features.

BERT Pretrained Embedding vector

BERT is a deep bidirectional pre-trained encoder model (Jacob, et al., 2019). It is available in two sizes: BERT-BASE, with 12 transformer layers and 768 hidden layers, and BERT-LARGE, containing 24 transformer layers and 1024 hidden layers. These two models are trained on the same datasets: BookCorpus, which contains 800M words, and the English Wikipedia, which holds 2500M words. Using BERT, we can extract features, namely word and sentence embedding vectors, from text data. These embeddings are useful for keyword search, semantic search, and information retrieval. They are also used as high-quality feature inputs to downstream tasks like clustering or semantic search. In our fine-tuned BERT classification model, we used embedding of the sentence-transformer model (Lee, et al, 2022) as initial input features. It maps sentences & paragraphs to a 384-dimensional dense vector space for multi-class classification.

1.2. Baseline Models and Proposed Model

In this section, we provide the details of two baseline models: xgboost classifier and logistic regression model and our proposed model fine-tuned BERT multi-class classifier.

Logistic Regression

Logistic regression is a classification model used in machine learning (Addanki, et al., 2019) (see Figure 1). The model predicts the probability of a dependent (*i.e* target variable) as a function of independent variables (*i.e.* input features). The dependent variable is the class that the model attempts to predict for a data point and the independent variables are input features. Logistic regression assumes that there exists a linear relationship between each independent variable and the logit of the dependent variable. The sigmoid function is used for mapping predicted value to probability (see Figure 1 (2)). The objective function is:

$$J(w) = \sum_{i=1}^{m} - y^{(i)} log\left(\phi(z^{(i)})\right) - (1 - y^{(i)}) log\left(1 - \phi(z^{(i)})\right) \quad (1)$$

where y is label , $\phi = 1/(1 + e^{-z})$ is the sigmoid function and $z = w1 \cdot x1 + w2 \cdot x2 + \ldots + wn$ is the linear function for mapping features to logit of label value.

Using logistic regression is straightforward to implement, interpret, and efficiently train. However, non-linear problems can't be solved with logistic regression because it has linear decision boundaries. In real-world scenarios, linearly separable data are rarely found. Furthermore, for intent classification in NLP, the TF-IDF feature vector is sparse and high-dimensional, leading to overfitting. Our experiment in the following validates this claim.

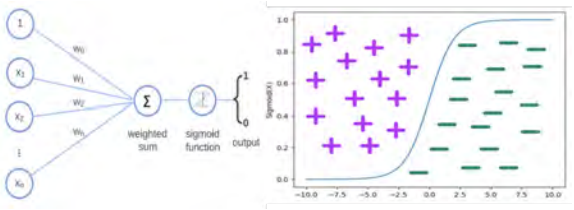


Figure 1. (1) Logistic regression function visualization (2) Sigmoid function for mapping probability (Addanki, et al., 2019)

Xgboost Classifier

Xgboost classifier is a tree-based sequential ensemble machine learning algorithm (Chen, & Guestrin, 2016). This model predicts a target variable by building a strong classifier from the number of weak classifiers in sequence. Firstly, a tree model is built from the training data. Then a second tree model is built, targeting to correct the prediction errors learned from the first model. As this step is continued, the models are sequentially added until either the prediction error achieves a certain threshold or the maximum number of models is added.

The training process of the xgboost classifier is shown in Figure 2. In the training dataset, there are a total 4 positive (+) and 6 negative (-) data points. At the beginning, the data is trained by the classifier 1 ($F_1(x)$). The classifier 1 incorrectly predicts two negative (-) and three positive (+) data points, which are highlighted with a circle. The weights of these incorrectly predicted data points are increased and provided to the next classifier 2 ($F_2(x)$) to fit for the error 1 (*i.e.* r_1) . The classifier 2 incorrectly predicts the one negative (-) and one positive (+) data point. The error 2 (*i.e.* r_2) is learned by next classifier 3. The classifiers are sequentially added until all the items in the training dataset are predicted correctly or a maximum number of classifier models are added. The optimal maximum number of classifier models to train can be determined using hyperparameter tuning. A combined final classifier is built to predict all the data points correctly.

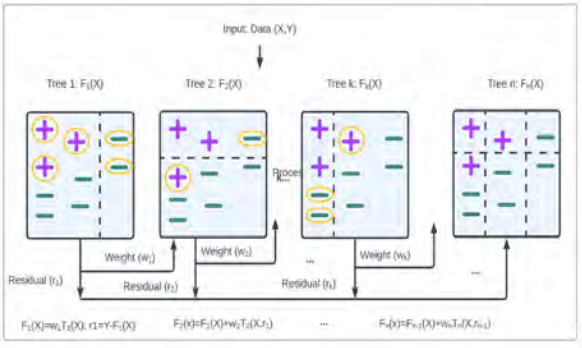


Figure 2. Gradient Boost Model

The objective function of the XGBoost model on the t'th iteration:

$$L^{(t)} = \sum_{i=1}^{n} l\left(y_i, \hat{y}_i^{(t-1)} + f_t(x_i)\right) + \Omega(f_t) \quad (2)$$

where $L^{(t)}$ is the cost function to be minimized for *n* training data points, the first term on the right side is the error generated by the previous classifier and the new fitted function. The second term is regularizer (Kingma, D. and Ba, J. 2015), which is used to control the model complexity.

Pretrained Language Modeling (BERT) and Transfer Learning

Recently, transformer-based pretrained language models have demonstrated state-of-the-art performance in the natural language processing

(NLP) domain. For example, BERT (Vaswani, et al., 2017) have achieved outstanding performance through masked self-supervised pre-training and transformer-based modeling. Transformer language modeling with pretraining and word representations combined with transfer learning (Lisa, et al., 2010), has significantly improved many natural language understanding (NLU) tasks, such as text classification and natural language inference. In the following, more details of the BERT model and transfer learning are introduced.

BERT is designed for training using self-supervised learning, wherein the model learns the context of a sentence during training by having a masked language model. The masked language model randomly masks tokens from the input text to predict the original masked word based on its context. This method allows BERT to consider the meaning of words based on the context in the training phase, thereby enabling the BERT language model to achieve performances comparable to those supervised learning with the help of human labeling cost. Furthermore, the next sentence prediction task allows the relationships between sentences to be learned based on text-pair representations. By applying next sentence prediction, BERT can be utilized in many downstream tasks such as question and answering as well as natural language inference by understanding the relationship between two sentences. In our approach, we will use it for sentiment multi-class classification tasks.

Transfer learning (Martín, et al., 2015) improves performance by sharing the parameters of a model that has been trained on similar task data in advance, unlike conventional machine learning that performs individual and single-task learning. In transfer learning, previously learned tasks are used when learning a new task; therefore, it is more accurate, and requires less training data. Moreover, its learning process is faster than that of a single-trained machine learning model. BERT can be applied to downstream tasks by fine-tuning all pretrained parameters.

BERT Fine Tuning Model Architecture (our approach)

In this work, we implemented a fine-tuned deep learning model for multiclass intent classification downstream task by utilizing BERT-based pretrained encoder and adding an output layer for classification.

The BERT-based model contains an encoder with 12 transformer blocks, 12 self-attention heads, and the hidden size of 768. BERT takes an input of a sequence of no more than 512 tokens and outputs the representation of the sequence. The sequence has one or two segments that the first token of the sequence is always [CLS] which contains the special classification embedding and another special token [SEP] is used for separating segments. The final hidden state h of the first token [CLS] is taken as the representation of the whole sequence. A softmax classifier is added to the top of BERT to predict the probability of label C: $p(c|h) = \text{softmax}(W_h)$, (1) where W is the task-specific parameter matrix. We fine-tune all the parameters from BERT as well as W jointly by maximizing the log-probability of the true label. We applied ADAM (adaptive moment estimation) as an optimizer and categorical cross-entropy loss as a loss function. The fine-tuned model architecture is as follows (Figure 3): tokenizer, encoding; output layer; softmax.

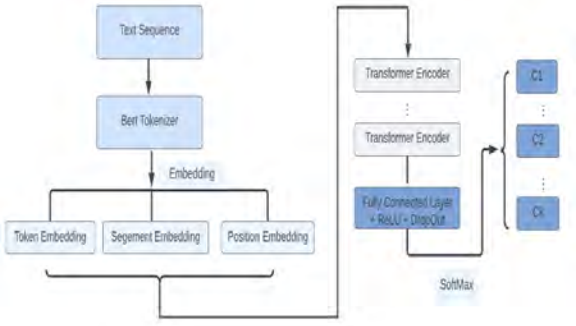


Figure 3. Fine-tuned Bert multi-classification model

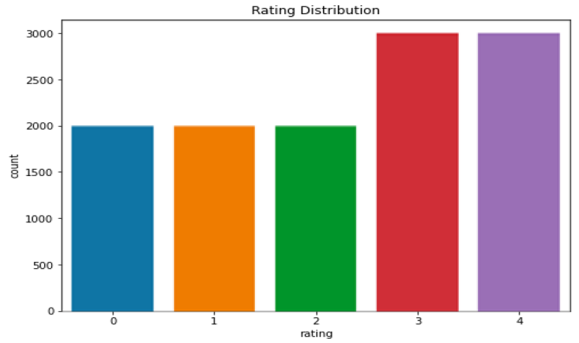
2. Materials and Methods

We evaluated the performance of the BERT fine-tuned classification models on an amazon open public book review dataset (Amazon review data, 2018) and compared it to the logistic regression and xgboost classifier. The experiments demonstrate the classification performance depending on the model architecture. The results show the BERT classifier performs much better than logistic regression and xgboost classifier.

2.1 Book Review Classification and Summary Dataset

The amazon book review dataset contains product reviews from Amazon, including 142.8 million reviews spanning May 1996 - July 2014. This dataset includes reviews (ratings, text, helpfulness votes), product metadata (descriptions, category information, price, brand, and image features), and links (also viewed/also bought graphs). Full dataset has 12,000 records and is randomly split for training and validation. Target variable is the review rating value(total 5 levels of rating: 1,2,3,4,5) and its distribution is shown in Figure 4 (1). A detailed description of an example from the dataset is presented in Figure 4 (2). Each data point has 3 columns: rating (0-5), reviewText and Summary. These three features contain the most relevant information to the rating classes.

- reviewText - text of the review (heading).
- rating - rating of the product.
- summary - summary of the review (description).



	rating	reviewText	summary
0	5	This book was the very first bookmobile book I bought when I was in the school book club. I loved the story then and I bet a dollar to a donut I will love it again. If my memory serves, I bought this book in 5th grade. That would have been about 1961. I am looking forward to reliving the memories.	50 + years ago...
1	1	When I read the description for this book, I couldn't wait to read it. Once I downloaded it to my Kindle, I found it extremely hard to keep reading it. To be honest, I stopped reading halfway through the book. It began slow and remained a slow, uninteresting read. It lacked passion; not making love passion, but passion for life. Neither Jada or Aaron were interesting characters and the story was too, too 'everything is perfect'. Everybody is just so understanding and accommodating--the bit of drama with his father and her grandmother was blah. To give an example of what I mean (and there are MANY), Aaron finally finds out almost half way into the book that he fathered a child 5 years ago--keep in mind that Aaron and Jada kept in contact for a few months after he left and she never mentioned to him that she was pregnant. When she finally tells him he has a son, Aaron becomes overwhelmed with emotions (misty eyed) knowing that he's a father. WTH! I think most men would be upset/angry to know that they had a child and the woman they love never told them! Not in this book; it's all good--all is well; NO PASSION. OMG, don't let me get started on the scene when father and son finally meet. It was so over the top, it made me want to barf. Maybe if this scene had been towards the beginning of the book, it would have been touching. In the middle of the book after just too much blah it made me thrown down my kindle. It was like eating a sweet dessert that was so sweet it made your teeth hurt. This book had a good theme, but no follow-through. Also, if we're to believe that Jada graduated from Harvard, then let it be reflected in her speech and her job. We're told that she has this wonderful personality which caused Aaron to fall in love with her--never saw it. If the author had described her as depressed and foolish--Yes! I would believe it in a heartbeat. She was boring. This book was so frustrating to read. I truly struggled to read it as far as I did. I finally stopped torturing myself because I realized it wasn't going to get any better.	Boring! Boring! Boring!

Figure 4. Overview of review data. (top) Rating Distribution, (bottom) one sample of Review text

2.2 Evaluation Metric

The accuracy score and confusion matrix are used as the evaluation metrics in this study.

Accuracy is one metric for evaluating classification models. Informally, accuracy is the fraction of correct predictions from our model. The calculation is:

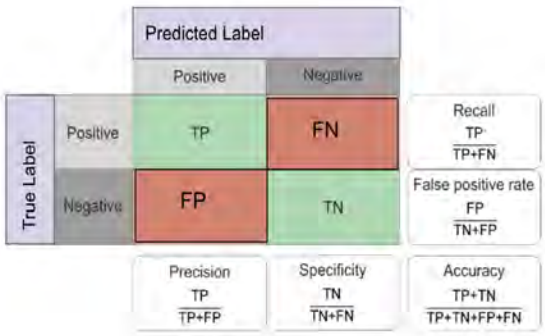
$$\text{Accuracy} = \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions} \qquad (3)$$

For binary classification, accuracy can also be calculated in terms of positives and negatives:

Accuracy= (TP+TN)/((TP+TN)+F+FN) (4)
where (TP: true positive, FP: false positive, and FN: false negative).

Confusion matrix is also often used to measure the performance of a classification algorithm, for instance: recall, specificity, accuracy, and precision classification metrics are easily obtained from confusion matrix, which is a table with 4 different combinations of predicted and actual values (Table1).

Table 1. Performance Metrics: Confusion Matrix . It is a table that is used to define the performance of a classification algorithm. It visualizes and summarizes the performance of a classification algorithm. The detailed explanation of each term in the table is listed in the "Note" below.



Note:
True positive (TP): Observation is predicted positive and is actually positive.
False positive (FP): Observation is predicted positive and is actually negative.
True negative (TN): Observation is predicted negative and is actually negative.
False negative (FN): Observation is predicted negative and is actually positive.
Precision: The fraction of positive values out of the total predicted positive instances.
Recall: The fraction of positive values out of the total actual positive instances
Accuracy: Accuracy gives the proportion of the total number of predictions that are correct.

Compared to the machine learning classification metrics like "accuracy" give less useful information, which is simply the difference between correct predictions divided by the total number of predictions. Confusion matrix is useful for deep analysis of model performance since it directly shows true positives, false positives, true negatives and false negatives.

3. Results

3.1 Logistic Regression

We utilized the sklearn package to build pipeline and grid search to perform hyper-parameter tuning (Pedregosa, F. et al 2011). The TF-IDF frequency features are created by pipeline. The responsible variable is the rating values={1,2,3,4,5}. Since it is a multi-class prediction, the training algorithm uses the one-*v.s.*-rest (OvR) scheme and the regularization is applied. After tuning, the best learning rate is 2 and L2 regularizer is recommended. Figure 5 shows the confusion matrix on training and validation set. Table 2 shows the accuracy for each class.

Train Validation

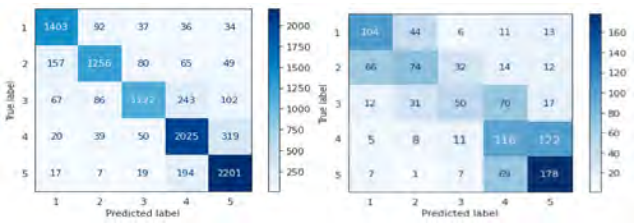


Figure 5. logistic regression output

Table 2. Accuracy of each class for Logistic Regression

Accuracy	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5	Accuracy
Training	87.46	78.15	69.25	82.55	90.27	82.30
Validation	58.42	37.37	27.78	44.27	67.94	47.62

3.2 XGBClassifier

Same as logistic regression, we also utilized the sklearn package to build pipeline and grid search to perform hyper-parameter tuning (Pedregosa, et al., 2011). After gridsearch, the best parameter are: {'clf__max_iter': 20, 'clf__penalty': 'l2', 'vect__max_df': 1.0, 'vect__ngram_range': (1, 2)}, where clf__max_iter is the max number of training epochs, clf__penalty is L2 regularizer, vect__max_df is the maximum document frequency and vect__ngram_range includes unigrams and bigrams. Figure 6 shows the confusion matrix on training and validation set. Table 3 shows the accuracy for each class.

Train Validation

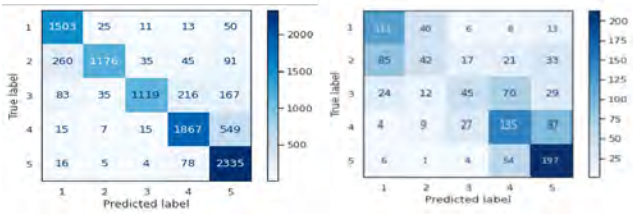


Figure 6. xgboost classifier output

Table 3. Accuracy of each class for XGBClassifier

Accuracy	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5	Accuracy
Training	93.82	73.17	79.07	76.11	95.77	88.28
Validation	62.35	42.92	25.00	51.53	75.19	49.81

3.3 BertClassifier

In our implementation,we used the transformer library of Hugging Face (Transformers, https://huggingface.co/docs/transformers/index). It contains PyTorch implementation of state-of-the-art NLP models including BERT and pre-trained model weights. We created a BertClassifier class with a BERT model to extract the last hidden layer of the [CLS] token and a single-hidden-layer feed-forward neural network as our classifier. Figure 7 shows the confusion matrix on training and validation set. Table 4 shows the accuracy for each class. Figure 8 (1) shows the training loss and validation loss with the number of epochs. Figure 8 (2) visualizes and summarizes the accuracy of logistic regression *vs.* xgboost classifier *vs.* BertModel on validation sets.

Train Validation

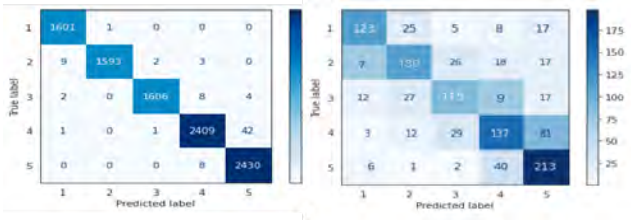


Figure 7. Bert classifier output

Table 4. Accuracy of each class for BERTClassifier

Accuracy	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5	Accuracy
Training	99.93	99.13	99.14	98.20	99.67	99.16
Validation	69.10	65.65	63.88	52.29	81.29	65.45

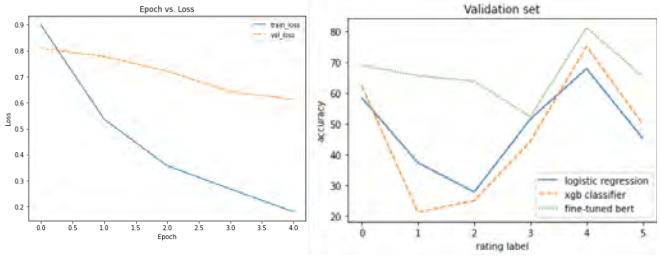


Figure 8. (left) Bert classifier Train and Validation loss vs. Epoch, (right) Bert vs. xgboost vs . logistic regression validation set performance

To summarize, the experiments above show the confusion matrix, accuracy of three models as well as the training/validation loss of the BERT model. We can see that a fine-tuned BERT model outperforms classical logistic regression and xgboost classifier. In the training phase, the accuracy goes up from 82.30% to 88.28% to 99.16%. During the validation phase, the accuracy increases from 47.62% to 49.81% to 65.45%. For each class prediction, the accuracy also increases from the logistic model to xgboost classifier to BertModel. The result validates the limitation of logistic regression and xgboost classifier which cannot handle large numbers of sparse and high-dimensional features. Furthermore, logistic regression can only learn linear boundaries. The BERT-pretrained model was pre-trained on a big corpus and the fine-tuned deep learning architecture can learn non-linearity and high-dimensional vectors very well without overfitting.

4. Discussion

4.1 Transformer Interpreter

To further support the deep learning model's performance, we ran a transformer interpreter (Charles, n.d.), which is a model explainability tool designed to work exclusively with the transformers package. It produces a dictionary of word attributions mapping labels to a list of tuples for each word and its attribution score. These explainer attribution scores are highlighted and display the visualization in-line with weights.

In the examples below (Table 5), each rating data point with the true class is displayed and corresponding attribute with higher-weight related to target variable is highlighted. For instance, for the first review text: *"The premise of this book was totally disgusting and I 'm sorry I read it. I deleted it. Don 't bother if you value your sanity"*. *"disgusting"* has more weights related to our target rating value (=1, very low raing). It is highlighted to reflect its corresponding low rating and the summary *"Disgusting premise"* also validates *"disgusting"* consistent with the content from our ground-truth data. The rest of the examples are the same as this interpretation.

4.2 Embedding Visualization

Furthermore, to have a good understanding of the review text, we generate the embeddings from trained models and visualize them in tensorboard (Martín, et al., 2015) shown from Figure 9. Figure 9 (1) shows 3-D visualization, each data point is the embedding vector learned by model and represents corresponding review text. If the mouse hovers over one particular data point, it also shows its content (*i.e.* raw review text), as you can see from Figure 9 (2). In the rest of this section, we list one review text with high rating and its nearest neighbor (shown in Figure 10); same for one review text with low rating and its nearest neighbor (shown in Figure 11). These two examples demonstrate the embedding vectors learned from our deep learning models can capture the content and sentiment very well.

Table 5. Bert classifier attribute visualization

Negative Neutral Positive

Rating	ReviewText	Summary
1	The premise of this book was totally disgusting and I 'm sorry I read it. I deleted it. Don 't bother if you value your sanity.	Disgusting premise
2	This is not a good ghost story , nor is it a romance. To me it was a poorly written Har le quin romance with a lot of sm ut thrown in. The author doesn't appear to know what genre she's trying to capture. There were numerous typos which I found annoying. The author also incorporated Elvis ' name, but did it in a way that I found disrespectful as well as inaccurate .	Lousy Read
3	I really thought this book was going to be better from the reviews. Maybe it was more of a teenage type book than an adult one. I didn't read the second book in the series was not that interested.	An okay read
4	Way too short. It is a good, fun story. It pulls you in and keeps you reading. It 's not that it was really too short, just that it was so fun , I tore through it too fast. It 's well written with very few errors. What few there were did not stop the flow.	Good... but ;)
5	This was a book that I thoroughly enjoyed from the beginning to the end. The story line was full of details and kept me involved and entertained. I loved the characters and their quirks. The story was smoothly written. Secret agents and art. Who would have believed how much fun and add a twist of fate and love. I will read this author again. Enjoy this book and you won 't be disappointed.	Wow and wonderful read with a twist

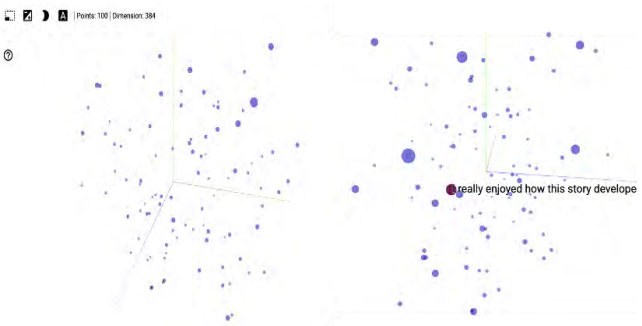
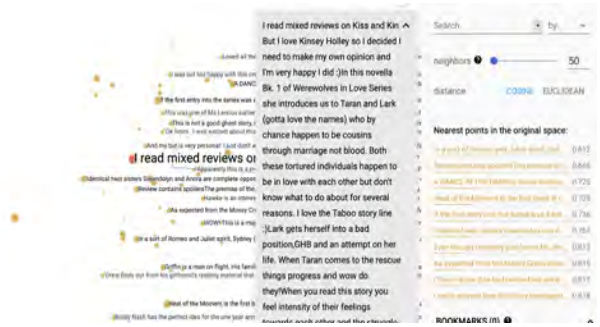


Figure 9. (left) 3-D TensorBoard UI, (right) Data Point and Label visualization

Review Text Visualization (Positive):



Nearest neighbor Text Visualization (Positive):

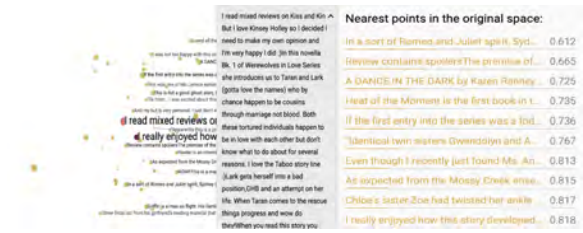
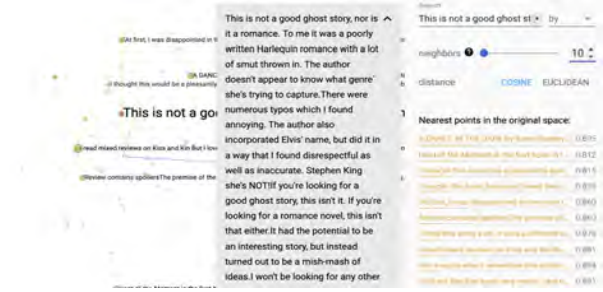


Figure 10 (1). Top: positive review text (2). Bottom: The neighbors of positive review text . On the right panel, it shows the top closest texts near to the given positive review text. The last text has the highest closest score. We can tell the texts close to each other have similar positive sentiments.

Review Text Visualization (Negative) :



Nearest neighbor Text Visualization (Negative):

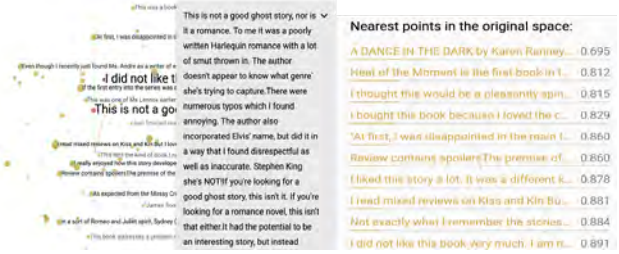


Figure 11 (1). Top: negative review text (2). Bottom: The neighbor of negative review text . On the right panel, it shows the top closest texts near to the given negative review text. The last text has the highest closest score. We can tell the texts close to each other have similar negative sentiments.

5. Conclusion

In this study, we investigated the applicability of fine-tuned bidirectional encoder representations from transformers (BERT) deep learning models in book review text datasets and evaluated them through multiclass classification. We compared the performance of BERT-based encoder models with the classical logistic regression and xgboost classifier. We verified and validated that the fine-tuned BERT model outperformed the other models in terms of classification. The better result can be achieved because BERT was trained on the huge amount and already encodes a lot of information about our human language. It also validates that BERT is one of the most powerful natural language processing (NLP) models available at present. In the future work, we will apply other fine-tuned models and multi-tasks models to different data sets for real-world applications. Furthermore, due to the large size of pre-trained model, we will also investigate the distilled model to reduce model size and keep the most important information on a small model.

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MusTENG: A Wearable Triboelectric Nanogenerator for Personalized Rehabilitation of Children with Cerebral Palsy

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Abstract

Cerebral palsy (CP) is a cognitive disorder in which a child's brain cannot send direct messages to the muscles of a body resulting in impaired motor functions. It is the most common childhood disability that affects up to 3.6 of 1000 kids in the United States. Health professionals currently provide a standard physical therapy plan that has proven to not significantly help. They lack the ability to distinguish the severity level and what is happening at the anatomy of a cerebral palsy patient. This leads to two main problems: without detailed information on which muscles are underperforming, children with cerebral palsy are not getting the most optimal exercises. The second challenge is that there is no method for tracking a child's progress because visual improvement can take months to even years.
This project's system presents a novel approach using a wearable Triboelectric Nano sensor that converts movement from a microscopic level into electricity. The sensors are utilized on the leg, where it gets readings from the three main muscles: quadriceps, hamstrings, calves. An autoencoder neural network machine learning algorithm is run on the data of a simulated cerebral palsy patient and compared to a patient without a disability to determine the severity and location of the spasticity. To test the accuracy of the system a series of comprehensive experiments were run where the sensors readings were compared to muscle tension. Ultimately this system achieved a greater than 83% accuracy in determining muscle spasticity in all 3 leg muscles. To test the applicability of the system, walk testing was conducted where the system was successfully able to give a complete analysis of a simulated Cerebral Palsy patient. With the accurate analysis, personalized exercises are given through a game to ensure the patient's motor functions are improved faster than standard physical therapy.

Keywords: Cerebral Palsy, Triboelectric Nanogenerator, Nanotechnology, Wearable Sensor

1. Introduction

Cerebral palsy is a group of movement-based disorders that primarily appears in childhood. It is caused by abnormal brain development or brain damage in which parts of the brain that work on the body's mobility, posture, and balance underperform. The core of the problem is that a child with CP's brain that controls the basic motor functions of a child sends mixed and delayed signals affecting the way a child moves. About 3.6 of 1000 children develop some type of cerebral palsy in early childhood making cerebral palsy the most common disorder among children.

A child with CP can face numerous symptoms including weak muscles, muscle tension, and tremors. Around ⅓ of all CP patients face severe symptoms such as seizures and lack of thought and reasoning. There are five main types of cerebral palsy: spastic, mixed, athetoid, hypotonic, and finally ataxic. Among all cases 77% are spastic otherwise known as hypertonic cerebral palsy. Spastic cerebral palsy is

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caused by damage to the brains motor cortex and pyramidal tracts which relays signals to the muscles. That specifically causes the muscles of a child to experience a problem known as hypertension, which is when the muscles are extremely tight and have a overload of tension. Some of the common symptoms of spastic cerebral palsy include abnormal walking, involuntary movements, contractures, and stiffness. There is no cure for cerebral palsy, but with the right treatment which can include physical therapy, medicine, and surgery a child can reach a near normal adult life. Physical therapy has proven to be one of the most effective sources of treatment for CP patients as it helps strengthen muscles and joints, reinforcing the patient's stability and positioning. Spasticity can be reduced by performing exercises regularly.

1.1. Challenges with Physical Therapy

Even though physical therapy is at the forefront of treatment for CP patients, it has a couple of main pain points. The first is the classification of the problem, because physical therapists use a basic evaluation method to determine which muscles need to be worked on and with what exercises. The problem with this method is that professionals lack data to corroborate their visual analysis, which can lead to misclassification and ineffective treatment. For CP patients it is vital to find the exact muscles that are under-forming and by how much to make sure exercises are not over-strain and counterproductive. The second problem with the current physical therapy for CP is there is no method for tracking progress and improvement which prevents the patient and professional from knowing if the treatment is truly helping and which exercises are helping the most. All these problems come from the inability to track muscle spasticity in a CP patient. The third problem with current physical therapy treatment for CP patients is therapist variation. A therapist often can have differing opinions to other therapists based on their individual analysis. Leading to incorrect and inconsistent exercise regimes and patterns for CP patients. Finally, the fourth problem with current physical therapy is the substantial cost. Year round for a child with cerebral palsy the family must pay up to $20,000. This is simply not sustainable for all families especially for kids with the disorder in 3rd world or developing countries. The high and increasing cost of physical therapy is preventing kids and adults with challenges such as CP right now from getting the care they need and deserve.

1.2. Existing Technologies

There are a variety of products available for improving the current process of treatment for children with Cerebral Palsy. Many of them track a CP patient's gait movements such as X sense, which is currently being used in very high-end therapy centers around the world. X sense gives the unique advantage of tracking the way a CP patient walks. It uses a 3D imaging system to model and analyze a child's gait (walking pattern). Another commonly used device or system used for treatment is the Opto-electronic system. Similarly, to the X sense system it tracks the gait or movement of a child with cerebral palsy. However instead of using a motion sensor approach it uses 12 precise cameras and machine learning. Some other commonly used medical devices to treat CP patients include devices like apple watches which track heart rate and steps.

1.3. Challenges with Existing Technology

Currently, there are limited solutions for evidence-based analysis of CP patients and the fundamental problem of gathering quantifiable muscle spasticity data for improvement of rehabilitation is unsolved

a. The current systems available for CP patients such as Xsense and Optoelectronic lack the ability to track a patient's muscle tension and spasticity.
b. All current technology is highly expensive and infeasible for many CP patients.
c. All the current and upcoming technology is focused on tracking how a patient walks which is not getting at the core of the problem caused by Cerebral Palsy which is the increased muscle tension.

Table 1: Limitations of existing technologies in quantifying muscle spasticity

Technology	Observation	Challenges
Opto-electronic system (Macintosh, A., et. al. 2021)	Detailed gait analysis of a CP patients using high resolution cameras and machine learning	Very expensive and not feasibly applicable to all CP patients daily. Also lacks the ability to track muscle tension
Activity Sensors (Sharan, D., el. al. 2016).	Activity trackers used movement patterns and gather data such as steps, and heart rate.	Does not directly target rehabilitation for CP patients due to the lack of data on muscle spasticity and tension.
Xsense (https://www.xsens.com/)	Xsense is a product to track a full body gait movement. Modeling system to recreate movements in a 3D platform.	Lacks the ability to track muscle tension and provide quantifiable data on the CP patient. Also does not provide direct biofeedback to patients to improve rehabilitation.

1.4. Objectives

The objective of the project is to develop a complete system for evidence-based analysis of a Cerebral Palsy patient using a custom-made sensor and machine learning algorithms. Furthermore, the project's overarching goal is to make the physical therapy process for children with CP more quantitative rather than qualitative. More specific objectives pertaining to the project include high accuracy rates in determining spasticity, a reliable physical therapy game, and a low cost yet highly reliable triboelectric sensor.

1.5. Hypothesis

The proposed system for improving CP therapy will achieve a greater than 80% accuracy in determining spasticity in the 3 major leg muscles. The sensor will reliably be able to convert muscle movements into electricity, which will be used for data. The proposed solution will create a closed loop system for physical therapy that can measure the spasticity in all 3 leg muscles at the same time and collect data that can be used to improve physical therapy.

2. Materials and Methods

Based on the research the problem that needed to be solved was determining personalized muscle spasticity data in patients with Cerebral Palsy. As seen in the previous section there's no cost-effective technology that can solve the problem today. Also, based on scientific literature personalized data and a biofeedback loop has been demonstrated to show improvement in CP patients.

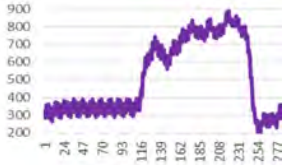
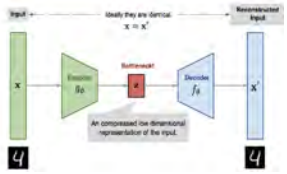
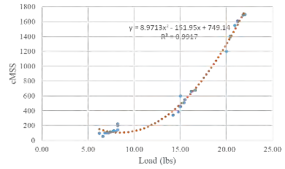
To tackle this rather large problem, the solution (method) was broken into four main parts. First, was to design a wearable custom Triboelectric Nanogenerator. This sensor is worn by the patient, and it generates continuous readings of muscle movement. Second, is data collection using the sensor for normal muscle movement and spastic movements. Third, is train an 1D convolutional autoencoder neural network and establish a baseline through the data. Finally fourth, the sensor values of a simulated CP patient will be compared to the baseline where the algorithm will produce a personalized muscle spasticity score.

To bring the entire solution together, the solution applies the sensor ability by simulating different types of CP patients, analyzing the individual muscles, developing a targeted exercise plan, and finally incorporating it all into an interactive game.

3. Sensor Development

The triboelectric effect is a type of contact electrification in which certain materials become electrically charged after coming into contact with another different material and are then separated. A triboelectric nanogenerator (TENG) is an energy harvesting device that converts the external mechanical energy into electricity by a conjunction of triboelectric effect and electrostatic induction. A triboelectric nanogenerator (Zhang, et. al., 2021) works in 3 primary steps. First is the initial

Table 2. Steps required for total solutions

Method	Visual	Description
Step1		Develop a custom wearable Triboelectric nanogenerator sensor. This sensor is low cost and has high sensitivity. Test it on various muscle groups. *Note: A custom sensor was developed since large, wearables, muscle sensors were not available. EMG sensors were evaluated as well.*
Step2		Collect the MusTENG sensor specific spasticity readings. Reduce noise with Notch filter Test on isolated thigh muscle to ensure sensor works effectively
Step3		Train an Autoencoder neural network. Establish a threshold for baseline conditions. Calculate anomalies beyond the threshold. Evaluate optimum threshold best results Source: https://lilianweng.github.io/posts/2018-08-12-vae/
Step4		The Area under the curve of the anomalies (MSE) between the actual and predicted values has a direct correlation with the muscle spasticity

generating layer which harnesses the electrons. Then the collecting layer with positive charge attempts to gain electrons. Where finally the trapping layer detects the transfer of electrons between the generating and collecting layers. In all regular Triboelectric nanogenerators there is some object or material that is charging the initial material and leading to the transfer of electrons such as the acrylic plate in the picture above. In free standing triboelectric layer based nanogenerators there is no acrylic plate causing the initial transfer in electrons.

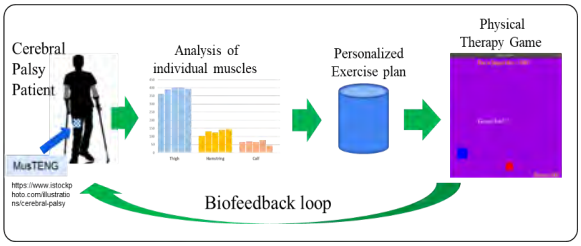


Figure 1. Solution Overview shows the different components of the projects and how those come together. With MusTENG sensor the project creates a Biofeedback loop (Pavlenko, V., 2022) for improved physical therapy of patients with CP

What is generating the electrons is the pure movement in the sensor. Free standing triboelectric nanogenerators allow the ability to track and gather energy from any arbitrary moving object. The charge transfer is also close to a 100% efficiency meaning any movement will cause all the possible electrons to transfer leading to extremely precise and accurate results while working with small movements.

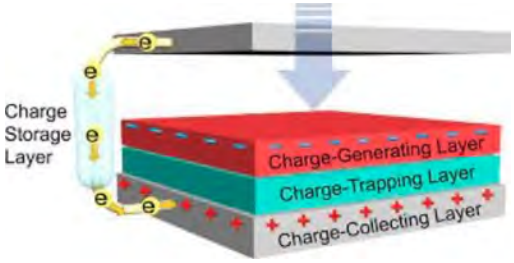


Figure 2. Representative components of a triboelectric nanogenerator (TENG) https://www.nature.com/articles/s41427-019-0176-0

3.1 Triboelectric charge testing

An initial sensor was built using a 2-inch by 2-inch piece of Nylon and Polyester fabric. The

charge trapping layer was a silver fabric. To evaluate whether the sensor would work, two standard tests for TENGs were run, the vertical displacement and lateral displacement tests.

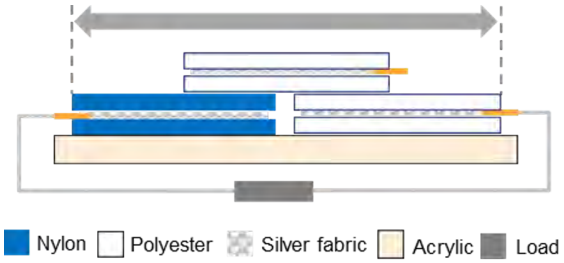


Figure 3. Lateral displacement test to evaluate triboelectric charge of different fabrics

For this test a vertical displacement of acrylic was moved over the sensor triggering the electrons to be transferred at different rates through the piezoelectric sensor. The results above came from an oscilloscope where the transfer of electrons was captured through the voltage.

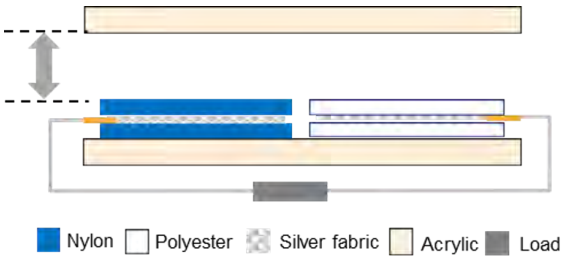


Figure 4. Vertical displacement test to evaluate triboelectric charge of different fabrics

For the lateral movement test the acrylic glass was moved laterally along the sensor and the electrons transfer was picked up and the results are shown above.

3.2 Fabric and Form-Factor Selection

To design a highly sensitive and high response sensor, different fabrics of polyester and nylon were tested with. 5 different combinations of fabrics were tried, and the best was selected. Then using strips of the best fabric, mesh patterns of different widths were tested. Again, optimizing for the highest range of sensor reading. Through this test the combination of 65% polyester and 100% nylon provided the best results. The best results directly correlated to the greatest range of sensor output, because that means there will be a noticeable difference between smaller changes in pressure, movement, and deformation of the sensor. The combination that yielded the best results had a sensor range of 468. The results are surprising, because logically the purest combination of polyester and nylon should provide the best results, but an interesting error occurred where the lower end of the range was substantially higher than the other fabrics due to the amount of noise the combination of 100% polyester and 100% nylon picked up.

Fabric Sensors	Poly Type	Nylon Type	Range
	90% polyester, 10% spandex	47% Rayon, 43% Nylon, 10% Spandex	128
	100% Polyester	82% Nylon, 18% Spandex	231
	60% Cotton 40% Polyester	90% Nylon 10% Spandex	320
	65% Polyester 35% Cotton	100% Nylon (interwoven threads)	468
	100% Polyester	100% Nylon	390

Figure 5. Fabric selection based on quantitative results from vertical and lateral displacement tests

Sensor Mesh	Strip size	Reading
	1½ inch width	Sensor output: 300 - 732
	1 inch width	Sensor output: 300 – 812
	½ inch width	Sensor output: 300 – 562

Figure 6. Sensor mesh size selection based on sensor output results

Once the type of fabric that yielded the best results was determined a series of 3 different lengths and widths were tested in a mesh format to again see the best sensor out of the data. The optimal results came from the 1inch wide by inch long squares. This provided the best results because it had the right ratio of amount of silver to collect energy as well as a strong mesh.

3.3 Sensor Fabrication

The following picture gives an overview of the sensor fabrication process. The sensor was built using Nylon and Polyester fabric strips that were later weaved into a mesh. Each strip is made up to either polyester or nylon fabric. The fabric sandwiches a silver fabric that acts as a conductor. At the end of the strip is a small copper wire to enable electrical flow.

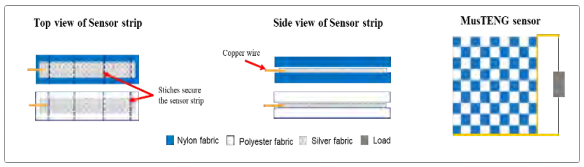
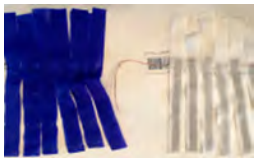


Figure 7. Design and components of MusTENG sensor and how the sensor is developed

Table 3: Sensor fabrication method

Method	Visual
Step 1: The nylon fabric and polyester fabric are cut into strips (1 inch wide and 8 inches long). The silver fiber fabric is cut into strips (1 inch wide and 6 inches long). The silver fiber fabric strip is layered onto the center of the nylon fabric strip using a sewing machine.	
Step 2: A lead wire is run through the nylon silver strips and the polyester silver strips and acts as a conductor. Then the two fabrics are woven together such that the nylon and polyester strips follow an in-out pattern.	
Step 3: The final woven triboelectric nanogenerator sensor (MusTENG) is developed by sowing the ends so that the sensor has structure. Finally, the ends are hooked up to an Arduino for collecting live reading	

3.4 Sensor Response

To test sensor sensitivity the sensor was moved with a lateral displacement using a mechanical force ranging from 0-20 hertz. This determined the sensor's peak value and the relationship between lateral displacement and the sensor output.

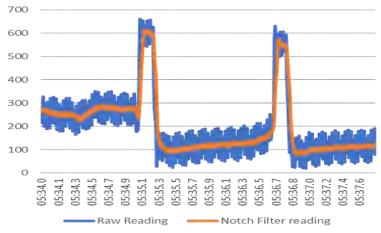


Figure 8. Notch filter usage to remove extraneous noise from sensor readings

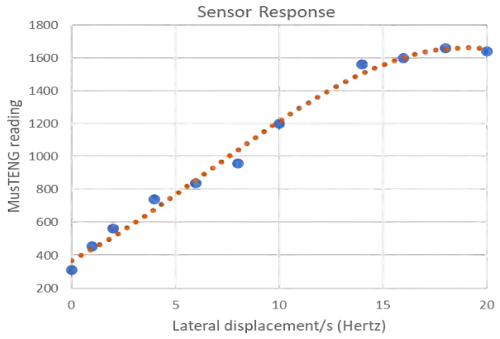


Figure 9. Sensor sensitivity based on lateral displacement test with varying mechanical force

One of the initial challenges with the sensor was its sensitivity to extraneous motion, sounds, and

forces. It made the data unreliable as it would pick up the voltage of these extraneous noises. To prevent this from happening a notch filter was applied to the Arduino code. The premise of the notch filter is that it works as an opposite of a low pass filter. It removes the outliers of a data set by looking for unrealistic peaks where the sensor values are >50 hertz and removes them allowing for consistent and reliable data.

4. Phase 1 Testing: Isolating Muscle Tension

The purpose of this test is to see if the MusTENG sensor has a direct relationship with muscle tension/spasticity through the isolation of the muscle contraction. Before doing movements and different motions while the sensor is attached to the leg it is vitally important to see the sensor's response to pure muscle movement. Literature and previously conducted tests show that the amount a muscle moves while contracting is directly proportional to the actual muscle's tension. So, to conduct a test where the MusTENG's response to muscle tension can be observed without the effect of other movement or noise a simple test was conducted. The premise of the test was to contract and release the thigh muscle without any leg movement while different loads of tension were applied to the leg. If the results data shows a significant increase as the load of tension is increased the MusTENG sensor is truly getting the muscle deformation movement readings.

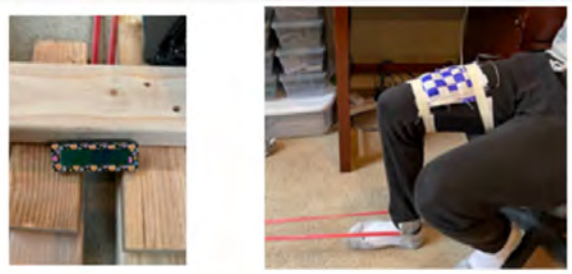


Figure 10. Apparatus for isolated muscle test

The Following graphs show observed results and the sensor readings. The red band with the lowest load or 6-8 lbs shows small peaks of sensor readings at the muscle contracts when the load is applied. As the load increased peaks of data were longer and more sustained. At the highest level of load the sensor pickups all the muscle activities of the smaller muscles of the thigh.

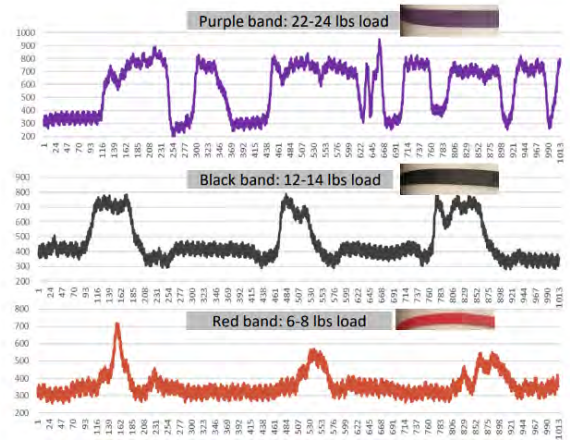


Figure 11. Sensor readings for different loads, ranging from 6lbs to 24lbs, on the isolated thigh muscle test

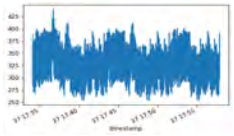
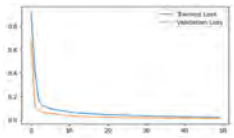
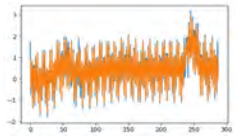
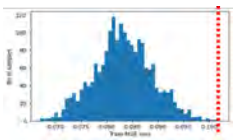
4.1 Calculation CMSS (Computed Muscle Spasticity Score)

Although the raw data has a correlation to tension and muscle spasticity an algorithm must be run on the data in order to compare when no added load was on the leg to different loads of tension. Comparing a simulated spastic child to a non spastic child. This enables the ability to determine the severity of cerebral palsy and muscle spasticity in any patient. This muscle spasticity score is the core of the solution because it is a method of representing the severity of a patient's cerebral palsy and spasticity. To create the cMSS score the algorithm goes through a multi-step process. First it trains the baseline data which is not shown above but it is the data when no load is added onto the leg. It trains over that set of data for 50 epochs or entire run throughs of the data until it fully learns the data. Once the data is fully learned it attempts to predict the data using its training it predicts through the whole data set and calculates the validation loss or error between each predicted point and actual point. The following table shows the steps to train an autoencoder neural network.

The largest error is then set as the threshold for

anomalies. So, any error greater than the threshold curated through the prediction would be considered an anomaly. Then an anomalous data set is taken into the algorithm for example the purple band data above with 22-24lbs of load. This is also the data for a simulated spastic cerebral palsy patient.

Table 4. Method to train autoencoder Neural Network

Training Autoencoder Neural Network	Steps to train autoencoder
	Baseline data is collected from the sensor with the leg under no tension. Then an Autoencoder neural network is trained
	Autoencoder is composed of 7 layers and over 9500 parameters. Training and validation loss shows model training over 50 epochs
	The plot above shows training data and model-predicted data
	Threshold = Max MSE loss. It is the worst the model has performed in reconstructing the sample

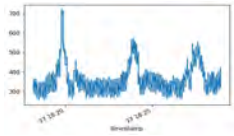
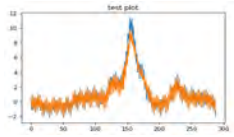
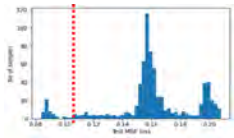
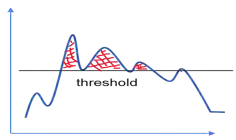
Using the same model trained model for the baseline data it compares the two data sets of a simulated CP patient with the purple band data above to baseline set by a non-spastic child. Then the errors or (MSE) values are calculated by finding the difference in a predicted value which is the base line and the purple band data which is much higher.

Any errors or MSE values over the threshold set previously with the training data are accumulated. This represents the area of error over the threshold and has proven to have a very strong relationship with muscle spasticity as explored later. The following tables shows the steps involved in calculating the cMSS.

5. Phase 2 Testing and Results

The purpose of phase 2 testing is to develop a relationship between added load on the leg to the cMSS or muscle spasticity values. This testing also will determine the accuracy and precision of the MusTENG sensor and the cMSS calculations.

Table 5. Method to calculate muscle spasticity score

Compare Test Data and calculate cMSS	Steps involved
	Now use data collected for muscle spasticity as Test input data
	Use the trained model to reconstruct the test data sample
	Calculate MSE loss. All the data points beyond the Threshold are considered anomalies.
	**cMSS** is the sum of MSE for all anomalies. It represents the Area under the curve of anomalous data

For thigh calf and hamstring-based testing a baseline was set by conducting an extraction of the thigh muscle without any added load. Then to simulate a CP patient spastic muscles pounds of load were added to the leg to simulate creating muscle tension. To conduct the test, a simple supination and pronation of the leg was performed with different movements that focused on each specific muscle group. It allowed me to conduct a basic yet reliable extraction and contraction of the right muscle. The tests were designed based on Modified Ashworth scale. The images below show how the thigh was extracted and contracted. The band that adds tension to the muscles can also be seen.

After conducting a total of 30 tests a strong relationship was developed between the added load in pounds to the calculated cMSS score or muscle spasticity. This means that the MusTENG sensor can distinguish the muscle movement of any level of a spastic muscle to a non spastic muscle with extreme precision. Furthermore, it is able to do it for each main muscle group on the leg being the thigh, hamstring, and calf. The following curves show the quadratic relationship that was developed after 30

tests with varying loads added to the leg. As more tension or load is added on to the leg the sensor and algorithm is able to not only determine it but precisely quantify the increase in muscle spasticity.

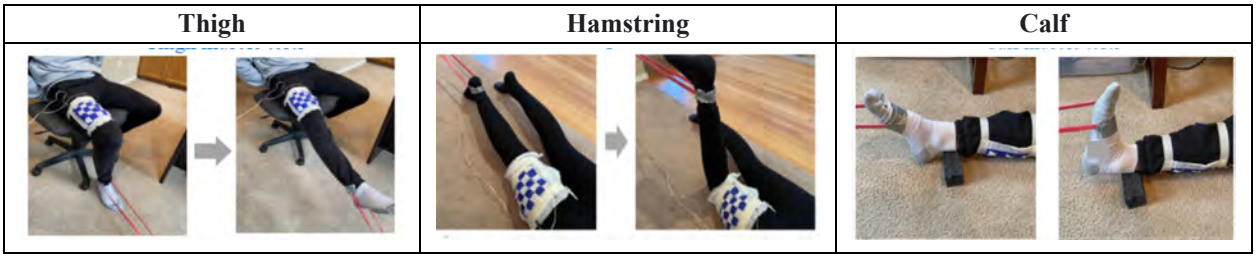


Figure 12. Muscle movement test for Thigh, Hamstring, and Calf muscl

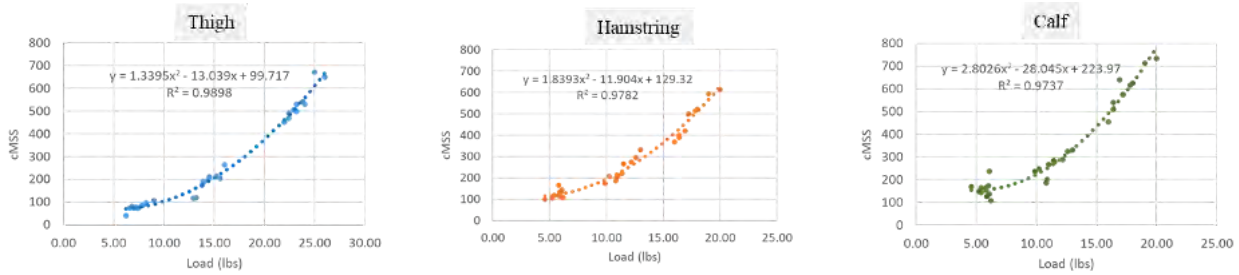


Figure 13. Muscle spasticity response curves for different muscle groups tested

5.1 Results: Precision and Accuracy of cMSS and MusTENG sensor

A total of 75 tests on the thigh, 40 on the hamstring, and 55 on the calf were run to determine the precision and accuracy of the sensor and algorithm. The tests were conducted at a variety of varying loads and a cMSS score was generated for each test. Each score was compared to the muscle spasticity curves equation shown above and an error of <5% was considered a successful reading.

Using that 5% threshold as a success the algorithm sensor and whole system was able to achieve a final 91% accuracy for thigh-based testing. 84% accuracy for hamstring-based testing, and finally 89% accuracy for calf based testing. These results enable the ability to track any CP patient's spasticity with the MusTENG sensor.

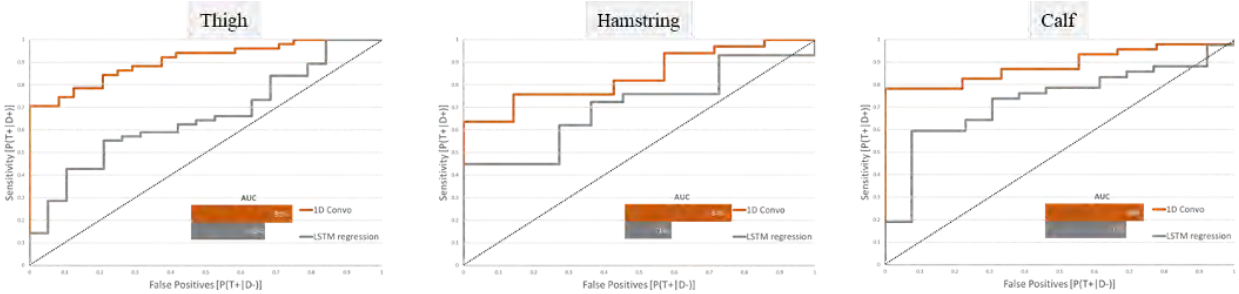


Figure 14. ROC curves of test results for different muscle groups tested

To optimize results the algorithm was changed from an LSTM regression to a 1D convolutional autoencoder. In addition, the calculated spasticity score was changed from a mean MSE + 3 sigma method to an AUC calculation. This provided a major benefit because instead of the algorithm purely looking at the peak of the data set it finds the area of the anomalies or difference between a spastic and non

spastic child's readings. This makes the algorithm encompass the whole muscle contraction and release rather than just the point of greatest results.

6. Phase 3: Walk Testing - Muscle Cohesiveness

The purpose is to observe how all the muscles of a CP patient work together while walking in order to develop a deeper understanding and generate extremely valuable data of the spasticity of each muscle at the same time.

6.1 Baseline

CP patients in most cases have three main walk patterns or gaits: true equinus, jump gait, and crouch gait. To establish a baseline that would be used for the rest of walk testing and to determine cMSS the researcher walked five steps without any load or rig. The raw MusTENG data from the sensor is trained upon and established as the baseline in the autoencoder neural network. For all the tests, the researcher walked a total of 5 steps down the hall with the rig and the added load. Then the average cMSS score calculated between the 5 steps. Furthermore, the researcher did 4 more trials and got 5 average cMSS or muscle spasticity readings for the thigh, hamstring, and calf for the true equinus walk.

6.2 Walk 1: True Equinus

The true equinus gait is when the knee is fully extended and restricted to extremely limited movement. To simulate this gait on a non-CP patient the researcher devised a rig using two simple wooden planks. The wooden planks extend up the leg on both sides and restrict the knee from bending. This all simulates a true equinus walk. A picture of the rig can be seen on the right. The researcher also added 10 pounds of load to the leg to increase the muscle tension as done previously to simulate a CP patient.

These results below show that for the simulated true equinus walk where 10 pounds of load were added to the leg the thigh had a very high cMSS or spasticity. The hamstring faced a moderate level of spasticity, and finally the calf experienced a low cMSS.

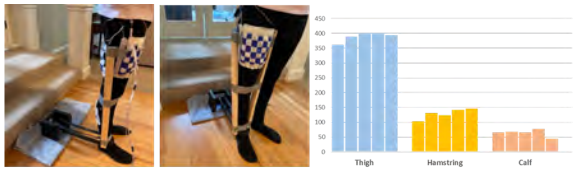


Figure 15. Apparatus and results for True Equinus walk testing

6.3 Walk 2: Jump Gait

The true equinus gait is when an anterior pelvic tilt, excessive knee, and hip flexion are caused by an excessive angle between the foot and leg. To simulate this walk, gait a wooden rig was designed that ensures a constant 115-degree angle between the foot and leg is maintained while walking. A picture of the rig can be seen below. Ten pounds of load was added to the leg to increase the muscle tension as done previously to simulate a CP patient.

These results blow show that for the simulated jump gait walk where 10 pounds of load were added to the leg the thigh had a very low cMSS or spasticity. However, the hamstring faced a high level of spasticity, and finally the calf also experienced an extremely high level of spasticity.

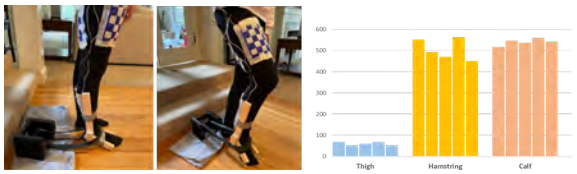


Figure 16. Apparatus and results for Jump gait walk testing

6.4 Walk 3 Crouch Gait

The crouch gait is when a child has excessive ankle dorsiflexion from an unnatural reduced angle between the foot and leg. To simulate this gait, a wooden rig was designed that ensures a constant 80-degree angle between the foot and leg is maintained while walking. A picture of the rig can be seen below. Ten pounds of load was added to the leg to increase the muscle tension as done previously to simulate a CP patient.

These results blow show the spasticity for the simulated crouch gait walk where 10 pounds of load

were added to the leg. The thigh had a moderate cMSS or spasticity. The hamstring faced a low level of spasticity, and finally the calf experienced an extremely high level of spasticity.

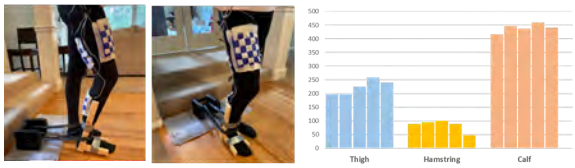


Figure 17. Apparatus and results of Crouch gait walk testing

These results give an in-depth analysis of each muscle's performance while walking, and show how different walk patterns affect different muscles in quite diverse ways and substantial improvement for CP based PT.

7. Physical Therapy Game

Based on the results in phase 3 a CP patient can simply walk with the MusTENG sensors on their thigh, calf, and hamstring and get an in-depth analysis on their spasticity levels. From there the data can be sent to experts where a personalized exercise plan can be given to the child. That personalized exercise plan now is input into a software game system.

The exercise plan is converted from exercises into a list of shapes that represent the exercises. Then the game drops a shape and begins collecting data from the exercises targeted muscle. For example, in a squat the game data collected comes from the thigh sensor. When the block reaches the bottom of the screen the data set is sent to the algorithm where the cMSS value of the patient is calculated. If the targeted muscle experiences a certain amount of tension measured by the cMSS values, it is considered a success. That cMSS threshold value is determined based on if the cMSS value has a 20% increase to the initialization quantity.

If the threshold cMSS is reached the game rewards a certain number of points and drops the next shape (exercise). The game ends when all the exercises are completed correctly.

The idea behind that is for children to be properly exercising their muscles they need to be experiencing a greater spasticity for a small period which is the basis behind all exercises. This ensures exercises are done properly and for the right muscle group. The game also provides the ability to observe how the muscles perform while doing different exercises and can give an even more in-depth analysis on how their muscles respond to exercises. The best part about the game is that it makes physical therapy more engaging especially for children with cerebral palsy.

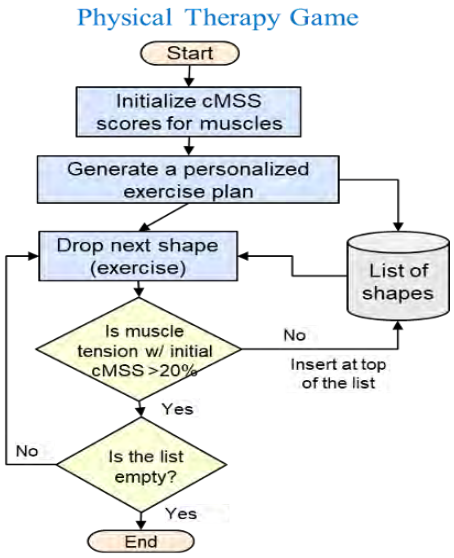


Figure 18. Flow chart for physical therapy game

8. Discussion: Improvement Analysis

Through this project a major leap was achieved in the data-based analysis of a CP patient. Currently in practice a method known as the Ashwood scale is used for determining a CP patient's severity level. After the therapist analysis the scale is used to determine the severity of the patients CP from a 1-4 scale. With this project the Ashwood scale was reimagined and designed through a wearable sensor and machine learning algorithms. Which provides specific data down to decimal places of a CP patient's muscle spasticity. Improving the analysis of CP patients increased muscle tension from a basic classification to an in-depth quantifiable number. This project even goes a step further and can analyze how the muscles work together while walking. This data of how each muscle is affected differently is

vitally important for CP patients because without it they are blindly exercising their different muscles without any data showing that they are doing the right exercises or making progress.

Cost Improvement: Cerebral palsy is a lifelong disorder that requires long-term care and treatment. In 2003, the center of disease control estimated that the lifelong cost for individuals with CP was approximately $1M in additional to normal living costs. CP patients expect to spend up to $20K in physical therapy costs annually.

Recent studies have shown that structured home-based exercise programs can help improve abilities of children with CP. The low cost MusTENG sensor enables CP patients to collect quantifiable data that physical therapists use and optimized exercise programs. Furthermore, the game that was developed using the custom MusTENG's ability can eventually make physical therapy at home the new standard. Even if the project can reduce 2 PT visits, a patient will save $8K/year and deliver tremendous value

9. Conclusion

This project was able to meet all the Engineering goals and design criteria. It was able to show that the MusTENG wearable sensor that was designed can accurately detect muscle spasticity conditions. It was able to achieve an accuracy of 91% on the Thigh, 84% on hamstring and 89% on calf muscle groups. After reading through literature, talking to Physical Therapists, and clinicians there is a understanding that lack of quantified and personalized data is the missing link in creating new systems and standard of care for CP patients. With the MusTENG sensor physical therapists can get adequate data about the muscle spasticity of the patient and recommend the right exercise and routines. But even further rehabilitation is driven by repetitive practice and is boring for kids. So, the game will help motivate the kids, but also enable tailored responses from the game to exercise the correct muscles of the patient.

Overall, the MusTENG provides several unique and important benefits to current physical therapy. It enables the ability to track progress, determine the most beneficial exercises, reduce physical therapy cost, and determine muscle cohesiveness. Once this sensor and system is implemented into the real world it will revolutionize the basis of physical therapy for children with cerebral palsy. In the future, this project can be improved in several areas. The following are key next steps for the project are:

- Improving the accuracy of the Muscle spasticity score algorithm
- Evaluate MusTENG sensor on different patients with CP and validate results
- Work with exoskeleton companies (Biomotum), and gaming companies (Microsoft) and incorporate the MusTENG sensor in their designs
- Evaluate other applications of this sensor beyond CP, potentially in sports injury and rehabilitation

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A Border Divided: The Correlation Between California's and Texas' Political Affiliation and Latino Nationalism

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Abstract

Latinos, the largest minority group in the United States, have grown in civic presence in the national elections from 2016 to 2020. Alongside this growth, the political use of Latinos in post- 2016 campaigning has shown how Latinos are seen as un-American in the United States. However, there existed a gap on whether this increase in connection to the United States through civic engagement, contrasted by that of an un-American political environment, has an influence on the culture of Latinos living on the U.S.-Mexico border. Looking at the trait of nationalism, this paper strived to answer if states' political affiliation impacted Latinos' sense of nationalism on the border in Texas and California. This was done through an exploratory sequential mixed-method analysis, where Instagram posts were coded for broad and specific feelings of 'Latino Identity' and 'Nationalism.' Contrary to the current belief that Latino culture is mostly Democratic as to reflect the popular notion that all minorities vote democrat, this research concluded that the Texan Latino culture reflected cultural values that mimicked the Republican party. Similarly, the Californian group reflected cultural beliefs that mimicked the Democratic party. This implied that the border Latino groups are non-homogenous and assimilating into U.S political identity, as previously hypothesized in the literature. For the future of American politics, this provides backing for the possibility of more targeted political campaigning, and a decrease in un-American advertising. This research provides further proof of Latino culture assimilation on the southern border of the United States.

Keywords: Latinos, U.S.-Mexico Border, Nationalism, Cultural Identity

1. Introduction

In 2019, Latinos became the majority-minority group with a population of 10.9 million in the United States (Batalova, 2020, fig. 1). In Texas and California, which have greater Latino populations, the political conversation focused on Latino immigration and its presence on the border (Batalova, 2020, fig. 2). This political fixation, dating back to the pre-1950s, changed recently in regards to the discussion of Latinos and U.S. nationalism. Following the 2016 Presidential Election, a further disconnect has been observed between the 'Latino identity' and the 'American identity' in media (Gonzalez, 2019). However, a gap exists in understanding how modern political extremism has affected Latinos' sense of American identity along the border.

1.1 United States Border Political Affiliation

Starting with President Trump, border political affiliation shifted in 2016 with a stronger national focus placed on border security, American nationalism, and Latino immigrants. According to Gonzalez (2019) in his research report published in

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the *Democratic Communiqué*, the 2016 election had a national influence on the way American media talked about Latinos; President Trump influenced an increased correlation between Latinos being criminals and 'un-American' through his speeches. This shift continued into the 2020 election cycle and reflected a voting stance taken by states across the border. According to Waldinger (2020) from the *American Sociological Association*: "Thus, while Republicans moved right, with business, pro-immigration voices stilled, Democrats moved left. That shift partially reflects the spillover from immigration to immigration politics" (para. 8). The immigration rhetoric influenced political polarization on the border, causing extreme Democratic views in states like California and extreme Republican views in states like Texas.

Moreover, states' political affiliation was changed by the surge in Latino voting to both parties from the 2016 election cycle to the 2020 election cycle (Frey, 2021). In the 2020 election, Texas and California voted for Trump and Biden respectively, defining their Republican and Democratic status (Federal Election Committee, 2020). The growth in minority voter turnout led to a Democratic win for Joe Biden, but was challenged by an increased Republican vote by Latino men along the border (Sonneland, 2020).

Despite the national voting shift in 2020, it is important to note that political affiliation is also tied to geopolitical areas. While two people might identify with a party, where they live changes how much they agree with the political party's beliefs, especially in relation to issues surrounding their state (Feinberg et al., 2017). On the border, this is seen in how Republicans are less "pro-wall" the closer they live to the U.S.-Mexico border (Gramlich, 2019). Based on this knowledge, studies about political beliefs must be limited to specific regions, as covering vast areas can introduce too much variation in regard to political status.

1.2 United States' Stance on Latinos and Immigration

Since its foundation, the United States has passed legislation against Latino immigration. Modern important legislation controlling immigration in the United States began with the Immigrant and Nationality Act of 1952 (Tienda & Sánchez, 2013, fig. 1). After its passing, most United States immigration strategies (1965-2001) focused on bringing in new immigrants, adding asylum status, and changing the number of visas allowed per country (Tienda & Sánchez, 2013). However, post-9/11 saw the discussion of immigration shift towards national security (Patten & Wade, 2011, p.8). Continued by Presidential Candidate Donald Trump, who spearheaded a campaign focused on harming views of Latino immigration (Gonzalez, 2019) and immigration as a whole (Anbinder, 2019), national motives focused on the security of the United States and how Latino immigrants were different from U.S. born citizens.

This stance has led to differing views of immigrants and the immigration system. According to a survey done by the *Pew Research Center*, 84% of foreign-born Latinos say that the U.S immigration system needs major or complete changes (Krogstad & Lopez, 2021, fig. 1). However, what needs to change varies most on immigration status, with naturalized citizens having the greatest difference in opinion from Latinos that have no green cards - believing in less versus more change, respectively (Krogstad & Lopez, 2021, fig. 4). This has affected the way U.S.-born non-Latinos view immigrants as well. A majority of U.S.-born citizens believe that most Latino immigrants are illegal immigrants (Gramlich, 2019). Moreover, the partisanship line splitting the Democratic and Republican parties sees a major divide among immigrants' rights, border control, and the border wall (Gramlich, 2019).

1.3 Latino Border Culture versus United States Border Culture

Latino culture has existed on the U.S.-Mexico border since the 1500s (Korrol, 1996, p. 2). The development of Latino culture in the greater United States stemmed from the border, where Latinos from various countries would come seeking economic prosperity, land, safety, or other needs (Korrol, 1996). Today, the Latino border culture has changed in regards to its impact on the United States' culture and politics. The increase in Latinos on the U.S.-Mexico border, along with the increase in the percentage of

refugees from war-torn Latin American countries, has created a political-cultural environment where Latinos are more active in demanding pro-immigrant change (McCaughan, 2020). This development has also been supported by the change in the political sphere surrounding Latinos, where Latino immigration is now a central topic of U.S. policy. This shift in Latino culture and border politics has changed the way border Americans view Latinos, with non-Latino Americans closer to the border feeling worse about Latinos in comparison to other Americans; this is inverse to Mexicans-Americans, who when living closer to the border, think higher of Americans (Chwe, 2017, fig. 1). This new development of border culture and border relationships shows how Latino-American culture and politics are intertwined through immigration, policy, and cross-ethnicity relations. However, the current body of research fails to define how this has directly impacted Latino culture and its trend for political and cultural growth in the future.

1.4 Nationalism in the United States and Latino Identity

Nationalism, defined by the Merriam-Webster Dictionary (2019), is "a feeling that people have of being loyal to and proud of their country often with the belief that it is better and more important than other countries" (para. 1). This definition is represented differently in every culture, with some of the most common identifying markers being pride in a country's democracy, social systems, fairness, or systems of equality (Mubotter, 2021). These common identifying markers have become a part of the American identity, with the backbones shifting from party to party and race to race, but encompassing the ideas of freedom, liberty, and pride (Dawkins, 2019).

On the border, this identity has shifted as an increase in Latino immigrants make permanent residents in the United States, changing the culture of the U.S. border and the values of the "American Identity." The drastic increase in Latino immigration has caused a shift in Latino culture as well; one of the new markers noted is an increase in assimilation into United States culture (Ramírez, 2021). It is noted that, while this increase in assimilation is occurring among border Latinos, it has a relevant impact on their political beliefs and interactions in the United States. This theory, previously proven by the public policy research facility *CATO Institute*, states that Latinos who identify themselves as Republicans are more likely to hold more "American" ideologies, such as voting against Latino immigration reform that would help undocumented immigrants, because these are popular stances in the Republican party (Nowrasteh, 2020). This shows that in order to be seen as more American, Latinos are willing to vote against their cultural self-interests. However, the overall political-cultural body of research regarding Latino immigration currently lacks clarification on how border zones and their political influence, especially with the modern change in Latino and U.S. culture, influence Latinos' perspective and willingness to feel nationalism in the U.S.

1.5 Gap Statement

Within the scholarly body of geopolitical and sociological research, the studies lack a clear connection between the political (nationalism, state affiliation, voting trends, and political law) lens and the etho-social/cultural (Latino culture, United States culture, the impact of laws on Latinos) lens **(**Dawkins, 2019; Feinberg et. al., 2017; Krogstad et. al, 2021; Gonzalez, 2019; Sonneland, 2020; Tienda, 2013). Currently, no study focuses on the connection between political affiliation and nationalism in Latinos on the border, merging the previously stated political and etho-social/cultural lenses in order to provide a human perspective on the immigration crisis and Latino identity. So, the goal of this paper, through the question of "How does state political affiliation affect Latinos sense of United States' nationalism in Texas and California?", is to examine the connections between political affiliation and nationalism. Through this paper, the researcher aims to provide a human narrative to the political research body.

2. Materials and Methods

In order to reach further conclusions about the connections between state political affiliation and the

nationalistic identity of the involved Latino communities, an exploratory sequential mixed-method analysis was performed. This type of analysis was chosen because it starts with qualitative data and transforms it into quantitative data. With one of the research goals being to connect the etho-social/cultural and political lenses, the researcher believed that incorporating qualitative perspectives (quotes, pictures, etc.) would help to showcase the cultural lens in the political data better than pure quantitative data. This analysis was done over social media, where Instagram posts were coded for themes of nationalism in order to derive feelings of identity. Social media was chosen as a sampling method for this study because of its ease of use. Because of the limitations presented during A.P. Research, the researcher was unable to leave New Jersey or obtain approval from an IRB. By using social media, the researcher was able to gain human opinions from Texas and California without directly visiting Texas and California

A general outline of this method is as follows: insert coded hashtags (Table 1) into Instagram, find Instagram posts, following needed location and scope criteria, sort the Instagram posts into Texas and California groups, code the caption, picture, and related hashtags by following the coding diagram (Table 2), graph data for analysis.

First, as per step one, the researcher downloaded Instagram and created a new account. A new account had to be created to avoid the algorithm from taking data from the researcher's previous searching history. Instagram was chosen because of its popularity as a social media platform, with over 1.3 billion worldwide users and 170 million users in the United States of America (Dean, 2022). In comparison to other social media platforms, Instagram gives multiple areas to express one's identity and opinion in a post (picture, hashtags, caption). This allows for the most available data per post and the most availability for cross-referencing, which is important for steps 2 and 3. Once the platform was downloaded, all of the hashtags were inserted one by one into Instagram.

As shown in Table 1, the generated hashtags were based on nationalist words that were drawn from the body of political literature in relation to nationalism. These words were chosen from keywords, graphs, or tables from these studies. Then, they were combined with the scope of the research question, which includes Latinos, Texas, and California in order to create high-frequency hashtags. Hashtags with over 1000 posts were selected in order to ensure diversity among the responses.

Table 1: Keywords and Their Formulated Hashtags

Keyword	Hashtags (greater than 100 posts)
pride	#latinopride #latinopower
nationalism	#nationlism #southernnationalism
patriotism	#patriotism #patriotismo #latinosunidos
freedom	#freedom #chicano
conservative; republican	#latinoconsesrvative #latinorepublican #latinosfortrump
democrat; liberal	#latinoliberal #latinodemocart #latinolivesmatter #latinosforbiden
political (general)	#latinopolitcs #USlatino #texaslatino #californialatino

Table 2: A List of Criteria for Post Selection

Criteria	Location in Instagram post to find information
1. Made by a Latino, Latino, or Latinx	username, biography
2. Posted in Texas or California	location tag, photo, caption, hashtags, biography
3. Relates to Latino culture, politics, or identity	photo, caption, hashtags
4. Contains an image, caption, and hashtags	photo, caption, hashtags
5.Made between June 18, 2019* and February 1, 2022**	post date

*: June 18, 2019 was chosen because of its indication as the start of the 2020 campaign cycle (Taylor, 2019), and thus indicating when this study can call Texas a Republican state and California a Democratic state based on the 2020 election

**: February 1, 2022 was chosen as the cut-off data to create a finite number of posts for the researcher to examine

Then, Instagram posts were selected. A plan for 60 posts was implemented in order to gain diversity among the responses. With 30 responses from each group, one response would not be statistically significant and thus one input will not drastically

change the results, leading to more accurate trends. These posts were selected following criteria created to match the parameters of the research gap and research question.

The researcher selected these criteria in order to ensure the research gap was adequately answered with the complexity of Instagram posts. This is similar to creating closed questions in a survey; however, the responses of Instagram have been predetermined and so this method of criteria allows for the correct responses to be selected so that the themes of nationalism and identity will be present in these responses. In this way, the researcher had to plan for avoiding sampling bias by sampling from all of the provided hashtags and avoiding taking responses that only aligned with any predetermined ideas of what would be correct.

For example, a post that was selected was:

Post Identification Number: T10

Location: Texas

Image: A picture of a hand holding an 'I Voted' sticker.

Caption and Hashtags: No matter what political views you have you need to do your civil duty and vote #proudrepublican #makeamericagreatagain #latinorepublicans

This post was selected because it met the five requirements for analysis. It was made by a Latino in Texas and is related to voting rights. It has a codable image and caption and was made in between the required data scope.

A post that was not selected was:

Post Identification Number: N/A

Location: Oaxaca de Juárez

Image: A picture of a Latino man holding a piñata heart and sitting next to a pinata figure of a skeleton for Day of the Dead

Caption and Hashtags: Don't keep your heart safe, be vulnerable... ♥#HappyHalloween from southern Mexico, where they celebrate #DayOfTheDead to help support the spiritual journey of the dead.

🇲🇽💀 *#mexicoculturayorgullo #cocovibes #fridakahlo #viveoaxaca #diadelosmuertos (: @Mexico_CulturaYOrgullo).*

#loveislove #halloween #happyhalloween2018 #visitmexico #visitoaxaca #mexicocultureandpride #remitlysignificamas #remitly #promisesdelivered #aeromexico #ammoments #ammomentos #volamoscontodo #mco #oaxaca #coco #frida #celebrandooaxaca #oaxacavive #travelvlogger #eldiadelosmuertos #joseresendez

This post was not selected because, despite meeting the requirements for analysis, this post does not meet the scope requirements. This post was made by a Latino who lived in Texas but was spending extended time abroad in Mexico. Because the posts were not made in Texas or California, it could not be counted.

After all of the posts were collected, they were sorted into groups by location. All Instagram posts that were selected must have a location tag, an indication in the hashtags, photo or caption, or a location marker in the biography of the user that states whether the post was made in Texas or California. The researcher used these markers and Google Slides to sort the posts into Texas and California groups. Google Slides was chosen because it allows for text and pictures to be easily imported into the software, as well as its availability as a free software.

After the posts have been sorted, the researcher coded for the caption, picture, and related hashtags by following the coding diagram in Figure 1.

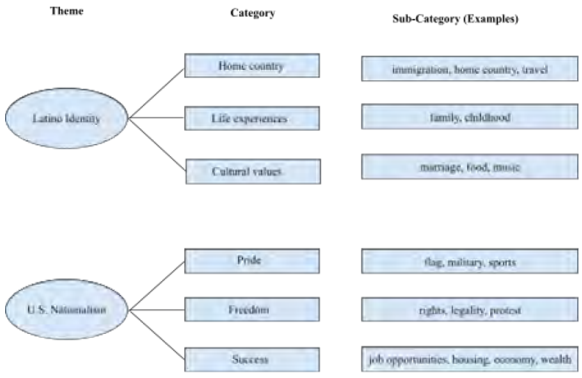

Figure 1:Coding Flowchart for Selected Instagram Posts

Following the diagram, the posts were coded by asking a series of yes/no questions in relation to the theme, category, and sub-category of the caption,

picture, and related hashtags. First, the caption was given a theme of Latino Identity or U.S. Nationalism. For example, a post discussing political structure in the United States would fall into nationalism. A post discussing Latino heritage in the United States would fall under Latino identity. Then, once given a theme, the posts were sorted into a more specific category, and then a subcategory. The category stated for the post was what was specifically being discussed that made the researcher choose that theme. For example, if the political structure of the US was being discussed, if that structure impacted human rights, the post would fall under freedom. If that structure discussed the economy, it would fall under success. Finally, a subcategory was chosen. This was the specific item that the post discussed, such as the economy, voting rights, etc.

For example, a caption that was coded was:

Post Identification Number: C2

Caption: #WeStandUnited 🇲🇽 🇸🇻 🇳🇮.

50th Anniversary of the Chicano Moratorium.

🗣 *"El pueblo unido jamás será vencido"*

Theme: U.S.Nationalism

Category: Freedom

Sub-Category: chicano, division, unity

Keywords: Chicano, unido

This was repeated for the image and related hashtags in the post.

Finally, all of this data was graphed and prepared for analysis. This study planed to use a mixed-method sequential approach to analyze the raw data. First, the frequency that each of the themes, categories, and subcategories were chosen per state was graphed. Then, the subcategories was analyzed for possible connotations and relations to identity and nationalism.

This method is limited because it cannot verify that the statements made on Instagram are true. This study assumes that all posts that are being coded match the opinion of the poster and are truthful. If posts seemed to be fictitious, they were discarded by the researcher.

The goal of the analysis will be to find deeper similarities and differences between the two regions based on this data. This method allows for an overall exploratory analysis, with no finite "yes/no" answer to the proposed research question.

3. Results

The following graphs depict the opinions of the posts presented under nationalist hashtags found on Instagram. A total of 54 posts were collected: 27 from Californian Latinos and 27 from Texan Latinos. First, demographic information was created in order to ensure that the averages of the survey aligned with that of the average Instagram sample. Overall, a majority of Latinos in this study did not identify a specific country of origin, so that data will not be considered for further analysis.

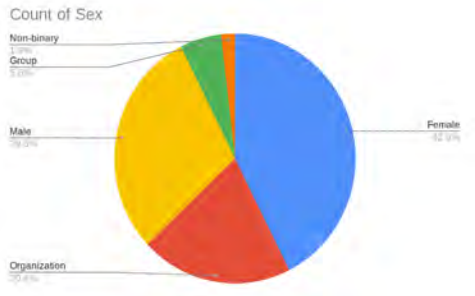

Figure 2: Percentage of Reported Gender and Grouping

The largest sample group by gender was females (42.6%), followed by males (29.6%), organizations (20.4%), groups (5.6%), and non-binary individuals (1.9%). While the percentages are not completely balanced, the researcher deemed them diverse enough to continue with the analysis. For the purpose of this research, organizations were defined as a page owned by more than one person where the specific identity of each person was not known. Groups were defined as a page owned by more than one person where the specific identity of each person was known. For both groups and organizations, every individual had to be Latino in order for the page to be considered.

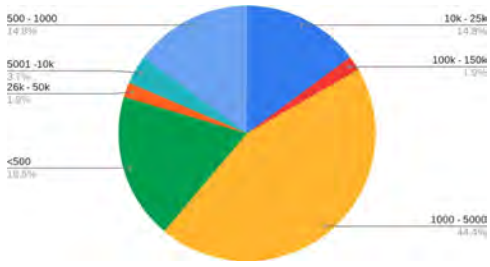

Figure 3: Percentage of Followers

The largest sample was from individuals who had 1000-5000 followers (44.4%) followed by those who had less than 500 followers (18.5%), and between 500-1000 (14.8%). In order to avoid the presence of 'bots' and 'trolls' on Instagram, which pose like real humans but produce fictitious opinions, this study tried to avoid large amounts of accounts that averaged low follower numbers (Ledford, 2020).

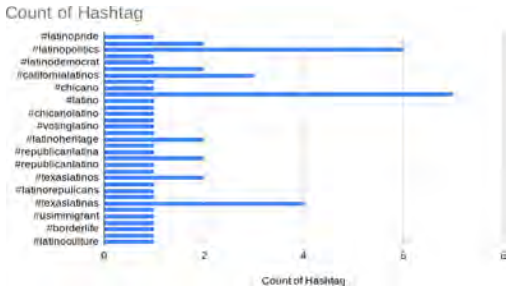

Figure 4**:** Hashtags Used to Search for Included Posts

This study aimed to use various hashtags in order to avoid pulling from one area of the Internet. These hashtags were either derived from the methods section or changed slightly in order to fit the updating format of Instagram (slight changes to spelling, word order, etc.).

Next, the posts were sorted into main themes of either 'Nationalism' or 'Latino Identity'. The data was broken up into results for the captions, photos, and hashtags, and then further divided into overall results and then results for California and Texas.

Figure 5: Themes of the Captioning

In the captions, there is a 23.7% increase in nationalism between Texas and California.

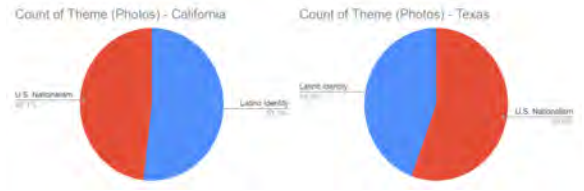

Figure 6: Themes of the Attached Photo

'Nationalism' and 'Latino Identity' remained the most consistent between the two photographs, with a smaller percentage difference than in Figures 6 and 8. However, Texas still saw a 13.5% increase in 'Nationalism'.

Figure 7: Themes of the Related Hashtags (Not Including the Searched Hashtag)

Within Figure 7, Texas still had higher levels of reported 'Nationalism' than California with a 23.7% increase. Equal to Figure 6, the theme graph for California has a relatively even divide between the 'Nationalism' and Latino Identity posts.

Overall, Texas has a consistently larger 'Nationalist' commentary than California, averaging 60.53% and 48.1% respectively between Figures 5, 6, and 7.

After overarching themes were chosen, posts were given categories. 'U.S. Nationalism' was broken into the subcategories of freedom, success, or pride. 'Latino Identity' was broken into the subcategories of home country, cultural values, or life experiences.

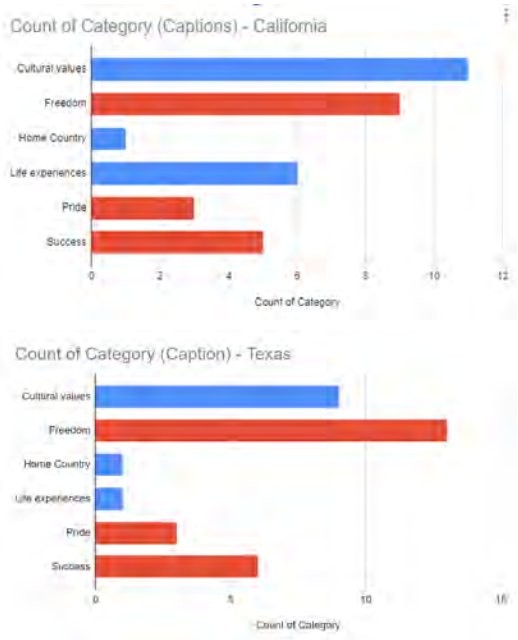

Figure 8: Categories for Captions

For captioning, Texas and California had similar values for all markers except for life experiences. California had an 83% increase in posts that reported life experiences that were a direct result of being a part of Latino culture. Texas had an 31% increase in posts that reported freedom as a focus of life as a Latino-American citizen. For captions, all six of the measured categories were reported.

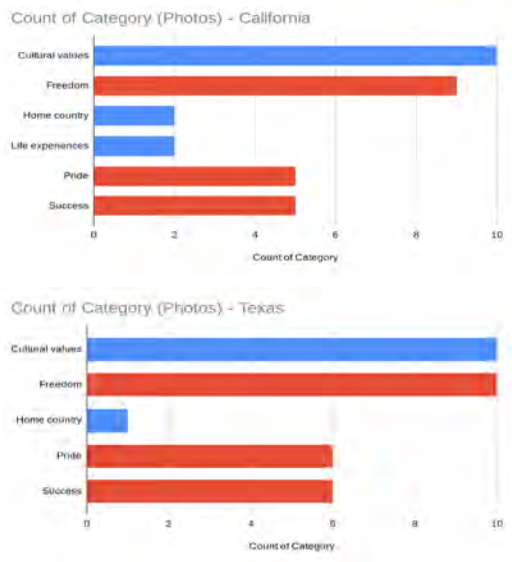

Figure 9: Categories for Attached Photo

California indicated high levels of cultural values and freedom, with ten and nine reported posts respectively. This continued the trend of a high median average for cultural values and freedom, with the median value for California being 5 and cultural values sitting at 10 and 9, 100% and 80% higher respectively.

For photos, Texas and California had similar values for all markers except for life experiences. Texas reported no posts with life experiences while California reported two.

Shown in Figure 10, Texas has a 20% increase in reported freedom and a 40% increase in reported pride in comparison to California. Similar to Figure Texas in Figure 9, Texas does not report posts with life experiences in Figure 10. Posts without life experiences for Latino culture were more frequent among the Texan posting group than the California posting group.

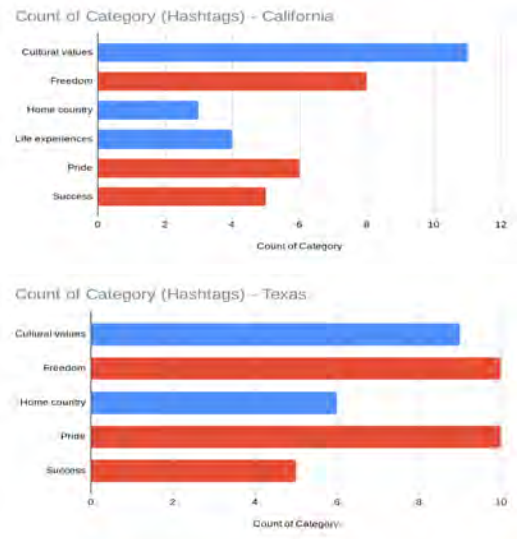

Figure 10: Categories for Related Hashtags

As shown in the figures above, Texas and California have similar levels of nationalist categorical markers (freedom, pride, and success). However, while Texas and California have similar levels of cultural values, Texas consistently shows less prominence for life experiences.

Next, posts were coded for their subcategories. These subcategories were chosen from major imagery, repeating keywords, contextual words, or emotionally charged language. Only words with two or more repetitions were graphed.

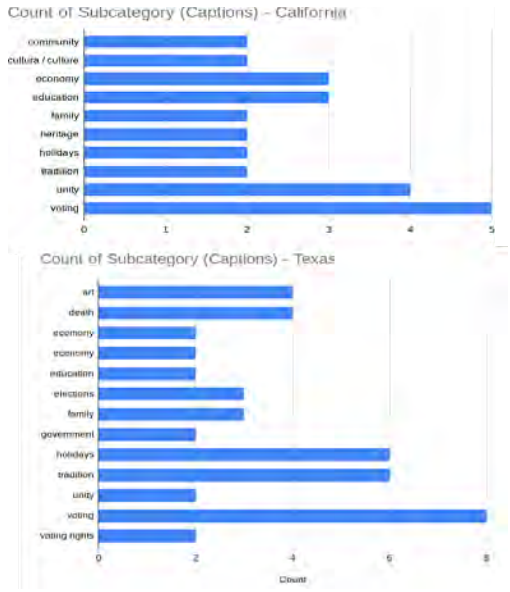

Figure 11: Subcategories for Captions

Words not included - California: art, celebrities, Chicano, church, coming of age, Democrat, discrimination, division, elections, family past, food culture, gente, housing, identity, immigration, independence, mask, progressive, protest, raza, registration, religion, Republican, roots, U.S. Flag, work ethic

Words not included - Texas: action, amendments, American pride, bigotry, border patrol, community, conformity, COVID, GOP, happiness, human rights, immigration, justice, leadership, love, military, power religion, representation, Trump

California's most common repeating words for subcategories include voting, unity, economy, and education. In regards to unity, the word was most commonly used in a political context to discuss voting.

Texas' most common repeating words include voting, tradition, holidays, family, elections, art, and death. Between both groups, the only common high-frequency repeating word in the captions category was voting.

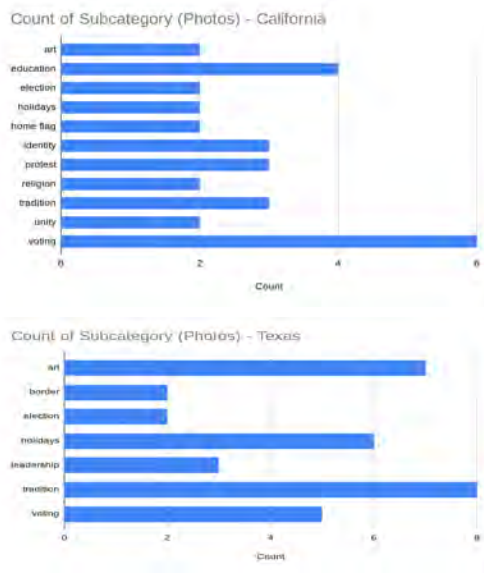

Figure 12: Subcategories for Photos

Words not included - California: business, Chicano, church, climate, clothing, coming of age, community, conservative, cultura, cultural, pride, economy, family, feminism, food culture, freedoms, housing, immigration, leadership, liberty, living things, media, Newson, newspaper,s political association, registration, skin tone Words not included - Texas: American football, business, candidacy, clothing, DACA, death, economy, education, family, flag, GOP, government, history, hope, human rights, immigration, justice, military, murals, presidents, pride, protest, representation, Trump, U.S. flag, unity, voting rights

California's most common repeating words include education and voting.

Texas' most common repeating words include art, holidays, and tradition. The word tradition was most commonly used to refer to Latino cultural tradition. Also, the world holidays was most commonly used to refer to Latino holidays.

Figure 13: Subcategories for Related Hashtags

Words not included - California: border, church climate, community, country, cultural pride, education, employment, family, food economy, freedom, immigrants, independence, liberty,

literature, patriotism, photography, policing, pride, raza, registration, religion, success, wall

Words not included - Texas: Biden, candidacy, capitalism, color, conservatives, DACA, Democrats, education, "flip Texas blue", history, Jesus, justice, La Catrina, LGBT, love, murals, party, patriot, peace, pets, pride, protest, sports, Texas, unity, voting rights

California's most common repeating subcategorical words include Chicano, Republican, tradition, voting, and racism. In the context of these posts, when discussing Republicans, it was more frequently spoken by members of the community that are Republican.

As shown above, both Texas and California have matching words such as art, holidays, tradition, and voting. When referring to the words holidays and tradition, the majority of the posts were discussing Latino holidays and traditions.

Finally, the keywords for the post were chosen. Keywords were not divided, so information for all posts could be drawn. Each post was given two to four keywords, with each word being written or shown through visual imagery in the post. When coding this information, similar words were combined (ie. unity, united, unite, and unido were all grouped together). Only words with two or more repetitions were graphed.

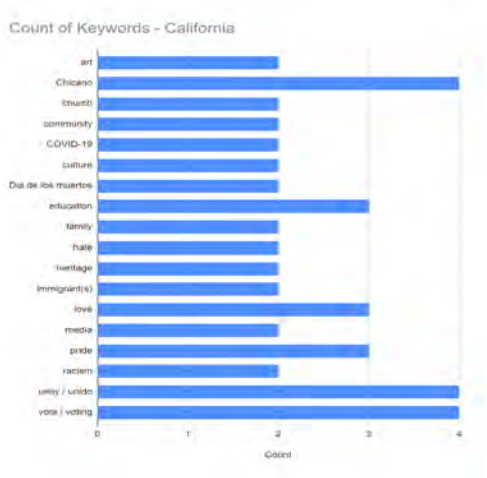

Figure 14a: Keywords (California)

Words not included - California: America, Bernie Sanders, border wall, "Brown lives matter", customs, "Democrats destroy", Dominican, election, employment, equality, fire, First Amendment, Goya, handouts, Hell, housing costs, identity, illegal alien, Independence, justice, liberty, lungs, mask, Mexico, mierda, movement, newspaper, opportunity, over-policing, painting, political science, polls, power, protest, race, Republican, Selena, sin, taxpayer

California's highest frequency keywords include unity/unido, vote/voting, chicano, and education, love, and pride. All of these words show Californian Latinos lean towards a more politically progressive and united sense of community.

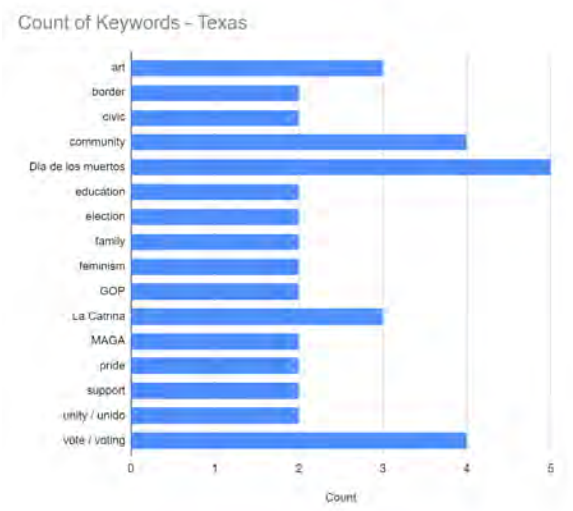

Figure 14b: Keywords (Texas)

Words not included - Texas: action, amendments, Biden, bigot, cages, capital, capitalism, chicana, color, COVID-19, creative, DACA, death, Democrats, "do not comply", Dreamers, faith, football, governor, heart, heritage, history, immigrants, Jesus, Joe Rogan, Justice, legislature, LGBT, love, media, Mexican, mural, Obama, party, patriot, peace, Republicans, skulls, soldier, sports, Ted Cruz, Trump, voting rights

Texas' highest frequency keywords include art, community, "Dia de los muertos", La Catrina, and vote/voting. Through these keywords, Texan Latinos show a deep appreciation for tradition and the continuation of the practices in their community and home-country culture in the United States through art, holidays, and stories.

Overall, most posts contained a theme of community, culture, or change, with all keywords having themes that relate back to those three

categories. The highest frequency repeating keywords (vote/voting, Chicano, community, unity/unido, "Dia de los Muertos") were words that stem back to themes of tradition or change within the Latino border community.

To show additional information about the feelings of the Latino community, the tone of the posts was collected. The tone of a post was based on overall markers such as connotations of words, facial expressions, present symbols and imagery, use of explicit language, and use of punctuation.

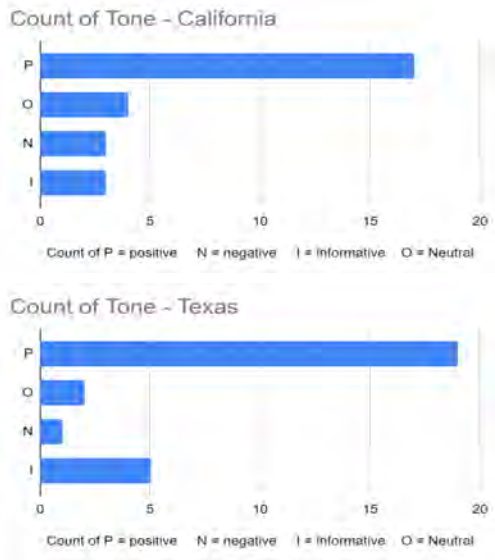

Figure 15: Tone

Both Texas and California had an overall positive tone throughout their posts. When speaking of their culture and the United States, both groups used words with positive connotations and inviting imagery (flowers, hearts, etc.) over negative imagery (fire, chains, etc). to promote ideas of freedom, change, pride, love, and diversity.

4. Discussion

The results of this study demonstrate how in the border states of California and Texas, political division between the Democratic and Republican parties has divided the Latino populations' feelings on nationalism and cultural identity on Instagram.

4.1 New Understanding

Found in Figure 5 through Figure 7, California Latinos demonstrate lower levels of nationalism than Texas Latinos. This aligns with a common value of the Republican party which is to be more nationalist and proud of the United States than the Democratic party (Nowrasteh, 2020). Moreover, Texas Latinos show stronger feelings of traditionalism, U.S. pride, and feelings towards traditional culture, holidays, and religion; California Latinos show stronger feelings towards liberalism like increased education and LGBTQ+ pride (Figures 8 - 10, 11 - 13, 14a, 14b). Thus, this study has found that within the Latino community, the Californian and Texan sub-communities have a stronger cultural alignment with the values of their respective political parties, despite Latinos as a whole voting Democrat in the 2020 election (Sonneland, 2020).

However, both sub-cultures have unifying factors that bring them together as one border Latino community. The two groups have a strong sense of community, unity, and feelings towards voting (Figures 11 - 13, 14a, 14b). This shows that despite the sub-cultures moving in different directions with the growth of the Latino community, both of them want a strong community that is represented within the United States. Within both of their keywords, the two groups showed a desire for positive change for the next generation; however, they disagreed on what that change was and which party would achieve it.

Finally, neither culture reports large feelings of self-hatred (Figure 15). With immigration policy moving towards the removal of immigrants within the United States and strong, anti-immigrant and un-American rhetoric (Gonzalez, 2019), the researcher hypothesized that there would be some level of self-hating behaviors forming among the border Latinos. However, according to Figure 15 (California) and Figure 15 (Texas), both California and Texas Latinos showed higher levels of positivity than negativity when discussing aspects of their cultural identity and nationalism in relation to their culture.

4.2 Relationship to Body of Research

Within the concepts of the literature review, this paper helps to narrow down the Latino border community into more specific groups and identify the

parallel changes that are occurring within the Texan and Californian communities. Previous research by Feinberg et al. (2017) theorized that political identity was shaped by a person's geographical location. This study furthers the conclusions of that research by finding that along the U.S.-Mexico border, a person's cultural identity is shaped by their geopolitical location. Further, this study helps to prove that the border is its own distinct culture separate from mainstream U.S. culture (McCaughan, 2020); however, these cultures are closely linked, especially in the ways that they view each other and how those views shape each other's identities. Finally, this study helps to verify the theories of Ramírez (2021), who said that political assimilation was occurring on the border. This study helped to prove that assimilation was occurring on a political-cultural level as well.

4.3 Future Implications

The future implications of this research could affect the Latino community during U.S. elections. In regards to the researched participants, this study could affect how those Texan and Californian Latinos are treated in media and election spaces. In political research and media spaces, Latinos are treated as one group along the border. This research sheds light on how the Latino community is broken up politically, and how those who live in Republican states could be more inclined to vote Republican than previously thought. For future major elections, Latinos in Republican border states could become a more targeted group by candidates. This research could affect the general American populous by further changing the trends of voting in the Latino border community. As this is a growing community, if campaigning becomes more targeted, that will affect all Americans, especially those living along the border. The change in media tonality could also affect the way the average non-Latino American views the Latino border population.

4.4 Limitations

The main limitations of the study relate back to the use of Instagram during the methodology. This study used Instagram as a sampling tool, so the conclusions might be limited to just social media. However, because of the frequent use of social media by the Latino population, the researcher believes this data can be extrapolated. According to the *Pew Research Center,* 52% of Latinos have used Instagram, which is above the national average for all ethnicities of 45.33% (Auxier & Anderson, 2021, fig. 3). This percent provides a statistically significant number of responses where it can be inferred that the Latino population on Instagram accurately represents that of the United States.

Moreover, this study had to make the assumption that all posts were made by real accounts and not bots (fictitious accounts posing as real individuals). In order to avoid this issue, the study collected samples from accounts with a consistent and long-standing post history, a follower-count that was either average or higher than average, and a face and/or name that could be traced throughout the post history. The follower count was important to this limitation because the average real account has a follower total of approximately 150, while bots will have a significantly lower number (Ledford, 2020). Thus, this study looked for accounts that were around or above 100 followers, only choosing accounts below 100 followers if they had a posting history that could help to verify the profile. However, this limited the study to its number of participants and could have increased the margin of error by reducing the sample to only people with a higher-than-average follower count. Moreover, this method could have introduced a sampling bias because the researcher coded for posts with certain qualifications, including the follower count. Subconsciously, the researcher could have then been sorting the posts. If this study is to be replicated, this is an area for further research or improvement.

4.5 Guidelines for Future Research

For future research, this study can be used as a framework in order to find more specific information about the Latino border community. With Texan and Californian Latinos showing differences in overall culture, future research can break down these cultures by age, country-of-origin, distance from the border, city population, or generation/years removed from

their country-of-origin. Moreover, this study could be reconducted with a larger sample of people both on Instagram and on other social media platforms to guarantee that when increasing the sample size, the overall trend of the data remains consistent. Also, further in-person interviews should be conducted in order to gain more in-depth information about the nuanced feelings of the participants and gain a further, fuller understanding about the connections between political association and nationalism. Other states along the border should also be considered in future research to see if the same pattern emerges or if this pattern is isolated to California and Texas. Thus, conclusions could be drawn if the shift in feelings of nationalism are based solely on the political party or are also influenced by state culture.

5. Conclusions

Thus, this study helped to prove how in the U.S.-Mexico border states of California and Texas, a differing political climate has changed the Latino culture to match that of the political parties in their states. In the future, this could influence elections and campaigns towards the Latino population, which would become more effective if it targeted the specific differences in these cultures. For continued research, different sub-groups within the Latino community, along with different border states, need to be examined to see if this trend continues or is limited.

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This paper is dedicated to my mom, for inspiring my love of knowledge and always taking me to the library when I was younger. Thank you for making me into the person I am today.

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Correlation Analysis of the Effectiveness of Covid-19 Vaccination Across Different Age Groups in California

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Abstract

For Covid-19 cases and deaths, the disparity among different age groups in California is very high, and so, it is important to know whether this is also a disparity of vaccine effectiveness between ages. Covid-19 cases and deaths data was extracted from data collected by the California government. For each of the age groups, the 7-day moving averages were calculated for deaths, cases, and full vaccinations. The hypothesis is that there is a negative correlation between the full vaccination rate and number of cases/deaths, and the correlation is more significant among older people than younger people. For each age group, visualizations of the full vaccination rates and number of cases/deaths was created separately, and correlation analysis of the variables was run. Finally, the correlations among the age groups was compared. The results suggest negative correlations between full vaccination rates and number of cases and deaths for all the age groups, except for those younger than 17. The significance of the correlations decreases as the group age decreases.

Keywords: Covid-19, Vaccination, Correlation Analysis, Effectiveness, Age Group

1. Introduction

In California, Covid-19 disproportionately affects the cases in the working-class population (18-49 years of age) and the deaths in the elder population (65+ years of age). All other age groups (0-17 and 50-64 years of age) have low death percentages and case counts proportional to the population of that age group in California (Tracking Covid-19 in California, 2002). California, in response, has fully vaccinated 75% of its total population eligible for the vaccine as of the end of April of 2022, administering approximately 25,000 new doses daily, which puts it on the 13th rank by the highest percentage of population fully vaccinated per state (Mayo Clinic, n.d.). Pfizer is the most popular vaccine, followed by Moderna, both of which are mRNA vaccines, while Johnson & Johnson's single-shot viral-vector vaccine is the 2nd runner-up (Los Angeles Time Staff, 2022).

Studies have been done to test the effectiveness of Covid-19 vaccinations on preventing Covid-19 -related health complications and death among adults (Henry et al. 2021; Zheng et al., 2022). These studies suggested that vaccines have been shown to reduce infection rates within the 14-day period after administration in clinical trials and have shown 90+% effectiveness in real-world studies. In another study done by Rosenberg et al. (2022), there was no significant difference in vaccine effectiveness of mRNA vaccines among different age groups. However, "Vaccine effectiveness" was not clearly defined in this study, and it could generally fit the CDC definition of vaccine effectiveness - "the proportionate reduction in cases among vaccinated

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persons" (Centers for Disease Control and Prevention, 2006). Nevertheless, given the disparity in cases and deaths across different age groups in California, there exists a need for a study on the effectiveness of vaccines across age groups. This study bridges this gap by analyzing the correlations between fully vaccination rate and Covid-19 cases and Covid-19 deaths across different age groups. The hypothesis is that there are negative correlations between the vaccination rate and Covid-19 cases, and between the vaccinated rate and Covid-19 deaths, and that the correlation strength is the strongest in seniors and the smallest in the youth group.

2. Materials and Methods

Publicly available data from the California government website (https://covid19.ca.gov/state-dashboard/#ethnicity-gender-age) for Covid-19 information for cases, deaths, and vaccinations by date and age group was used for this study. The range of the data in the analysis was from July 27th, 2020 to December 19th, 2021. In particular, the total case count, deaths, and cumulative fully vaccinated population (any vaccine) per day was extracted from the database. Then, the 7-day moving averages for these measures was calculated using Python and divided into four age groups that were presorted in the original data set: 5-17, 18-49, 50-64, and 65+ years of age. After this preprocessing, visualizations of the moving averages of the total cases and deaths against the cumulative vaccinated number by date were created using the Excel visualization tools to see trends. Finally, a correlation analysis was run on all age groups between all moving averages to see if there are statistically significant correlations between vaccination rates and deaths/cases across populations and how the correlations differ among different age groups. Visualizations of cases versus deaths were not generated, but correlation analyses were run between their moving averages.

3. Results

3.1 Visualizations of Moving Averages of Fully Vaccinated People and Covid-19 Cases and Deaths Over Time

Figures 1 and 2 illustrate the moving averages of cumulative fully vaccinated people and daily Covid-19 cases and deaths over time among seniors (ages 65+).

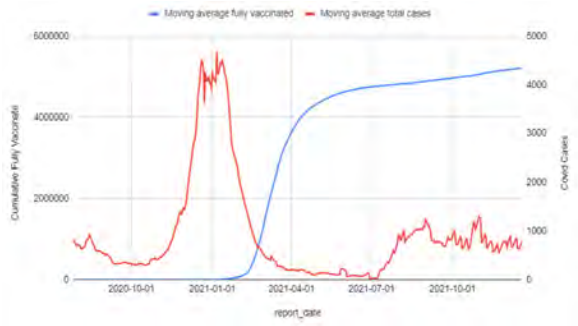

Figure 1. Cases versus Vaccinations: the cases show a spike while vaccinations steadily increase and later plateau

Figure 2. Deaths versus Vaccinations: the cases show a spike while vaccinations steadily increase and later plateau

Figures 3 and 4 illustrate the moving averages of cumulative fully vaccinated people and daily Covid-19 cases and deaths over time among those of 50-54 in ages.

Figure 3. Cases against Vaccinations: a similar visualization as that of Seniors

Figure 4. Deaths against Vaccinations: a similar visualization as that of Seniors

Figures 5 and 6 illustrate the moving averages of cumulative fully vaccinated people and daily Covid-19 cases and deaths over time among those of 18-49 in ages.

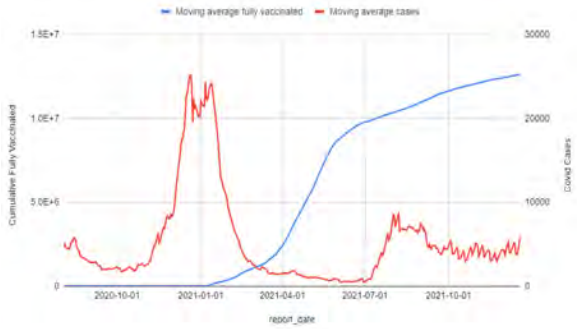

Figure 5. Cases against Vaccinations: a similar visualization as that of older age groups

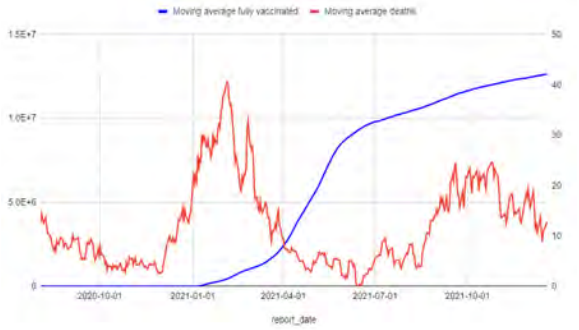

Figure 6. Deaths against Vaccinations: a similar visualization as that of older age groups

Figures 7 and 8 illustrate the moving averages of cumulative fully vaccinated people and daily Covid-19 cases and deaths over time among those younger than 17.

Figure 7. Cases against Vaccinations: the spike of vaccinations occurs a later than the drop in cases as compared to other visualizations

Figure 8. Deaths against Vaccinations: the deaths do not show any seamless pattern as compared to other visualizations

Figure 9 shows the comparison of the correlation coefficients of the moving averages of cumulative fully vaccinated people and daily Covid-19 cases and deaths across the four age groups.

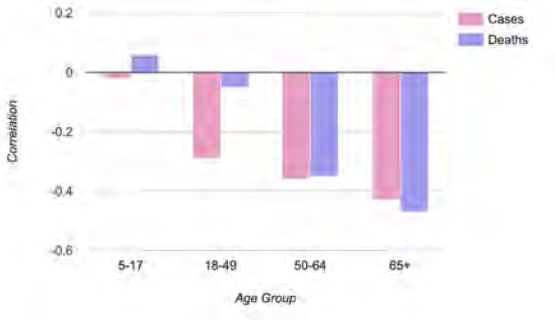

Figure 9. Correlation Coefficients steadily Decrease down Age Groups

4. Discussion

The graphs of deaths and cases show spikes

during the most vulnerable times in the population, such as the 2020 holiday season the data encompassed. In all age groups case counts slope downhill as vaccination increases, except for the underage group in which the case count starts decreasing a few months before vaccination starts to take place. Cases in all age groups do decrease around the same time period (February/March of 2020), and so it can be speculated that the vaccination of the older population, who got their vaccines first, helped curb the spread in the youth. All age groups see an uptick slightly before July in cases, and in turn an uptick in deaths slightly after July (except the underage group, which does not have enough deaths to produce a viable graph). This can be due to the outbreak of the Delta variant and the removal of restrictions in California starting June 2021.

Correlation analyses between cases and deaths show a strong positive correlation of 0.62 in the age group 65+, weaker correlations of 0.46 and 0.41 in age groups 50-64 and 18-49 respectively, and no significant correlation of 0.05 in the age group 5-17. This trend of decreasing correlation across age groups continues for vaccinations. In terms of Covid-19 cases, vaccination has a significant negative correlation of -0.43 in ages 65+, -0.36 in ages 50-64, and -0.28 in ages 18-49. There exists no significant correlation of vaccines and cases in the underage population. Similar correlation is seen with deaths: -0.47 in group 65+, -0.35 in group 50-64 (statistically significant) and -0.05 in group 18-49 and 0.06 in group 5-17. Thus, significance of the correlation of vaccines with cases/deaths decreases across age groups.

From the strong negative correlations it can be inferred that vaccinations are more effective for older populations than younger. Especially in the under-eighteen population, vaccinations seem to have no effect at all, even showing a slight positive correlation between vaccines and deaths. However, the youth population has significantly less cases and deaths than other age groups, which would also lead to insignificant correlation coefficients and an unworkable deaths plot. Every other age group has viable data, and so the correlation coefficients are logical indicator to the effectiveness of vaccines on Covid-19 casualties in different age groups.

The decreasing significance of correlation down age groups can be a result of the vulnerability of older populations to Covid-19. Generally speaking, younger populations have a lower risk of deaths than older populations, thus leading to the decreasing correlations down age groups between cases and deaths. Vaccines would also be much for significantly effective for older populations, since they are much more likely to suffer health complications after contracting Covid-19.

5. Conclusion

Although it has been widely acknowledged that Covid-19 vaccination plays an important role in preventing people from getting seriously ill, being hospitalized and even dying, there has not been a systematic study on comparing the effectiveness of vaccinations among populations of different age groups. This study serves to fill the gap.

The correlation analyses show that while Covid-19 disproportionately affects different populations, vaccinations also disproportionately help different populations. The oldest population, those of ages 65+, is the most vulnerable population to Covid-19 but also the one with the highest negative correlation between vaccinations and Covid-19 casualties. From this study, it can be seen that vaccines are effective in producing desired effects in California, since they significantly lower cases and deaths in the most vulnerable populations.

However, this study is limited in accounting for variables that might affect cases differently across age groups, since it is not a controlled experiment. In addition, as Covid-19 variants continue to evolve, we need to continually monitor the effectiveness of the vaccinations with more updated data.

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