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ACADEMIC JOURNAL

February Issue

Issue 24

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The Effect of Education on Men and Women When Responding to Low-Promotability Tasks by Lucy Zheng

Introduction

To this very day, gender differences remain a problem in the workplace, where women progress professionally slower than men. One explanation for the perceived gender differences in the workplace is that women are more likely to volunteer or be asked to volunteer for less-promotable tasks (work that helps the organization but not the individual's career) than are men in the same work environment (Babcock et al. 2017). For example, women more frequently accept the request to take on roles like writing reports, organizing events, or serving on a committee, while their male colleagues choose to dedicate more time to tasks like researching and experimenting. Babcock et al. demonstrate that the behavior when allocating and accepting tasks is not based on the fact that there is greater generosity towards men or that women are more altruistic than men, but instead that these behaviors are influenced by the conventional belief that women will agree more often than men to do less-promotable tasks (2017). Every time people act according to this belief, we may expect that it reinforces the belief itself and strengthens gender differences, resulting in the appearance that women are less suitable for skillful tasks. Repeated often enough, and women may consistently feel more obligated to volunteer for low-promotability tasks and men may consistently expect women to do so.

One factor that might interfere with the gender expectation in accepting task requests is education. Research shows a positive correlation between education level and core task performance as determined by supervisors' ratings, peer or subordinates' rating, self-rating, and objective measures (NG and Feldman 2009). This same research demonstrates a stronger education-performance relationship for high-complexity jobs than for low-complexity jobs (NG and Feldman 2009). To maximize productivity, it makes more sense to expect more-educated workers to perform more skilled tasks (which in most cases are more promotable or profitable tasks) and less educated workers to do otherwise, regardless of gender. Less-educated people are expected to undertake low-promotability tasks for the sake of minimizing opportunity costs associated with highly skilled workers doing low-skill labor, but women are expected to do these less-promotable tasks because of the common perception that women are more likely than men

to agree to such tasks. When the education expectations overlap with the gender expectations, it is possible that it may offset the gender effects that place women at a disadvantage.

Given that women more than men are likely to volunteer to perform low-promotability but collectively beneficial tasks in a group setting because both genders expect women to do so, I designed an experiment to test if people's willingness to volunteer for less skilled and profitable group tasks would differ when knowing the education levels (which correspond to task performance skill levels) of their peers. Specifically, I aimed to test how knowledge of women's higher education and corresponding skill levels affected men's behavior, and how knowledge of men's lower education and corresponding skill levels impacted women's behavior.

Based on evidence from existing studies, we can hypothesize that 1) men, when informed of the genders of their colleagues, would less likely volunteer for the less-skilled and lower-profit group task if members of the group are women than if their peers include only other men, because the men would most likely expect that the women will volunteer; and 2) individual women, when informed of the genders of their peers, would more likely volunteer for less-profitable tasks if they are the only woman in the group than if the peer-group also includes other women, because individual women are aware of the gendered expectation that they accept the less-promotable task.

We may also predict that 1) when a highly educated individual is informed of the education levels of their peers, but not the genders of peers, that individual would less likely volunteer for the less-skilled and lower-profit task if the person is the most educated in the group, than if the individual's peer-group includes others with similar education levels, because such high-educated persons would most likely expect those with lower education to volunteer; and 2) when a less-educated individual is informed of the education levels of their peers, but not their peers' genders, the individual would more likely volunteer if he or she is the least educated in the group than if the individual's group of peers includes others with similar education levels, because the individual's comparatively low skill level makes he or she more suitable to volunteer.

My experiment investigates 1) how low-educated men, when given both gender and education information of their peers, respond to requests to perform the less-skilled and low-profit task if they are the only male as well as the least-educated in the group, compared to if their peers include other less-educated men like them; and 2) how highly educated women, when

given both gender and education information of their peers, respond to requests they perform the less-skilled and low-profit task if they believe themselves to be the only females as well as the most-educated in the group, compared to if their peer groups include other highly educated women. The objective is to determine which effect--gender or education--will overrides the other for men and for women. Hence, it may be determined whether education differences can affect gender differences in the workplace. Ideally, additional information related to ability or education levels would lead people to rely less on gender norms.

Method

I aimed to recruit 600 online participants through Prolific, an online research platform; 300 men who have not gone to college, and 300 women with advanced degrees--MS or PhD--in mathematics, physics, accounting or engineering. The experiment included 334 male participants and only 183 female participants, terminating after ten days when new participation had slowed considerably. The study assigned each participant to a mixed-gender group of three, and asked each to choose between an individual task and a group task. The individual task represented a highly promotable task, and required the participant to solve 25 math questions and earn one cent for each correct answer. The group task, designed to represent a less-promotable task, required the participant to transcribe in reverse order a non-English passage for the group.. Only one member of the group was required to transcribe the passage, but members were not able to communicate with each other. Group members were informed that if one person in the group transcribed the passage, each member would receive a 50-cents bonus. These incentives constitute a hawk-dove game, in which individuals would ideally like to do the individual task while a partner does the group task, ensuring themselves maximum benefit as the hawk in the group, but would prefer to do the group task themselves as the dove in the group if they knew that none of their teammates would do it.

Every group would either have two highly educated women and one less-educated man or one highly educated woman and two less-educated men. An even randomization ensured that each participant was notified of different information about teammates. Each participant would be randomly provided with their group mates' gender information, education information, or both. The combination of three informational conditions in each of two group compositions offered six distinct experimental conditions. The less-educated men would receive information

about being in a group with one of the following combinations: 1) one woman and one man, 2) two women, 3) one person with an advanced (MS or PhD) degree in math/physics/accounting/engineering and one person who has not gone to college, 4) two people, each with an advanced degree in mathematics, physics, accounting or engineering, 5) one woman with an advanced degree in math/physics/accounting/engineering and one man who has not gone to college, 6) two women, each with an advanced degree in mathematics, physics, accounting or engineering. The more-educated women would receive information about being in a group with one of the following combinations: 1) one woman and one man, 2) two men, 3) one person with an advanced degree in mathematics, physics, accounting or engineering and one person who has not gone to college, 4) two people who have not gone to college, 5) one woman with an advanced degree in mathematics, physics, accounting or engineering and one man who has not gone to college, 6) two men, each of whom has not gone to college. The goal is to find out if people will make different decisions based on what information they know about their teammates.

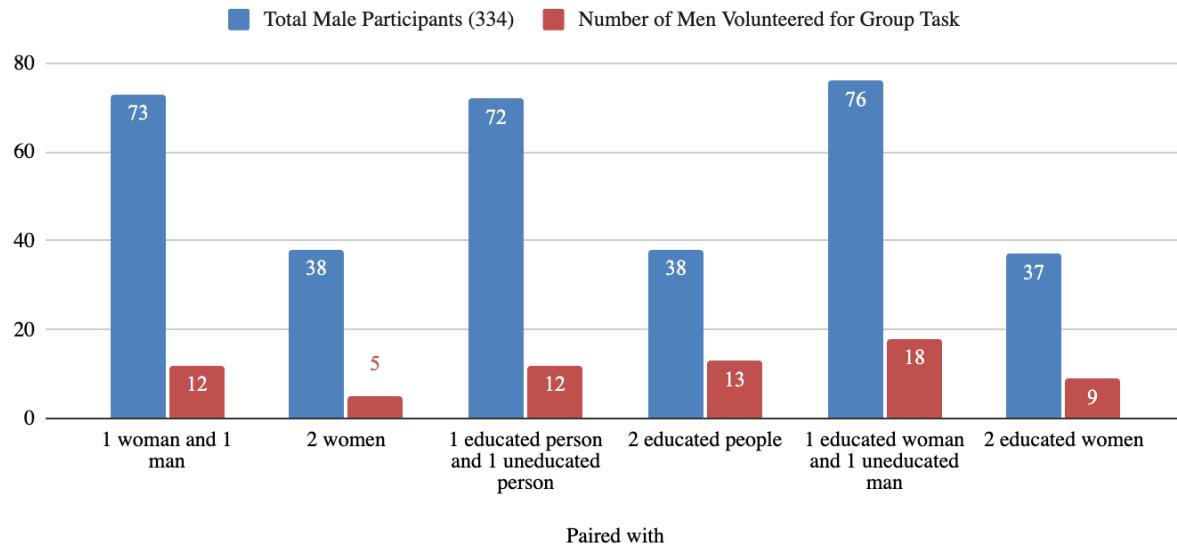
The first section of the results compares the groups of men informed of the genders of teammates; groups of men informed of the education levels of teammates; and groups of men informed of both the genders and education levels of teammates. The second section of the results compares the groups of women informed of the genders of teammates; groups of women informed of the education levels of teammates; and groups of women informed of both the genders and education levels of teammates.

Results

Screening for Less-Educated Men

The study had recruited a total of 334 men below college level education on Prolific. Of those 334 men, 64 volunteered for the group task. Figure 1 shows how many of these participants volunteered for the group task based on the identification information they had for teammates.

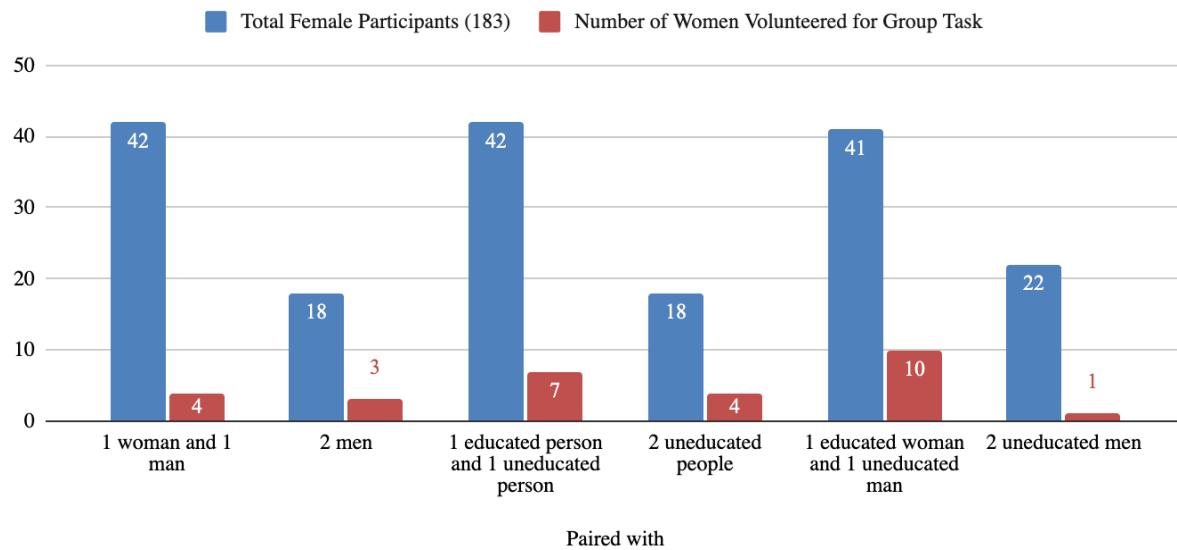
Number of Less Educated Male Participants & Number of Which Volunteered



Screening for Highly Educated Women

The study had recruited 183 women with advanced degrees in math/ physics/ accounting/ engineering online participants on Prolific. Of these women, 29 volunteered for the group task; figure 2 shows the number of women who volunteered for the group task based on the information they had about their teammates.

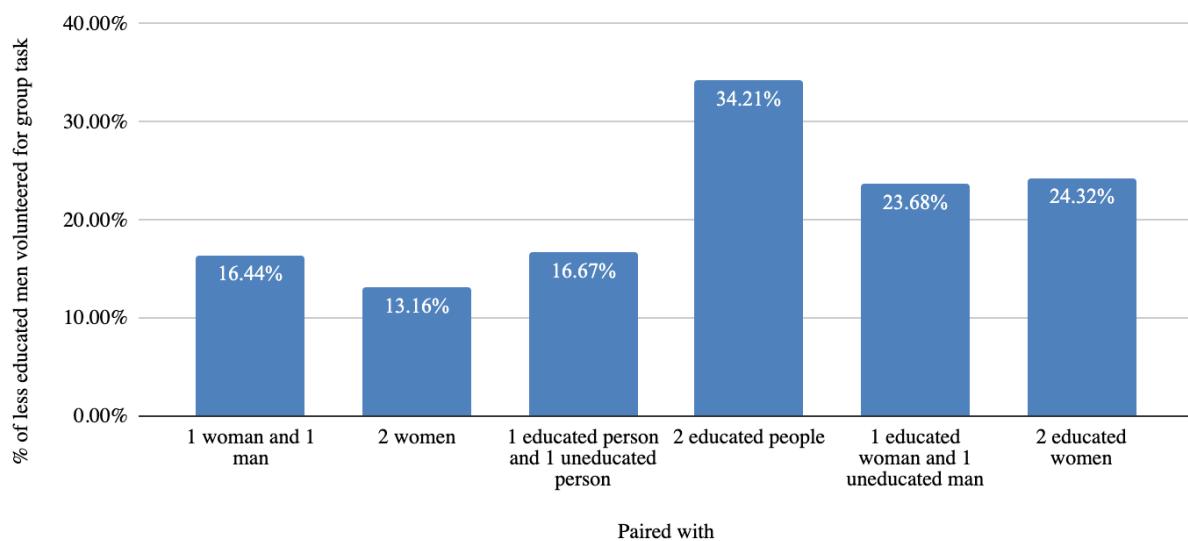
Number of Highly Educated Female Participants & Number of Which Volunteered



Results for Less-Educated Men

Figure 3 shows results from this experiment for the less-educated men who participated in this study. In the two pools of men who had received only gender information about their group-mates, the percentage of male group-task-volunteers was lower among those paired with two women than that among those paired with one woman and one man. Out of the men who knew their teammates to be two women, as described in figure 3, 13.2% volunteered, and out of the men who knew their teammates to be one woman and one other man, 16.4% volunteered. The difference was not significant ($p = 0.65022$).

Percentage of Less Educated Male Volunteers in Each Appeared Group Setting



When comparing the two pools of less-educated men informed only about the education levels of members of their groups, the data display a significant difference. The pool of men who were informed that both their teammates were highly educated volunteered significantly more than did the pool given the information that only one of their teammates was highly educated. Out of the men who knew their teammates to be two highly educated people, as presented in figure 3, 34.2% volunteered, and out of the men who knew their teammates to be one highly educated person and one other less-educated person, 16.7% volunteered ($p = 0.04040$). We see that when the less-educated men know that they are paired with only highly educated people, they are more inclined to volunteer.

In the two pools of less-educated men who were exposed to both gender and education information about their group-mates, the percentage of male group-task-volunteers in the groups

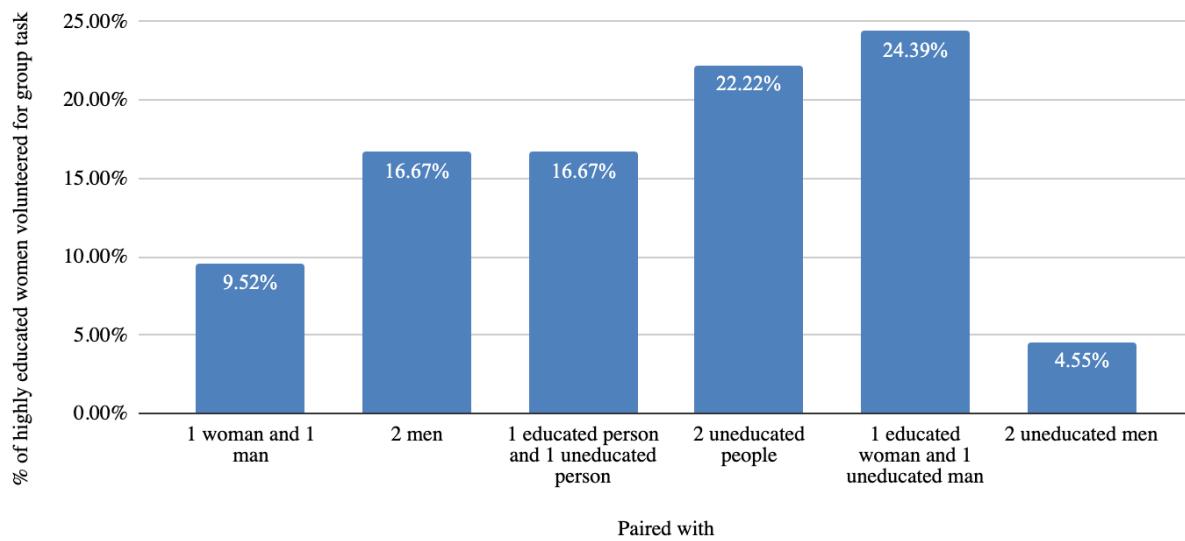
with two highly educated women was almost the same as that in the group with only one highly educated woman. Out of the men who knew their teammates to be two highly educated women, 24.3% volunteered, as again shown in figure 3, and out of the men who knew their teammates to be one highly educated woman and one other less-educated man, 23.7% volunteered ($p = 0.94051$). The data indicates that when gender information is added along with education information, the education effect for men discovered in the previous data set's comparison diminishes.

It can be inferred that knowing the education information of their peers may change men's response to low promotability task demands. Men are more likely to volunteer when finding themselves to be the least educated among the group. When, however, gender information is provided in addition to education information, the men revert to behave according to gender norms: they still expect women in the group to volunteer for less-profitable tasks, even knowing that the women are more highly educated.

Results for Highly Educated Women

Figure 4 shows the results for highly educated women with MS and PhD degrees who participated in this study. In the two pools of highly educated women who were provided with only the gender information of their group-mates, the women paired with two men volunteered for the group task more than those paired with one man and one woman. Out of the women who knew their teammates to be two men, 16.7% volunteered, and out of the women who knew their teammates to be one man and one other woman, 9.5% volunteered. The difference may not be significant ($p = 0.43418$). The result corresponds to evidence of gender effects in existing literature, which suggests that women feel more obligated to volunteer for less-promotable tasks when their peers are men.

Percentage of Highly Educated Female Volunteers in Each Appeared Group Setting



In the two pools of highly educated women who had received only the education information of their group-mates, the pool of women who were informed that both their group-mates were less educated volunteered more than did the pool given the information that only one of their group-mates had lower education. Out of the women described in figure 4 who knew their teammates to be two less-educated people, 22.2% volunteered, and out of the women who knew their teammates to be one less-educated person and one highly educated person, 16.7% volunteered. This result defies our expectation that people are more likely to feel the need to volunteer for lower promotability tasks when they know they are the least educated among their peers. The difference in the data was not significant ($p = 0.61303$).

When comparing the two pools of highly educated women who are informed with both gender and education information about their group-mates, the data display a significant difference. The pool of women who were informed that both their teammates were less-educated men volunteered significantly less than did the pool given the information that only one of their teammates was a less-educated man, as we see in figure 4. Out of the women who knew their teammates to be two less-educated men, only 4.5% volunteered, and out of the women who knew their teammates to be one less-educated man and one highly educated woman, 24.4% volunteered ($p = 0.09459$). The data indicates that for highly educated women, when education information is added along with gender information, the effect is opposite of the gender effect and affirms what we expected of the education effect.

Under the influence of existing gender norms, women's response to low promotability task demands may be affected by the gender information of their peers: they are more likely to volunteer when finding themselves to be the only woman among the group. However, when education information is provided in addition to the gender information, women give the education effect precedence: when women know that they are the only woman in their peer group, and the most-educated among that group's members, they are likely to disregard the gender norms and expect the men to volunteer for less-promotable tasks because of the men's education-derived skill level.

Discussion

When the expectation for women to volunteer for low-promotability tasks in the workplace overlapped with the expectation that the less-educated volunteer for those tasks, the men and the women in this study responded differently to those task volunteer requests. Results indicate that for the men, when additional information of gender differences is added to education information, the gender effect overrides the education effect that would encourage the less-skilled to volunteer, and these men continue to embrace gendered expectations of women group-mates. For the women, however, the additional information about the difference in education overrides gender expectations for less-skilled and low-profit tasks in mixed-gender group settings.

Some comparisons of data in this study may not be statistically significant (with a p-value more than 0.05) or have contrasted findings from existing research. These might have been a result of not large enough sample size. The study did not recruit on Prolific the expected number of 300 female participants with advanced degrees in mathematics, physics, accounting and engineering, which may be due to low availability of such participants, a failure of the platform to reach such participants, or another unaccounted-for factor.

This study aimed to test if information of education differences can reduce the inequitable expectations on women that place them at a disadvantage relative to men for promotion in the workplace. I initially hypothesized that to maximize productivity and minimize opportunity costs, individuals who know themselves to be less educated in a group setting will be more likely to take on tasks that are less individually profitable or likely to lead to promotion but collectively

beneficial, regardless of their group-mates' gender. Results suggest that, for men, effects of gender norms overshadow knowledge of the education disparity within peer groups. We can infer that the education information indicating that women may better suit high-promotability tasks than low-promotability, low-education-level-appropriate tasks fails to reduce gender discrimination by men in the workplace. However, the information of education disparity encourages women to resist the gendered workplace norms and may incentivize for women to fight for workplace task equity. Nevertheless, gender inequality in the workplace is a severe and obstinate problem that may resist the effort of women only. To maximize productivity and profit for an organization, higher promotability tasks should be assigned to those who are the most capable and fit, and workers' ability should be determined through equitable and transparent means without respect to gender, so that women may compete fairly with their male colleagues.

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A Review of the Impact of Context on Aesthetic Emotions and Experiences by Rebecca Byers

Abstract

Current work on aesthetic emotions shows that understanding and ease of processing of an artwork can lead to aesthetic pleasure and, in contrast, a lack of understanding can lead to confusion and displeasure. There is also an indication that impacting this processing through the contextualization of artwork, such as the use of a descriptive title, can influence a viewer's aesthetic experience. In addition, the mere presence of an artwork in a museum space can increase the likelihood of interest and appreciation of the piece. The goal of this paper is to compile a review of the progress and work in the area of aesthetic emotions research. Specifically, we hope to focus on how the environment or other people in the space impact the viewer's aesthetic emotions. This will involve the review of past and current work that examine the factors that affect aesthetic emotional experiences. We hope to understand how competing stimuli affect focus, understanding, and appreciation of artwork. We also hope to see how the presence and aesthetic experiences of other people affects understanding or emotion. This work can add to the field of aesthetic emotion research in providing a compilation of work to be easily accessed and built off of. In addition, it can possibly provide valuable insights on the role of distractions and emotion contagion in the field of aesthetic emotions. Lastly, this work can help museums improve patrons' understanding and appreciation of artwork.

Introduction

The purpose of this paper is to present a review of current work in the area of aesthetic emotions, and in doing so, better understand how the social and physical context in which a person views an artwork affects their aesthetic experience. Aesthetic experiences and emotion are closely related to a person's understanding of a piece of artwork, as understanding can positively impact a person's opinion of an artwork and increase the pleasure felt. Context can often impact understanding and classification of an artwork, thereby impacting aesthetic emotions. For example, there has been evidence to suggest that the use of a descriptive title increases the understanding of abstract artwork (Leder et al., 2006). Emotions can also be impacted by other people, through empathy or emotion contagion. The feeling or pressure to

socially conform can also affect one's emotions and judgements. In this paper, we will be asking about the ways context (e.g. people and the environment) impact the emotions experienced by the perceiver of a piece of artwork. This has greater relevance for the presence and practices of museums. Many of the papers indicate that museums positively impact people's aesthetic experiences, in that the museum settings allow people to view artwork for longer and enjoy it more. This validates the place and purpose of museums as well as their general benefit to society. In turn, discussing current work in the area of aesthetic emotions can benefit museums by helping them gain a better understanding of how to display their artworks and improve their reach to wider audiences. An example of these benefits is how strategies can be improved from implementing findings of papers. Papers analyzing the impact of guided tours and other common aspects of a museum trip on a person's aesthetic experiences may also help museums find best practices in providing tours and increasing patron engagement. Additionally, a concise review of papers examining the impact of context may be useful for future research in this area in that it would provide a summary of advancements in the literature and give researchers a sense of where additional progress can be made.

Overview and Contextualization:

Aesthetic emotions are emotions that arise from the viewing and evaluation of something for its aesthetics, or its beauty and artistic value. While there remains debate over the specific boundaries or set of features defining what an aesthetic emotion is, there is a general prototype. First, aesthetic emotions arise only from visual, auditory, or cognitive processing. Further, the aesthetic appeal of a stimuli (rather than its usefulness) must be what causes an aesthetic emotion (Schindler et al., 2017). In addition, aesthetic emotions influence aesthetic judgment, or feelings of pleasure or displeasure, and can therefore predict the liking or disliking associated with such feelings (Menninghaus et al., 2019). They are also only those which are elicited by artwork, and not necessarily those which are depicted within the stimuli (Schindler et al., 2017, Menninghaus et al., 2019). Finally, aesthetic emotions, alongside aesthetic judgements (e.g. liking or disliking), are the result of an aesthetic experience. An aesthetic experience is a cognitive process of understanding and evaluating stimuli regulated by or alongside affective, or emotional, feedback (Kuchinke et al., 2009, Leder et al., 2004). Current theories of aesthetic experiences and emotion indicate that understanding or cognitive mastery of a stimuli or artwork has a large impact on the

interest and pleasure experienced by the perceiver (Kuchinke et al., 2009, Leder et al., 2004). Essentially, eventual cognitive mastery or understanding of an artwork increases aesthetic appreciation and pleasure, while the lack thereof decreases them. Another theory, which applies more to social context, is the theory that social conformity pressure affects aesthetic judgements. This theory posits that when in a group, people judge artwork in a way that conforms with the aesthetic judgements of those around them. Lastly, there is the idea that the state of full connection with and perception of an artwork is a solitary one, and that the presence of others impacts focus, connection, and the framing of the experience. These are all important to recognize in order to understand why context may affect a viewer's aesthetic emotions and experience in a specific way. For this paper, 'context' will be defined as physical context (environment), social environment or the presence of other people, description or contextual information (descriptive title, background or description of the artwork), and prior experience. Various articles in this space have examined how each of the different contexts mentioned here might impact the aesthetic experience of the viewer. This paper will examine the information and conclusions within them.

One significant form of context is the social context, i.e., the presence or opinions of others (or the lack thereof). Museum visitors who arrive in a group have distinctly different aesthetic experiences than those who come alone. Those who came as a group found the artwork less surprising, beautiful, and thought-provoking. They also felt less of a connection with the artwork, and their understanding of the art showed less improvement (Tröndle et al., 2012). This is likely because to be fully immersed in viewing art, it is important to be fully focused on the artwork. Full focus on observing the art happens more often when one is alone, rather than splitting attention between the others in their group and the art. Additionally, visitors who came in a group had differing experiences depending on how much they conversed with the other people with them. Those who talked more felt less of a connection with the artwork, and didn't feel like they were able to silently enjoy the artwork, but they felt that they were more entertained. In contrast, those who talked less found the artwork more beautiful and surprising. (Tröndle et al., 2012). Furthermore, the simulation of social conformity pressure and of other people watching affected people's judgements of an artwork's value. In one study, researchers showed artwork to the viewers alongside ratings supposedly given by others, but these ratings were actually significantly higher or lower than the original ratings people had provided.

Participants gave significantly lower ratings to the artwork's quality when it was presented alongside the lower ratings. However, they did not give higher ratings when it was presented alongside the higher ratings. The asymmetrical nature of the conformity pressure is hypothesized to be a result of a difference in the real ratings of the artwork's quality between participants in this study and the group which provided the 'real' ratings of the work. Participants' conformance in the lower ratings condition nonetheless suggests that the opinions of others affected the participants' opinions. In a subsequent study, researchers added eyespots to simulate a sense of being watched. This also led to lower ratings, possibly due to the fact that being watched or even the eyespots themselves led to a negative emotional state, and therefore a negative experience. While it is unclear whether the ratings given show actual change in the viewer's opinions, or simply outward compliance, it is clear that the simulation did affect how people said they experienced the art (Hesslinger et al., 2017).

Aside from the social context, the physical context is also relevant to one's aesthetic experience. The physical context, or environment, around an artwork has significant effects on one's aesthetic emotions and aesthetic experience as a whole. Most studies focus on the difference in experiences at museums and laboratories. For example, some studies have found that people viewing art in a museum tend to look at artwork for longer (Brieber et al., 2014), rate the artwork as more interesting and aesthetically pleasing (Brieber et al., 2015, Pelowski et al., 2017, Szubielska et al., 2021, Grüner et al., 2019), and feel their emotions are stronger or more significant (Szubielska & Imbir, 2021, Szubielska et al., 2021). The fact that in both scenarios, however, people had relatively the same level of understanding suggests that just the emotional response to art is stronger in the museum than in the laboratory (Brieber et al., 2014). In addition, another paper had participants first look at artwork in either a museum or laboratory setting, then return and view them in a laboratory. When viewers looked at the art again in a laboratory setting, those who had looked at the art in the museum the first time were more likely to remember the artworks. These viewers were using spatial cues from the museum's layout to aid in recalling the artwork (Brieber et al., 2015), clearly showing how physical context impacts one's entire aesthetic experience. From these papers, it is also clear that there are a lot of contextual factors that are not in a laboratory setting that are present in a museum. For example, many physical features, such as the texture, size, or authenticity of the painting, cannot be fully replicated in the lab. This loss of information impacts the art's reception and therefore the full

aesthetic experience. Other important factors that are changed in a laboratory study include the characteristics and motivations of those who visit a museum compared to those who participate in a study, impacting the engagement with the art. Further, many of the presentational aspects, such as the framing, the distance, or the general physical space, also cannot be replicated in a lab (Pelowski et al., 2017), all affecting the aesthetic experience and the emotions of those in the laboratory compared to the museum. In addition to laboratories, other locations, such as classrooms and streets, have been studied alongside museums. One study which compared aesthetic experiences in either a classroom or a museum indicated that those who viewed the art in the museum felt like their emotions were more from the heart, and natural (Szubielska et al., 2021). Other studies focused on the difference between a museum and a street have shown that the effect of physical context can still be influenced by style of art. For example, while modern art, in accordance with the examples listed above, was rated by viewers as more interesting and aesthetically pleasing when seen in a museum in comparison to on the street, graffiti art had generally the same ratings in both contexts. Both still had longer viewing times in the museum (Gartus et al., 2015).

Another form of context that must be considered is the contextual information (e.g. title, description, background) that the art is presented with. This also has effects on a viewer's aesthetic experience and emotions. One of the most researched examples of this is the effect that titles (or lack thereof) have on one's aesthetic experience. The addition of descriptive titles has been consistently shown to lead to increased reported levels of meaningfulness and understanding, but evidence supporting changes in aesthetic pleasure and liking have been mixed (Russell & Milne, 1997, Russell, 2003, Gerger & Leder, 2015, Millis, 2001). In some studies, the addition of a title had no effect on aesthetic pleasure (Russell & Milne, 1997, Szubielska et al., 2021). Another study, which used a within-participants design, did find evidence of increased levels of aesthetic pleasure with the addition of a title and description of the artwork. This difference in results may be due to the fact that a within-participants design is more sensitive to changing variables, as they are conducted within the same group of people (Russell, 2003). A study by Gerger & Leder, which utilized artworks without titles, with matching titles, and with non-matching titles, also had mixed results in terms of titles' effect on liking. While the addition of a matching title did not affect the liking ratings, the addition of a non-matching title decreased ratings, with the effect being the strongest with abstract art. These results appeared to support the

theory that some level of dis-fluency (to make the art seem complex or new) that encourages elaborative thinking, alongside understanding, leads to aesthetic pleasure. However, too much dis-fluency, or a lack of eventual cognitive mastery still negatively impacts the pleasure experienced (2015). A very similar study also gave similar, but slightly different results, in that for most paintings (non-abstract), the addition of matching titles did increase liking. This may more closely support the ‘understanding leads to liking’ theory, with indication that other factors, such as style, can also impact one’s appreciation for a painting (Belke et al., 2010). Another study by Millis, in which either descriptive or elaborative/metaphorical titles were presented, also appeared to support this theory, as only elaborative titles led to increased reported levels of aesthetic pleasure (Millis, 2001).

Further contextual information has also been shown to impact the viewer’s aesthetic emotions and experience. Some work suggests that it improves understanding and appreciation (e.g. Swami, 2013, Park et al., 2015, Belke et al., 2006). For example, the addition of information related to the history or context of paintings by Max Ernst and Pablo Picasso affected both appreciation and understanding. Contextual information increased both appreciation and understanding of Max Ernst’s work and Picasso’s abstract work. The fact that it only affected the experience of viewing abstract art and not his representational work could be due to the fact that representational art needs less additional information to reach understanding and subsequent appreciation than abstract art (Swami, 2013). Other studies done on artwork by other artists and other styles of art similarly indicated an increase in appreciation following the addition of style-related information (Belke et al., 2006, Szubielska et al., 2021). This is at least in novices, or those who are not experts in the art field (Belke et al., 2006); the experts in this study may have felt that the addition of the information was unnecessary and trivializing, as they already knew it, and it therefore did not improve their appreciation of the artwork. Other contextual information, such as commentaries given by both the artist and an art critic, have also been shown to impact a viewer’s aesthetic experience and emotions. Both of the commentaries given led viewers to increase their ratings of aesthetic pleasingness, but only the critic’s commentary led viewer’s to actually change the way they looked at the painting, in that they began to focus on the specific areas of the painting that were commented on. This indicates that while an artist’s commentary may lead to increased understanding of the theme of the painting, a critic’s commentary may lead one to scrutinize certain areas of the painting as one attempts to

follow a third party's perspective of the painting (Part et al., 2015). A similar study done with only artist statements showed that the addition of it led to an increase in reported interest and appreciation, but only for some artist statements, indicating that some contextual information may be more effective than others (Specht, 2010). In a Jucker et al. study, knowledge of the effort and intention put into a painting or photograph also increased appreciation and evaluations as a work of art (2014). Further, another study indicated that a guided tour, or an extended period in which contextual information was presented, also led to increased understanding, appreciation, and feelings of aesthetic pleasure or beauty in participants (Szubielska & Sztorc, 2019).

In addition to just adding more contextual information, the way in which the contextual information is presented could potentially impact one's aesthetic emotions and experiences. Szubielska and Imbir found that when the contextual information was read instead of listened to, participants felt their emotions were more important, that they had more control over them, and that they came from a more rational and reflective place (2021). Another study indicated that the time in which the information is presented is important as well. When participants viewed the artwork while listening to the contextual information, they liked it more. In contrast, they liked the artworkless when they viewed it after listening to the contextual information. This may be because of the difficulty of attempting to remember the information while looking at the artwork afterwards, leading to a worse experience. On the contrary, the act of receiving stimuli from multiple senses (visual and auditory), may have improved the participants' aesthetic experiences, leading to higher appreciation (Szubielska et al., 2018). Further, the order in which information is given may affect memory. When information was presented in a way that was consistent with the general theory of aesthetic experience (first classification or surface elements of the painting, then moving on to themes and further knowledge), at least in the museum context, participants in one study were able to remember the artwork and information better (Specker et al., 2017). This was not the case in the laboratory, which may be due to the fact that parts of the guide were irrelevant because of the loss of visual details.

Lastly, another factor that must be considered is the viewer's prior experience – either with the artwork or with art in general. Some studies have shown that paintings which were familiar to participants were liked more by them (Leder, 2001, Van Paasschen et al., 2015), but that this effect decreased when people looked at the paintings for longer, indicating that the effect that familiarity has on appreciation is more spontaneous, and as knowledge of the artwork

increases, it decreases (Leder, 2001). However, more extensively studied is the effect that experience with art in general (i.e. art novice or art expert) has on one's aesthetic emotions and experiences. A multitude of studies have shown that depending on one's prior experience in art, they perceive and react to art differently (e.g. Van Paasschen et al., 2015, Hekkert & van Wieringen, 1996, Silvia, 2013). For one, experts focus more on style or compositional elements of the painting (Silvia, 2013, Szubielska & Imbir, 2021), and do not increase their appreciation of art pieces with the addition of contextual information (Belke et al., 2006) which may be due to their more extensive knowledge in this area. Experts also deliver more emotionally detached value judgments of artwork, both in appreciating 'negative' artwork more than novices and in having overall more neutral ratings of pleasure (Leder et al., 2014). This may be due to more frequent exposure to art and their different way of processing art (possibly due to knowledge and expectations). Further, the aesthetic judgements of novices and experts also differ in terms of abstract vs. representational art, and in the application (or lack thereof) of color. Experts indicate no preferences in terms of aesthetic pleasingness or appreciation for abstract and representational art, while novices tend to prefer representational art (Van Paasschen et al., 2015, Hekkert & van Wieringen, 1996). In addition, in one study, when paintings were altered to be in black and white, experts had similar ratings of appreciation when altered or unaltered, while novices preferred the unaltered version. (Hekkert & van Wieringen, 1996). This again may be due to experts' greater focus on the style and composition of a painting, as well as their greater ability to find deeper meaning in the painting. Experts have also been shown to differ from novices in terms of specific emotions or feelings experienced (Van Paasschen et al., 2015, Silvia, 2013). In one study, experts rated paintings as more beautiful, and wanted them more, but rated them similarly to novices in terms of valence and aesthetic pleasure experienced. This may support the theory that experts differ from novices in the cognitive aspects of aesthetic experience (which include beauty and wanting art), as this is based more on knowledge, while affective aspects (such as valence) are similar as it's more based on the characteristics of the art (Van Paasschen et al., 2015). In another study, experts also experienced knowledge emotions (confusion, interest, surprise) differently to novices. Abstract artworks were generally rated as more interesting and less confusing by experts, and novelty was connected to interest ratings (Silvia, 2013). Experts' greater knowledge and prior exposure to artworks may lead to different methods of processing

art (again, with greater focus on style and composition) and perhaps greater appreciation for the unique compared to novices.

Conclusion

There are a few theories that may help explain why aesthetic experiences and emotions are affected by context. One of these is the theory that the understanding of an artwork is closely linked with the pleasure experienced. Essentially, eventual cognitive mastery over or understanding of an artwork increases aesthetic appreciation and pleasure, while the lack thereof decreases them. Other theories applying to social context include the idea of social conformity pressure affecting aesthetic judgements, or the idea that viewing artwork with others impacts focus, connection, and framing. These are all important to recognize in order to understand why context may affect a viewer's aesthetic emotions and experience in specific ways, and they can all be applied to understand the effects of context noted in the papers reviewed.

Overall, the various types of context discussed in this paper have a significant impact on the aesthetic emotions and overall experiences of viewers of artwork. First, the social context in which an artwork is viewed alters the total information being presented, the framing of the experience, and the viewer's focus on the artwork. This may lead to different levels of engagement with the artwork, and different classification of the work. Which in turn results in different aesthetic judgements and aesthetic emotion experienced, in that understanding is altered and viewers may feel the pressure to conform to others' judgements (social conformity pressure). For example, viewing artwork in a group (compared to alone) leads to a lesser connection to the artwork, lesser understanding, and dampened emotions, but can lead to a heightened sense of entertainment (Tröndle et al., 2012). Even the simulated presence of others can lead to altered or conforming emotions (Hesslinger et al., 2017). Besides just social context, the physical context in which an artwork is in can have a significant impact. In presenting an artwork in different contexts, and with different contextual information, the totality of the stimulus being experienced and the framing of it is altered. Understandably, this leads to differences in the classification and understanding of the work by the viewer. Given the close relationship observed between understanding and liking, these differences subsequently lead to changes in aesthetic judgment and emotions. For example, compared to other environments, museums intensify and improve people's aesthetic experiences (e.g. Szubielska & Imbir, 2021, Szubielska et al., 2021, Grüner et

al., 2019), and can improve recall (Brieber et al., 2015). Even beyond this, the contextual information provided can also impact aesthetic experience, such as through increased understanding and appreciation (e.g. Belke et al., 2006, Russell, 2003, Swami, 2013). Further, all of these effects may be influenced by a viewer's past experiences, either with the specific artworks or with art in general. Familiarity has been shown to increase appreciation (Leder, 2001, Van Paasschen et al., 2015), and art experts interact and react to art in significantly different ways to those who are untrained (e.g. Van Paasschen et al., 2015, Hekkert & van Wieringen, 1996, Silvia, 2013). Prior experience and education leads to an increased amount of knowledge, thereby affecting classification, the process of evaluation, and level of understanding. Given the theories explained above, this understanding therefore affects aesthetic appreciation and judgements. All of these factors and their impacts are deeply important to understanding a viewer's aesthetic emotions and experience, and how it may be affected.

All this information has been gathered within this work because of the benefits to both museums and researchers. Expanding on its greater relevance to museums, the attribution of more positive and significant aesthetic experiences to museums in general validates the presence of museums and may be used to encourage funding. In addition, many of the papers include information that may help museums find best practices for displaying their artworks. Findings on the general positive effects of contextual information (such as information related to style or history, or an artist statement) placed alongside artwork may encourage museums to do so for more work. Besides this, discoveries on how hearing the context, rather than reading it, positively impacts a viewer's aesthetic experience may encourage museums to give out more audio guides, or provide more frequent guided tours. Further, this summary provides a concise review of the work already done in this area, but more importantly, highlights areas which still need to be studied. For example, the effects of the presence of others (such as through emotion contagion between viewers) on a viewer's aesthetic emotions and experience has rarely been studied. In addition, there remains conflicting results on the effects of titles on a viewer's aesthetic appreciation, and there are few studies on the effects of different environments outside of museums and laboratories. Further, little research has been done on how the specific contextual information provided affects a viewer's aesthetic experience, although some evidence suggests that not all information or artist statements affect viewers the same. So, although this paper shows the breadth of work that has been collected about the effects of context on one's

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Gated Recurrent Unit Neural Network Trained with Cryptographic Hashes by Matthew D. Grupenhoff

Abstract

Hash functions are functions with variable-length inputs and fixed-length outputs that produce large differences from small changes in the input. This study aimed to test the feasibility of computing hashes through a neural network through processes similar to those used for language translation. To conduct this study, a model was created that processes characters as tokens in the encoder with a standard Gated Recurrent Unit (GRU) neural network, while it used a decoder that consisted of a fully connected layer, a logistic layer, and optionally a normalization layer, outputting a fixed size result with a probability for each bit. These probabilities were rounded at the end to obtain predictions for validation, while the probabilities themselves were used for gradient descent when training the model. This showed to not have any improvement in bitwise accuracy beyond 50%, and it was shown through the addition of a normalization layer that even when learning was a significant factor, training was not able to help any more than simply keeping the resulting probabilities for both training and validation as close to 50% as possible. Analysis of this phenomenon made it clear that the hash function used in this study cannot be learned by a standard GRU-based network due to various properties of hash functions such as the bitwise operators that cannot be written in terms of the activation functions used in GRU networks. However, using a different recurrent unit with a discontinuous activation function may solve this problem, and is a potential future direction to research.

Introduction

Hash functions are functions that map variable length input data to a fixed length output. The important property of hash functions is that they can be computed efficiently, but given an output, a corresponding input cannot be found efficiently. These functions have many uses, one of which is secure password storage. If a security breach occurs on a server that stores raw passwords, then people can easily use the passwords to find accounts on other websites, posing a huge threat to user privacy. As a result, most web servers instead pass the password to a hash function, and verify that an attempted password is correct when signing in by computing the hash a second time.

These hash functions have a number of properties that keep them secure when the security is critical, such as in the above example. One common property that causes this lack of

invertibility is the fact that a small change to the input results in a large change to the output, known as the avalanche effect (Castro et al.). Another common property of hash functions is that if two outputs are the same, it can almost be guaranteed that the inputs are also the same. When a user enters their password to sign in, the server puts the entered password through this same function and compares the output with the stored output, removing the need to store the raw password. These functions are known as hash functions, and the outputs to hash functions are known as hashes. Hash functions take a variable length input, but have a fixed size output.

The hash function used in this project is known as SHA-1 (Secure Hash Algorithm 1). SHA-1 uses a recurrent algorithm that has 5 32-bit numbers labeled A-E as the state, and one pass of the recurrent unit moves A-D to B-E, although B has a bitwise rotation applied before it is placed in C. E is added to a nonlinear function that is based on bitwise operations, as well as a rotated A, a constant that depends on the round, and the current word, which is either the value in the input data (rounds 0-15) or a bitwise operation on some of the previous words (rounds 16-79). If more than 16 integers exist in the input (64 characters), then the input must be divided into 16-integer blocks, but because passwords are typically below 64 characters, this is not an area of concern for this project. Once all characters have been processed, each 32-bit integer in the final result is obtained by adding together all of the corresponding state variable's values between blocks, including the values from the initialization vector (Technology).

While the main threat to cryptographic primitives such as hash functions is typically the increased efficiency of breaking the primitive through quantum computing, stored passwords have an additional vulnerability: the general patterns found in text created by humans. For example, human-created passwords often contain English words, which significantly reduces the security if the passwords can be predicted (*Top 200 Most Common Password List 2021*). One potential way to predict these English words would be through a neural network that takes the hashed password as an input and predicts the input password.

To do this, there must be an association between inputs and outputs of a hash function that can be learned by a neural network. The goal of this study is to train a neural network to approximate existing hash functions in the forward direction, since this could provide an initial measure of how hash functions perform with neural networks. Hash functions with these associations have previously been created by defining them in terms of a neural network, which

shows that this by itself is not a loss of security (Lian et al.). As a result, it remains plausible that hash functions can be computed by a neural network.

Machine Learning

To begin, concepts regarding machine learning must be defined. Machine learning is the process of computers predicting information based on patterns as opposed to hardcoded algorithms. The most powerful way to do so is through a neural network, which is a method of due to a theorem known as the universal approximation theorem that states that certain types of neural networks can be configured to approximate any function operating on finite-dimensional space within a given error bound (Brownlee).

The important feature of neural networks is that they can be trained with input-output pairs by adjusting parameters—usually the weights and biases of linear layers—in the direction that reduces error, as directed by a function to summarize error known as the loss function. This is done through gradient descent, the process of calculating the gradient of the loss function with respect to all parameters, which points in the direction that would increase error the most, and adjusting the parameters in the opposite direction by the amount obtained by multiplying the negative gradient vector with a value known as the learning rate. The gradients themselves are computed through successive use of the chain rule, given the derivatives of the functions involved.

In addition to these parameters that are tuned through gradient descent, a few values, known as hyperparameters, exist that control the network as a whole, such as the number of layers, the size of each layer, and the learning rate. Because adjusting these through gradient descent does not make sense, hyperparameters are instead tested through brute force.

One type of neural network that is commonly used for variable length input and/or output is a recurrent neural network (RNN). An RNN consists of an RNN cell that can be used a variable number of times by maintaining a hidden state that gets passed from one iteration to the next, all while receiving an input tensor and possibly producing an output tensor.

RNNs and hash functions have many similarities, which makes an RNN optimal to approximate a hash function. The obvious similarity is that an RNN can be configured to take a sequence of data as an input and output a fixed-size result, which is ideal for a hash function. However, the more subtle similarity is that hash functions also use recurrent units, and their

hidden state is the vector containing the A-E values together with the current round number. This will provide guidance for how the model should be set up.

The recurrent unit used in this study is the GRU, which selectively filters information in the hidden state to ensure important information within the hidden state is retained between iterations of the RNN cell (“Gated Recurrent Unit (GRU) With PyTorch”). The control over which contents are retained is achieved via gates, which are computations involving the logistic function. Afterward, further computation is performed with other functions such as the hyperbolic tangent function to obtain a new hidden state (Kostadinov). The GRU was chosen for this study because of its ability to retain long-term memory and its relative efficiency (Yang et al.).

Methods

To test this hypothesis, data was downloaded from the NordPass list of common passwords when using real passwords, or randomly generated when more passwords were needed (*Top 200 Most Common Password List 2021*). A total of 4314 real passwords were available after removing duplicates when limited by the JavaScript array size limit, with the addition of the word “PASSWORD” because it simplified the scraping algorithm. A total of 40000 passwords were also generated to provide more training data. 80% of this data was allocated for training, while 20% was allocated for validation.

This PyTorch model can be divided into an encoder and a decoder, which are composed of smaller components. The role of the encoder is to convert the sequence of characters in the input to a single value in the model, while the decoder converts this value to a hash output.

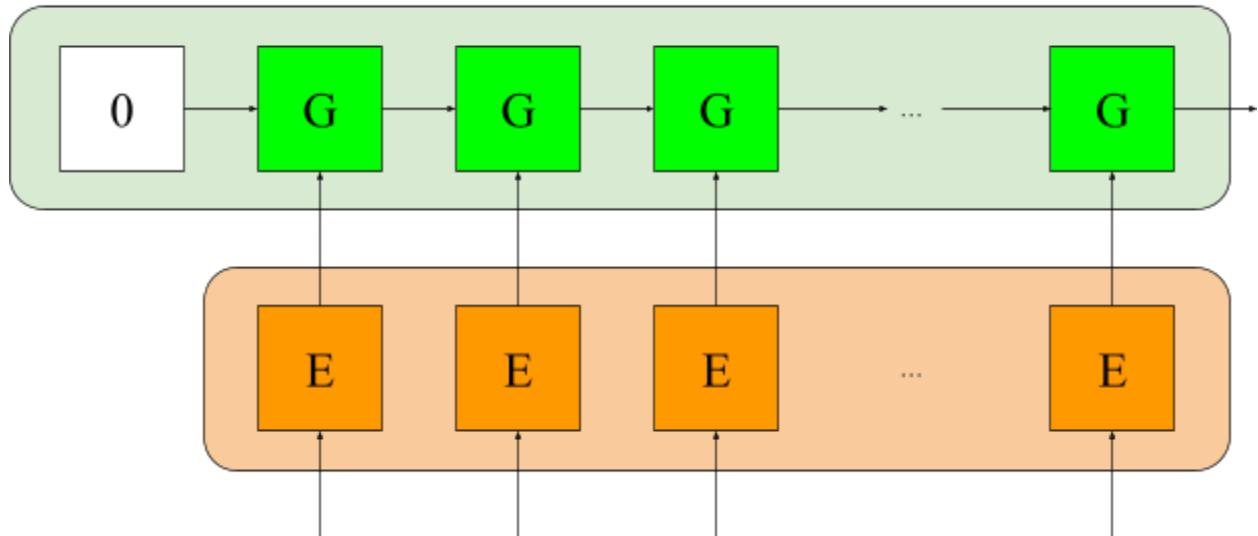
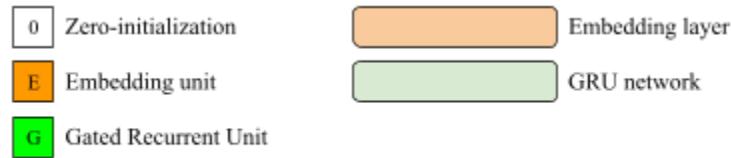


Figure 1. Structure of the encoder.

The encoder consists of an embedding layer with an embedding vector dimension of 49 due to this being half of the number of tokens allowed in the input. The embedding layer passes its output to a GRU network with the hidden state initialized with zeros.

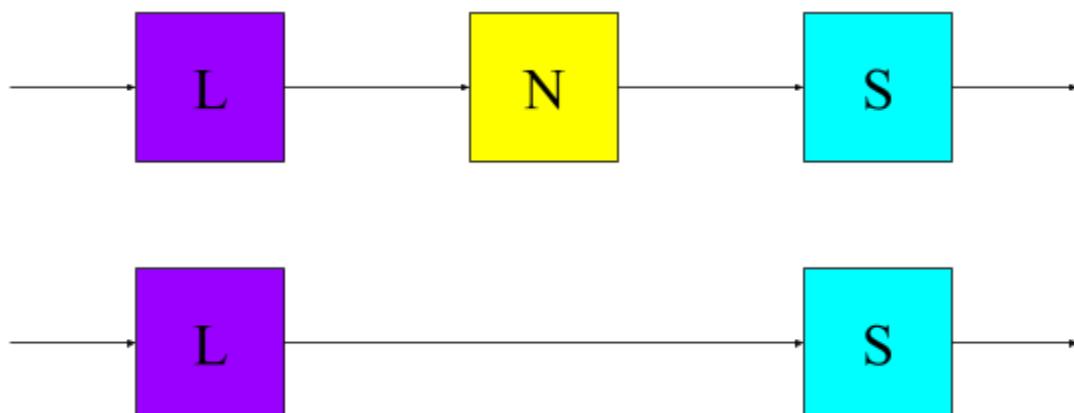


Figure 2. Structure of 2 versions of the decoder.

The encoder passes its output to the decoder, which consists of a linear layer, a batch normalization layer (in certain experiments), and a logistic sigmoid layer to convert outputs that can be any real number to probabilities between 0 and 1. All parameters in this model, in both the encoder and decoder, were randomly initialized with normally distributed values.

When training this model, unweighted binary cross entropy loss with mean reduction was used due to this being a series of binary classifications. After the training completed, this model was evaluated by measuring the accuracy in the validation set, defined by $A = \frac{n_{correct}}{n_{total}}$ (where $n_{correct}$ is the total number of correct bits across all hashes in the dataset and n_{total} is the total number of bits), between epochs. From there, hyperparameters (hidden state, learning rate, and batch size) were manually tuned by observing how the average accuracy changed when a given hyperparameter changes.

All experiments were run on Google Colab in a GPU environment without Colab Pro. The model was created using PyTorch, which was given seed 42 for its randomness. Other random values, such as the randomly generated passwords, were not generated with a predefined seed.

Results

The first tests were performed to obtain a baseline performance before tuning hyperparameters, and they used both models with and without a normalization layer. They ran 90 epochs as a baseline number to observe learning patterns, and they used a hidden size of 49 due to it being the same as the embedding vector's size. The learning rate and batch size were arbitrarily chosen to be 10^{-3} and 64 respectively. The accuracy from validation data was graphed after each epoch. The 50% accuracy horizontal line was also included as a reference.

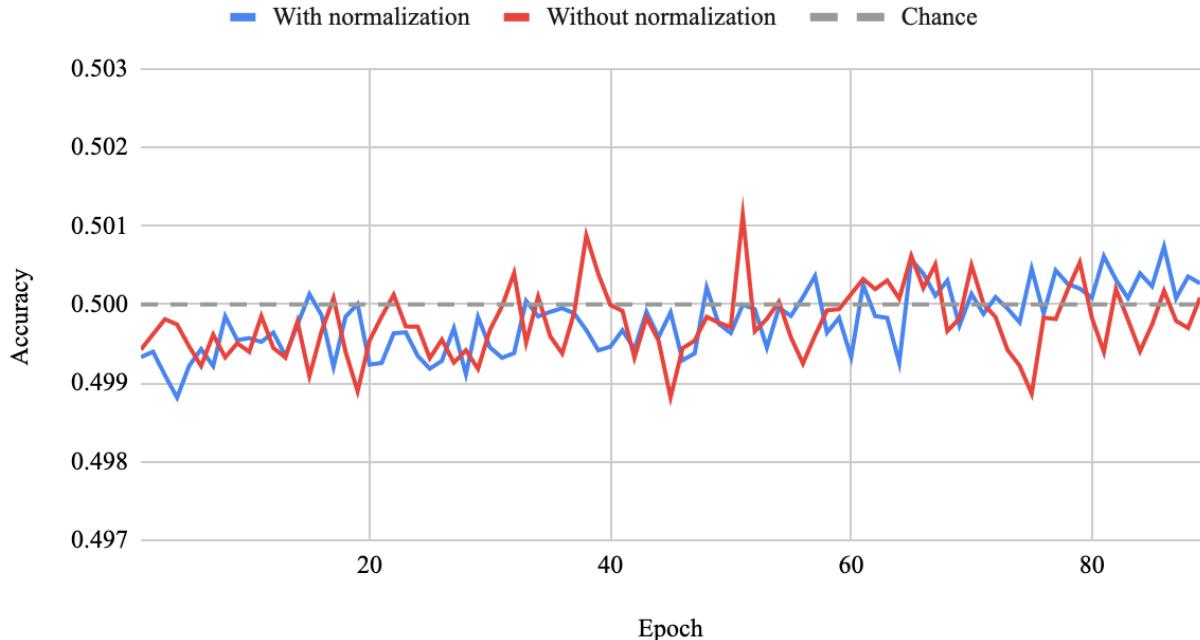


Figure 3. Accuracy across all training epochs.

As seen in Figure 3, there is barely any change in accuracy that deviates from chance. While the blue graph does have a slight upward trend, it is small across the whole graph relative to the random fluctuation present throughout. This general similarity makes sense, since the probabilities were all roughly 50%, which corresponds to logits being approximately 0, so while normalization can make the difference in probabilities more noticeable, it does not change the rounded probabilities. However, normalization also contributes to smaller gradients, which is why it was removed in future tests.

One useful conclusion from this information is that it is not necessary to run 90 epochs to confirm that there is no learning. Instead, for future tests, only 10-20 epochs were used, reducing the time needed.

The first test to use this rule was a test to ensure the network was learning by tracking the gradients under the current set of hyperparameters. The gradient of the loss with respect to each parameter was collected every 100 batches in an epoch (leading to 5 sets of gradients per epoch),

and each gradient tensor was reduced to a scalar by computing the L2 norm ($|G| = \sqrt{\sum_P G_p^2}$).

The gradients were averaged, and the data has been recorded in Table 1.

Epoch	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
1	20.553	58.031	11.745	104.583	94.551	57.893
2	29.391	43.755	41.476	16.122	23.458	30.840
3	89.726	7.172	70.103	34.144	15.020	43.233
4	25.031	44.413	40.797	14.190	32.753	31.437
5	7.490	27.705	12.623	5.168	13.668	9.737
6	3.562	4.212	2.876	2.419	10.825	3.268
7	3.013	1.183	4.246	0.562	3.247	2.450
8	3.747	4.324	0.726	1.795	2.108	2.540
9	0.412	0.507	2.292	1.007	0.368	0.573
10	0.296	0.401	0.441	0.348	3.131	0.372
11	0.772	0.104	0.423	0.325	0.433	0.411
12	0.892	0.334	0.140	0.162	0.330	0.372
13	0.717	0.204	0.366	0.317	1.154	0.552
14	0.316	1.339	0.323	0.767	2.836	0.686
15	0.179	0.605	1.598	0.324	0.496	0.401
16	1.909	0.426	0.587	0.302	0.309	0.406
17	1.483	0.183	4.762	0.885	0.297	0.712
18	0.187	0.174	0.900	2.163	0.677	0.484
19	0.274	1.546	0.261	0.304	0.211	0.262
20	1.432	0.112	0.281	0.530	0.222	0.286

Table 1. Average loss gradient sizes over 20 epochs. Outliers are shaded and are not included in the calculation of the average.

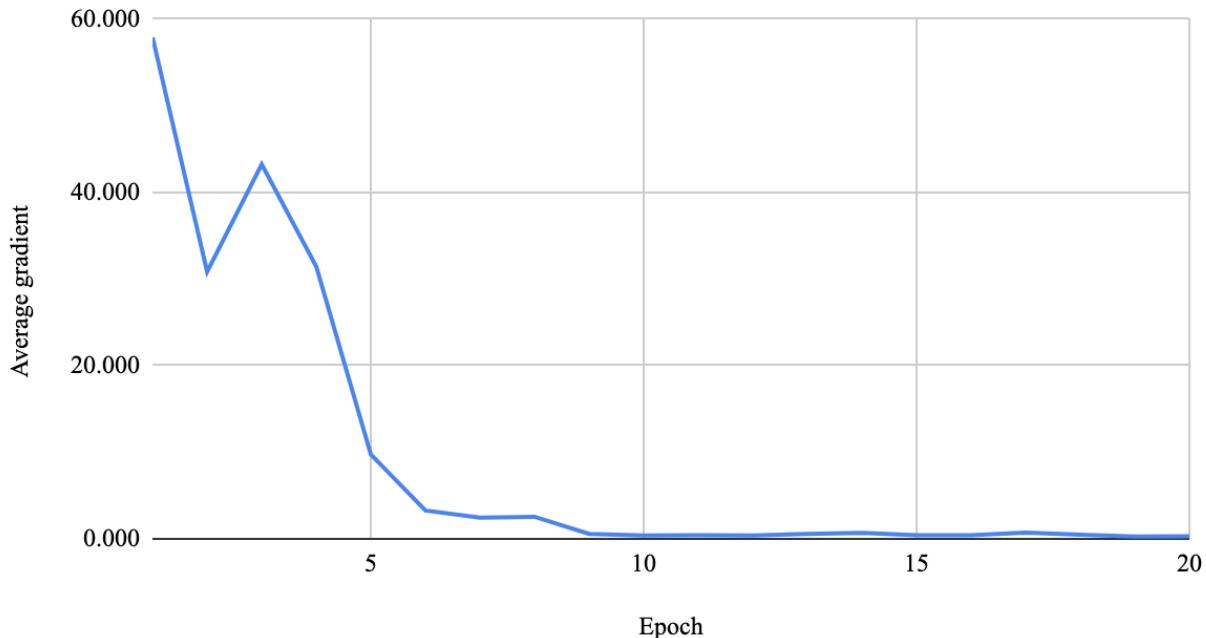


Figure 4. Decrease of average loss gradient toward horizontal asymptote.

Figure 4 shows that the average gradient approaches a horizontal asymptote of $y = 0$, indicating that learning is not happening. The higher gradient before this horizontal asymptote may explain the small increase in accuracy in Figure 3, which would mean increasing the learning rate should improve the accuracy. This will be revisited in the Discussion and Conclusion section.

To investigate the effect of changing the learning rate, select values of the learning rate, both higher and lower than the original learning rate, were set, and the accuracy is recorded in Table 2. For these tests, batch size was fixed at 64, and hidden size was fixed at 49.

Learning rate	Average accuracy
10^{-6}	0.499733
10^{-3}	0.500027
10^0	0.500056
10^3	0.499881
10^6	0.500005
10^{10}	0.499731
10^{15}	0.500201

Table 2. Average accuracy for select learning rates.

From this data, it is clear that there is no general increasing trend for accuracy when changing the learning rate. While there is some variation in these accuracies, the standard deviation from the mean of 0.499948 is a mere 0.000175, indicating that there is simply no improvement in accuracy from changing the learning rate.

Because of this inability to increase the accuracy, the logical next step was to look at the losses between epochs as a measure of overfitting, which is when the neural network can only produce accurate outputs on training data. For this, the hidden size was 49, the learning rate was 10^{-3} , and the batch size was 64. The model was also tested without normal initialization to identify a possible cause, and all data from this experiment was recorded in Table 3, with summary statistics in Table 4.

Epoch	Average training loss (Normal initialized)	Average validation loss (Normal initialized)	Average training loss (Zero initialized)	Average validation loss (Zero initialized)
1	2.284	1.950	0.693158	0.693169
2	1.700	1.465	0.693153	0.693176
3	1.275	1.106	0.693154	0.693169
4	0.981	0.876	0.693154	0.693165
5	0.809	0.759	0.693154	0.693168
6	0.732	0.714	0.693154	0.693169
7	0.705	0.699	0.693154	0.693169
8	0.696	0.695	0.693155	0.693172
9	0.694	0.694	0.693155	0.693168
10	0.694	0.694	0.693153	0.693172

Table 3. Average losses for training and validation.

	Average training loss (Normal initialized)	Average validation loss (Normal initialized)	Average training loss (Zero initialized)	Average validation loss (Zero initialized)
Mean	1.057	0.965	0.693	0.693
Standard deviation	0.543	0.427	1.32×10^{-6}	3.06×10^{-6}

Table 4. Mean and standard deviation of the data in Table 3.

The training and validation losses end at roughly the same value, despite varying at the beginning. This initial varying can be attributed to the fact that the average training loss is taken from network states earlier and later in the training phase, while the average validation loss is

taken in the final network state of the epoch, which theoretically has the best performance. As a result, there is no overfitting present in this training, so further investigation must be done with the lack of learning.

To do this, the average losses were graphed with respect to the epoch in Figure 5. A horizontal asymptote was also marked for further investigation.

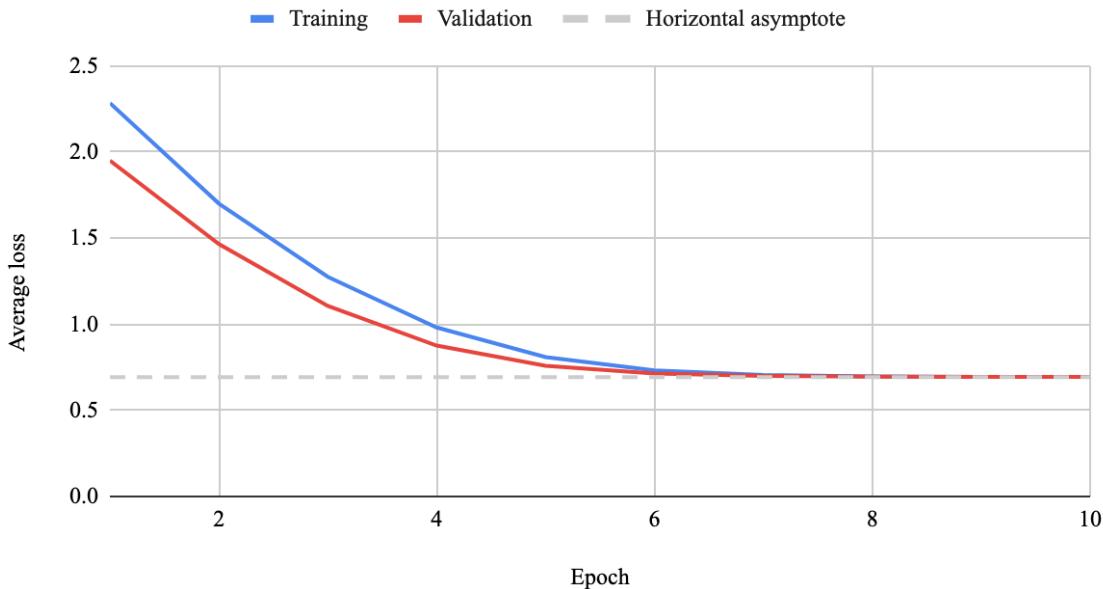


Figure 5. Decreasing training and validation losses bounded by a horizontal asymptote.

From here, it is obvious that the loss is decreasing, lining up with significant gradients observed when tracking gradients. However, the horizontal asymptote for both graphs is estimated as $y = 0.693$, which is also roughly the average loss when the network was zero initialized.

The significance of 0.693 should now be investigated. The first step is to apply the definition of the loss function used for training: unweighted binary cross entropy loss with mean reduction is defined as the mean of terms $l_n = -(y_n \ln(x_n) + (1 - y_n) \ln(1 - x_n))$ where x_n is the predicted probability and y_n is the ground truth (*BCELoss — PyTorch 1.12 Documentation*). The loss is essentially an average of logarithms of the predicted probabilities. However, $e^{-0.693}$ is approximately 0.5, suggesting that this is simply learning to output results that are approximately 0.5, since there is no direction in the parameter space where the loss can be lower. This can be

confirmed by the fact that each term is always either $-\ln(x_n)$ or $-\ln(1 - x_n)$, which both equal $-\ln(0.5)$, or approximately 0.693. Additionally, this is consistent with the zero-initialized network, which initially outputs 0.5 because the all-zero encoder outputs zeros, and the decoder applies a sigmoid, which maps the 0 to 0.5.

To confirm that the cause of the small gradients is the randomness of SHA-1, the average gradient was computed for different batch sizes and is shown in Table 5. To optimize data collection, this was done on the first batch with zero-initialized parameters, which is very similar to what happens as the gradient with normal-initialized parameters approaches the horizontal asymptote.

Batch size	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Standard deviation
1	0.00565	0.00565	0.00565	0.00565	0.00565	0.00565	0
2	0.00426	0.00399	0.00412	0.00407	0.00414	0.00412	9.82×10^{-5}
8	0.00215	0.00191	0.00206	0.00207	0.00206	0.00205	8.54×10^{-5}
64	0.00068	0.00070	0.00070	0.00069	0.00070	0.00069	8.71×10^{-6}

Table 5. Average loss function gradients for select batch sizes.

Table 5 shows that larger batch sizes lead to smaller gradients. This will be discussed in the Discussion and Conclusion section.

Discussion and Conclusion

In general, this GRU network has shown to not be able to learn the SHA-1 hash function, instead always displaying an accuracy of 50%. This consistent 50% accuracy can be explained by the fact that if the output had no correlation with the input (i.e. a random sequence of bits regardless of the input), then an initial network would have a 50% chance of outputting each bit correctly. While SHA-1 is not completely random, properties such as the avalanche effect may cause SHA-1 to effectively behave randomly, which is demonstrated in the network.

To compare these results with the gradients, an analogous case of a group of people fishing can be used. If there is a circular pond with a fish in the center, a different effect comes from a different number of people fishing. This can be visualized in Figure 6, where the arrows represent the directions that the fish is being pulled, and the square represents the fish.

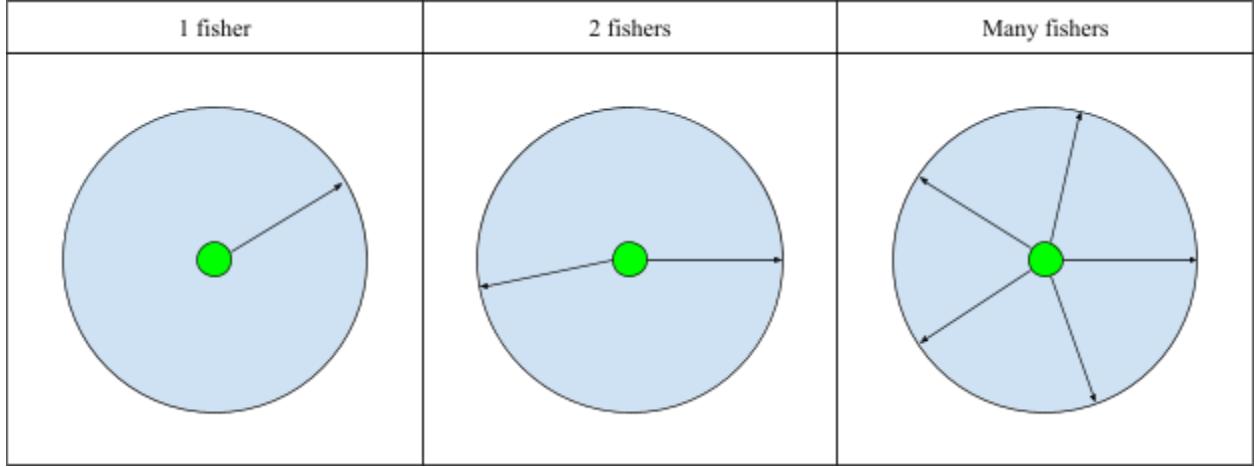


Figure 6. Effect of different amounts of fishers on a fish.

Figure 6 demonstrates that with 1 fisher, the fish can be pulled, while with 2 fishers, the 2 fishers often pull away from each other, causing almost no movement. As the number of fishers increases, this becomes less predictable, as any balance can be slightly disrupted by one fisher.

In this analogy, the pool represents the parameter space, while the fish represents the current parameter tensor, and the fishers represent hashes that can be learned. These fishers pull the parameters toward themselves through the gradient components they contribute, analogous to the pulling forces. The number of fishers represents the batch size, meaning higher batch sizes result in less predictable gradients. The important property of this is that since each gradient effectively has a random direction due to the random selection of data points, any random learning that causes the parameters to move toward one side of the circle will be negated in the next batch due to the gradients pointing away from the opposite side now being greater.

Now that it is clear that SHA-1 cannot be learned by a GRU network, the cause should be examined. While SHA-1 has several nonlinearities that can cause the network to not learn, the simplest is the bitwise rotations, which can be written as

$$\text{rot}_n(x) = 2^n x \% 2^{32} + \text{floor}(2^{n-32} x). \quad \text{The resulting graph is shown in Figure 7.}$$

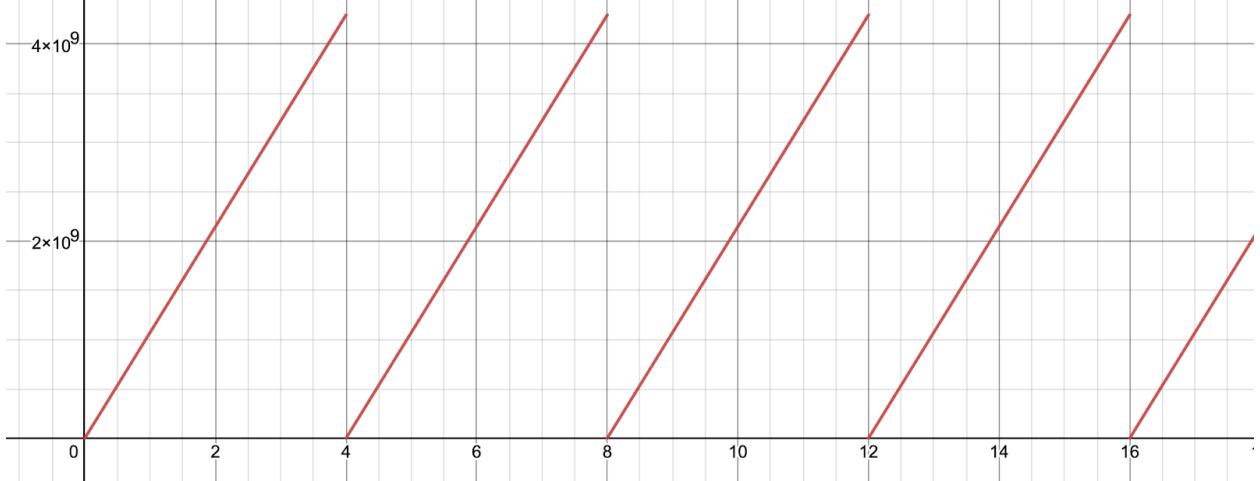


Figure 7. Graph of rot_{30} .

Figure 7 shows that there is a discontinuity every 4 units for $n = 30$, which cannot be constructed from a series of continuous functions present in a GRU network. While it is possible to change the graph's trajectory between $x = 3$ and $x = 4$ and all corresponding locations, this would result in a function that alternates between increasing and decreasing $2 \times \frac{2^{32}}{4} = 2^{31}$ times, something that cannot be constructed through a handful of strictly increasing positive activation functions due to them having no periodic behavior. This remains consistent with the universal approximation theorem, which states that there must be a sufficiently large number of activations for the approximation to be effective (Brownlee). As a result, it is clear that while a GRU network is incompatible with SHA-1 hashes, the hashes could be learned by including more activations to better simulate the discontinuities.

However, this is not the only possible way to learn the SHA-1 hash function. If the discontinuities are left intact, then a discontinuous activation function could be used. While gradient descent will not work because of the gradients being undefined at the discontinuous points, a different algorithm known as pseudo-gradient descent can be used for training (Goodman and Zeng; Plagianakos et al.). An RNN that learns hashes through a discontinuous activation function and pseudo-gradient descent should be researched next to further understand the relationship between hash functions and learnability in a neural network.

To summarize, the SHA-1 hash function cannot be learned by a GRU network. All apparent learning has solely been minimizing loss by training the network to consistently output

probabilities around 50%. This could potentially be solved with a larger RNN cell, or by using a discontinuous activation function, both of which can better emulate the nonlinear operations in SHA-1. Constructing an RNN that uses discontinuous activation functions is the next step to investigate the ability for a neural network to learn SHA-1.

Acknowledgements

I would like to thank Dr. Xiao for guiding me over the steep hill of machine learning. He was an outstanding mentor who made this paper possible. Additionally, I would like to thank Polygence for connecting me with Dr. Xiao and providing a great platform to support student research.

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Alexander the Great: Herald of Cultural Exchange by Ojas Gupta

The young ambitious king had a radical court practice that he wanted to introduce to the court. Alexander had the very clear idea of the adoption of foreign practices into his daily life. He has already portrayed himself as divine to the Egyptians and his divine Greek lineage also supports this claim. He believes that everyone should bow to him as opposed to a descendant of Cambyses or Xerxes. . However, an average mortal shall also not deserve them as the gods themselves would be extremely wrathful with the average individual if they try to take the reins of divinity. Alexander, on the other hand, deserves this as he is the king of kings, conqueror of conquerors and last-if not the most important-the King of Asia. Nonetheless, the Macedonians were still discontent with the idea of performing this act of Proskynesis towards Alexander. They believe that it is meant for a post-mortem divine being, like Heracles, but since Alexander was still alive, it wouldn't work as no oracles or godly signs declared him to be a god. The new "King" of Asia must now choose whether to alienate his royal guard and fellow Macedonians by performing a "barbarian" act or to stand with them and not adopt such "barbarian" customs.

The Macedonians then started to adopt this practice but also somewhat made fun of it. The soldiers would tease each other to "bend" lower to the ground in front of the soon-to-be furious king. This may soon be his undoing as like the Scythians with Cambyses and the Greeks with Xerxes, these "rulers" were soon brought down to the real world and placed on a pedestal no higher than his station. Alexander soon decided to allow some of his followers to practice Proskynesis as he ordered and for the others, he used a helping of various things like threatening them. In the end it managed to work as his followers soon decided for the most part to attempt to follow it even though they abhorred the practice. This did not endear himself to a couple of his subordinates such as his general Parmenio who also happened to be second in command of the Hellenic army. He hatched a dangerous plan to rid any influence of the old guard from his list of advisors by plotting to get rid of Parmenio and Alexander's other disrespectful officer Philotas. He got rid of the first by executing him and managed to get rid of Parmenio by also executing him. It was pretty clear that Alexander's mental stability was failing.

Alexander the Great was perhaps one of the most important historical figures in the Ancient World. The young man was the architect of many different events around the world. One of the main events was the Hellenic Age. He was wholly responsible for the wave of Hellenic

culture being spread throughout the world even centuries after his death. In question, Alexander facilitated cultural exchange through his encounters with other groups such as the Egyptians and Persians and these interactions are present in language, architecture and art. Alexander the Great facilitated cultural exchange through his encounters with other groups—such as the Egyptians or the Persians—and the consequences of these actions are apparent in language, architecture, and art to this day.

Background

As the emperor of the Macedonian empire, Alexander was an influential leader in the Hellenistic Age. For that reason, he is credited as the founder of the Hellenistic Age, as well. His main achievement which supports the previous statement is the fact that he was the Emperor of the Macedonian empire. He sought to conquer Persia after subduing the Greek city states with his father. After Phillip died, Alexander held on to the territory by continuing to subdue other Greek city states, including a very brutal sack of Thebes. He was exceptionally skillful in military encounters, outmaneuvering the Persians on many different occasions.

The terms that are important to remember are “cultural exchange”—which is to share ideas, traditions and knowledge with someone who has a completely different background from you. Another term is “satrap”—a provincial province which is part of a bigger empire. Another relevant term is “talent”—a term of measurement which has close regards to monetary systems. The Final important term would be “lingua franca”—the language of wider communication.

Alexander was a complex man and was motivated by a series of desires which compelled him to go on a conquest of Persia. One such desire was to outdo his father, as Phillip was the architect of the conquest of many of the Greek cities such as Athens and Thebes. One other thing that Alexander wanted to surpass was the fact that his father brought glory to the Macedonians. Aside from the conquest part of his goals, Alexander wanted to spread culture and exchange it like his father did. He saw his father send emissaries to the Greek cities and learned customs from them and became “civilized.” Alexander also was privy to the fact that Philip helped build the city of Macedon from the ground up, and turned it from a backwater area of Greece to the most powerful empire Greece has ever seen aside from the Persians. Like Alexander, Philip inherited a standing army and instituted some revolutionary army reforms. Philip instituted regular pay, better training and weapons, a promotion pathway, and a system of cash bonuses and

land grants in conquered territories. He invented a highly effective new weapon, the sarissa, a 14 to 18 foot pike with an iron spearhead, and he trained his infantry to fight in a new phalanx formation. Alexander also used this tactic while fighting the Persians during his own conquest. An important thing that Philip was good at was using both Diplomacy and War to get what he wanted. He often used them hand in hand while subjugating the Greek city-states. Alexander definitely used this as well. Philip also set Alexander up for success by arranging for him to receive education from the best intellectuals in the country, such as Aristotle.¹

Philip and Aristotle had a connection. The two individual's families had good relations. Aristotle's father was a member and physician of the court of Amyntas III who was Philip's father. This however soured thanks to Philip's decision to raze Stagira and sell most of its inhabitants to slavery; which coincidentally was Aristotle's hometown. This animosity was soon resolved when Philip hired Aristotle to teach his son and in return, the king would rebuild Stagira. Aristotle taught Alexander biology, ethics, literature, mathematics, medicine, philosophy, politics, rhetoric and zoology. There is some debate on whether this actually occurred as there was no evidence of benches and vineyards where this took place. However, there is quite a bit of evidence of a "military" academy and a gymnasium in the Mieza Sanctuary where Aristotle taught Alexander and 150 other students. Aristotle also instilled in Alexander an interest in the natural world. When the young prince became king, he brought naturalists with him as he marched into Asia. Those naturalists collected information and samples from fauna and flora sources and sent them back to Aristotle. Alexander also brought scientists, engineers and philosophers along with him for his invasion. Aristotle gave Alexander his copy of the Iliad and Alexander who was also inspired by the Homeric Epics took it with him.

However, Alexander disagreed with his teacher on one point. That all non-Greeks were barbarians and possible slaves but Alexander instead included them in his army and administration. The young king also advocated that his subjects living in both Afghanistan and Greece have citizenship. This directly clashed with Aristotle's belief that individuals of other nations deserve the treatment akin plants and animals.² Alexander also disagreed with Aristotle's point of view and this is with the fact that "Alexander was driven by the excitement of fighting , which he loved, and the Homeric idea that war brought glory," he says. "Once he had defeated

¹ Richard Grant, The King and the Conqueror, Smithsonian Magazine

² Ibid.

the Persian Empire, he needed a practical way of governing a vast territory with many different languages. His solution was to hire locals. Gradually this led to the blending of cultures.”³

Evidence of Cultural Blending Coinage

Alexander influenced many things and one of them was coinage. Some of the influence comes far after his death when the Greco-Bactrians are in power. One ruler was especially important, that being Eucratides who made the largest gold coin in the Hellenistic World.⁴ One very important title that Alexander the Great received was the father of the first single currency, this is rather important as it signifies the importance of what he has done. This image shows linking both the Phoenician and Greek culture together. This specific example is Heracles being portrayed on one side while the national emblem of Carthage (a horse’s head) is represented on the other. The coin is a Siculo-Punic variant, minted in a Carthaginian mint in Sicily.⁵ An example of this is seen below.



There are other examples of coins as seen with ones from the Seleucid Empire which depicts a rumored ancestor of Alexander’s dynasty which is Heracles. This matters since even though Alexander is open-minded towards other cultures, he is also calling back to Greek history and the renown of the Greek hero solidifies his legitimacy. There are two more noteworthy examples with them being made in imitation of existing Greek coins. These examples show how far the surrounding groups of people sought to emulate the Greeks. Many of Alexander’s successors (Diadochi) followed in Alexander’s footsteps and starting minting coins in his and Heracles’s image.⁶ His influence on coinage is no small portion. There were many other iterations of coins like these, the Parthians and Bactrians both followed suit, with Greek styles on their

³ Anthony Everitt, *The King and the Conqueror*, Smithsonian Magazine

⁴ Frank L. Holt, *Eucratides I*, Oxford Reference

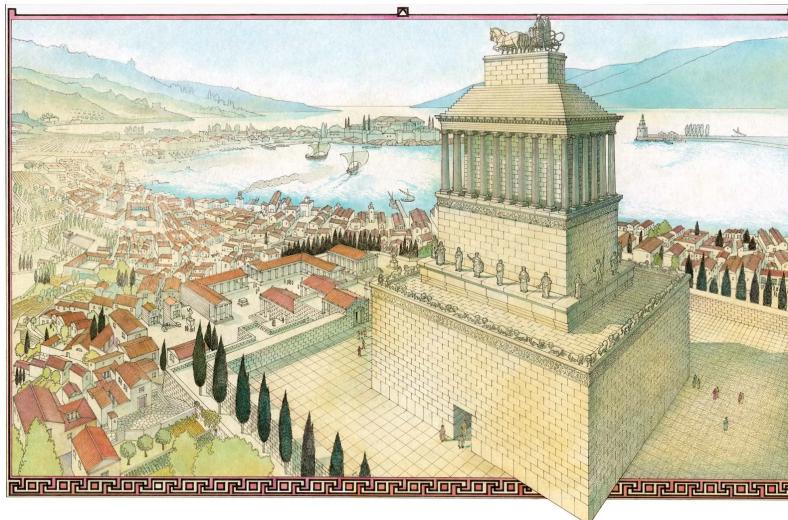
⁵ Money Museum, “Alexander the Great--Father of the First International Currency.” .

⁶ Ibid.

coins. The Indo-Greeks struck their coins in Greek and their own native languages. The impact in the west was less felt as the Romans soon replaced the Greeks in that regard. One of the main things which made the coins minted by the Macedonians unique was the standard they set. Alexander and Philip were fine if their names on coins and of Greek deities as well.⁷

Architecture

He was somewhat responsible for Antipater of Sidon to make a poem which was about 7 different sites of the Ancient world.⁸ These were the Seven Ancient wonders of the Ancient World. One rather big example was the Mausoleum of Halicarnassus, which incorporated Greek influences since a single Greek architect designed each of the sides with there being four architects: Scopas, Bryaxis, Leochares and possibly Timotheus.⁹ This statue connects to the idea of Alexander as a facilitator of Greek culture throughout Asia Minor.¹⁰



For the Pillars of Ashoka in particular, there has been some evidence of Hellenistic influence, in addition to this, the evidence is that bead and reel pattern, the ovolo, lotuses etc. are influenced by Greek arts.¹¹

⁷ Carol Humphrey and Vivian Sutherland, “From Alexander the Great to the end of the

⁸John Giotto, “Alexander the Great and Hellenistic Age,”

⁹Amy Tikkanen, “Mausoleum of Halicarnassus,” Encyclopedia Britannica

¹⁰ Ibid

¹¹P.N Chopra, B.N Puri, M.N Das, A.C Pradhan, A Comprehensive History of Ancient



Art

One thing which rulers who succeeded Alexander did was portray themselves as being divine beings. They did this by building monuments for tombs and statues after the ruler's death. This style was very apparent in the Hellenistic world.¹² The two main styles were the Ionian and Corinthian styles which were used in pillars. The pharaonic art from Egypt retained its original characteristics while gaining new one in the form of Hellenic characteristics. Alexander's staff already included individuals from Egypt and Persia. The specific art has a mostly Egyptian style with the Greek influences being the tresses beneath the headcloth and asp.¹³ His influence on art was profound in numerous ways. After the dissolution of his empire, the art craze with Hellenic Art exploded. The Romans, in particular, copied many of the original Greek murals and managed to preserve them.¹⁴

Language

He spread the Greek language all across the East and helped make it the *lingua franca* of the Eastern Mediterranean. His influence also stretched to when the Roman Empire was prominent as the Greek Language was also rather common in the provinces of Libya, Egypt,

¹²Ancient Greek, Britannica

¹³Liebieghaus, Alexander the Great as a Pharaoh

¹⁴ William O'Connor, "How Alexander the Great changed the Art World Forever."

Arabia, Judea, Syria, Persia, of course Greece and the Asia Minor. Moving on to the Persians, he found a community of Greeks in Bactria, what is now northern Afghanistan and massacred them, believing them to be traitors. After being forced to withdraw from invading India anymore thanks to his troops, he stationed 20,000 troops in Bactria and those troops went on to found a kingdom which was the Greco-Bactrian kingdom and this kingdom survived for more than two centuries.¹⁵

The Romans actually went on to adopt words from Koine Greek as their language Latin was missing some words and they needed to fill the semantic gaps. Greek shares commonalities with Latin despite being far older. This is because of how close the languages were with each other. Another important thing about Greek was the fact that it was spoken throughout the Mediterranean from Sicily to the Asia Minor. It was also rather important in the city of Alexandria in Egypt which was the multicultural capital of the Ptolemaic Dynasty of Egypt. Even through Roman rule, the Greek language persisted throughout the eastern Mediterranean. When the Romans were conquering the Mediterranean, they absorbed Greek ideas and values and created a fusion that would eventually become Greco-Roman. The educated Romans were bilingual in both Latin and Greek and this helped spur the adaptation of hundreds of Greek words into Latin. The main fields in Linguistics where Greek influenced Latin were: Literary and Visual Arts, pure science, medicine, mathematics and philosophy.¹⁶

Alexander's influence on Religion

The religion quickly spread because of the accessibility of a common language throughout the area. Because of Alexander's creation of the silk road, religion also spread throughout the Road especially Buddhism. One important thing to note was how the Greeks influenced the Buddhists to make Buddha into a statue. It flocked eastward from India to China thanks to traders who translated the texts into Chinese. However, the Persians slowed this spread westward as they reestablished themselves. There was also some religious syncretism with how one of Alexander's successors managed to combine two different deities, Osiris and the Apis Bull. Another one of cases of religious syncretism came when the Greeks did was the invasion of the Indian subcontinent which was huge and managed to make a form of cultural syncretism

¹⁵ Peter Trudgill, Where the Greek language lingered, The New European.

¹⁶ Peter Smith, Greek and Latin Roots Part II: Legacy of Greek, 97.

which appeared in the form of Greco-Buddhism. Menander the first was responsible for this development. He also believed himself to be a son of Zeus and had the Egyptians call him god. Phillip influenced Alexander as he constructed statues of the Twelve Olympians and sought himself to be isotheos--the equal of the gods. Alexander was rather influenced by this and also rose in power by becoming the son of Zeus, Justice incarnate, Avatar of Vishnu and finally invincible god. When Alexander cut the Gordian Knot, he attained the title of "King" of Asia. This title was rather misleading as the Greeks only knew of part of Asia but not the entirety of it. He sacrificed at the Apis Bull as he knew that it would be important to the Egyptians. The titles that he accepted from the Egyptians included "beloved of Amun" and "chosen by Ra". One was rather important which was the "Son of Helios", he used this to connect his lineage to the Sun and Zeus. The reasoning behind this choice includes inspiring loyalty in his troops and also keeping them united. During a campaign in India, the enemies' elephants and chariots were stuck in the mud after a particularly hard rainshower. Alexander used this to his benefit. His successors in the Hellenistic and Roman empires emulated what he did and deified themselves.¹⁷

Alexander's influence on Trade

The trade cities were already formed before Alexander's time but more were formed after his conquests. The new cities introduced Greek art to foreign cultures and also exposed Greek artists to new styles, techniques and precious stones.¹⁸ These stones included rubies, emeralds and amethysts. These stones were then included in the Greek's jewelry and were highly prized.¹⁹ He also directly influenced trade because of his conquest of the Persian Empire. This feat allowed him to gain access to the gold that the Persians hoarded. What he did with the gold was melt them down into coinage and this made certain individuals rather rich and trade was stimulated as a result. One of the cities that Alexander founded which was rather important was the city of Alexandria in Egypt. It connected the Mediterranean and the Middle East with India. The goods from Egypt included grains, cotton, perfumes, fruits and vegetables.²⁰ While on the eastern side of the empire, the Greeks imported metals, animals and spices.

Alexander's influence on Culture

¹⁷ Darci Clark, The Impact of Alexander the Great's conquests, Semiramis Speaks

¹⁸ Seán Hemingway, Ancient Greek Colonization and Trade and their Influence on Greek

¹⁹ Ibid.

²⁰ Bennet Sherry, The Macedonian Empire, Khan Academy

Alexander had many influences on culture. He adopted the practice of Proskynesis which is the act of kneeling in front of or kissing the king. However, this act was soon opposed by many of Alexander's soldiers as they viewed this act as being reserved for the divine and them doing this would make Alexander divine. They also opposed this act as since Alexander was not dead, there would be no honor which would be bestowed on a living man.²¹ There were some men who wanted to adopt the practice Alexander was asking them to perform but most were against.

Alexander spread Greek culture throughout the Persian Empire, including parts of Africa and Asia. He respected the traditions and cultures of the conquered peoples and subsequently integrated aspects of those cultures with his own.. He also started wearing Persian clothes and married a Sogdian princess as well.²² These choices that Alexander made led him to create the Hellenic Age where Greek culture exchanged ideas and goods with other cultures.²³ And this was all possible thanks to what Alexander did.

A counter argument to my thesis.

Alexander the Great may have conquered Persia as an act of revenge. This is shown in the letter that Alexander sent to Darius which states that "Your ancestors came into Macedonia and the rest of Greece and treated us ill, without any previous injury from us. I, having been appointed commander and chief of the Greeks, and wishing to take revenge on the Persians, crossed over into Asia, hostility being begun by you."²⁴ Another possible motive behind why Alexander conquered the Persians was that he needed money. Philip had already wanted to attack Persia before he died and he planned to do so by preparing an army. This army required a bit of money and soon Philip was in debt. After he died, Alexander had to pay off said debt and he decided that instead of disbanding his army, he would go and conquer another kingdom to pay off his debt.²⁵ Randolph Bourne, who was an early 20th century intellectual, once said that "War is the health of the state. Alexander therefore had many reasons for invading the Persians aside from spreading Greek culture. The king may have had an overwhelming urge to conquer and conquer until the entire known world was under his command."²⁶

²¹ Jonas Lendering, "Arrian on the Introduction of Proskynesis," Livius

²² John Giotto, "Alexander the Great and Hellenistic Age"

²³ Ibid.

²⁴ Cam Rea, "Why did Alexander the Great Really invade the Persian Empire, Ancient

²⁵

²⁶

Conclusion

One of the goals that Alexander always had was to spread Greek culture throughout the world. Scholars have chalked this up to a variety of motives; however, the evidence of his encounters with the Persians, Egyptians and other cultures support this interpretation of Alexander as a herald of cultural exchange. This is why he is responsible for the creation of the Hellenic Age and is responsible for the most influence on the successor states that formed after his death and the dissolution of the empire. He was deserving of not only the title “Son of God” but one of the “Fathers” of the Hellenic Age.²⁷ His legacy from his conquests lives on in so many different facets that it is a monumental task to try to gather them.

²⁷ This is referring to the fact that he in

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Increasing Consumer Acceptance of Cultivated Meat by Addressing Barriers Such As Cost and Taste by Yi-Mei Liu

Abstract

Industrial livestock production has created one of the largest health and environmental crises of the modern era by emitting large amounts of greenhouse gasses each year, and contributing heavily to antibiotic resistance. Cultivated meat provides a promising alternative to livestock production, and has the potential to be a sustainable meat source. Yet the industry is still in its infancy, and many obstacles have to be addressed before it can become a viable alternative to conventional meat. This paper will discuss the two major uncertainties regarding customer acceptance of cultivated meat, being its cost and taste. Here I review existing research to offer potential solutions to address these limitations, and identify areas where further research is needed.

Introduction

Cultivated meat, also known as cultured meat, is grown, or “cultivated”, from cells collected from a live animal. The concept of using cultivated meat as an alternative to unsustainable livestock raising has garnered a fair share of attention over the past decade, both from the scientific community and the media.

Responsible for 14.5% of global emissions, or more than 7 gigatonnes of CO₂ equivalent every year, the livestock industry has raised significant concerns regarding its contribution to climate change (Gerber et al. 14; Clark et al). In fact, a report by the Food and Agriculture Organization of the United Nations (FAO) determined it to be one of the top contributors to several of the most critical environmental issues, not just global warming, but also water pollution, land degradation, and loss of biodiversity. The same report also found that in order to prevent further damage, the environmental impact of the livestock industry has to be cut in half (Steinfeld et al. xx).

The livestock industry’s adverse effects are not just limited to the environment, either. The gasses produced from animal manure are not only potent greenhouse gasses, but also human health risks – it has been estimated that up to 30% of factory farm workers suffer from occupational respiratory diseases such as bronchitis and asthma. Industrialized, high speed meat

production is also a breeding ground for foodborne diseases, and the large amounts of antibiotics used to tackle these runs the risk of creating new, resistant strains of pathogens (Horri gan et al. 451; Espinosa et al. 1020).

It is clear that the industry has to change, yet demand for meat is also on the rise: global meat production has quadrupled in the last 50 years, from 70 million tonnes in 1961, to 340 million in 2018. Meat consumption is strongly correlated with GDP per capita, and as more countries develop, global meat production will most likely continue to rise (Ritchie and Roser). It has been estimated that meat production will reach 465 million tonnes by 2050 (Steinfeld et al. xx).

Furthermore, it is highly unlikely that the world will let go of meat anytime soon: with meat holding significance in many cultures, attachment to meat is still very prevalent, which has shown to be associated with higher consumption of meat and less acceptance of alternatives (Graça et al. 114). Several other factors could also influence a person's willingness to eat less meat, ranging from emotional resistance, price, and dietary habits (Stoll-Kleemann and Schmidt. 1272). Even as meat is gradually becoming associated with negative connotations, studies have shown that this critical attitude towards meat has not led to reduced consumption (Holm and Mohl).

Cultivated meat addresses this dilemma by allowing consumers to make more sustainable choices without having to sacrifice meat. Estimates for the greenhouse gas emissions from producing a kilogram of cultivated meat average around 3 to 7 kg of CO₂ equivalent, whilst a kilogram of conventional beef typically generates anywhere from 20 to 40+ kg (Lynch and Pierrehumbert 19). The most recent Intergovernmental Panel on Climate Change (IPCC) report acknowledges these “emerging food technologies”, including cultivated meat, as having the potential to significantly reduce emissions from food production (IPCC 5; ch. 12). It is important to note, however, that if cultivated meat was to have a carbon footprint significantly lower than that of conventional chicken or pork, the production process would have to run on renewable energy (Sinke 25-28).

With recent breakthroughs, such as Singapore being the first country to approve of its commercial sale in 2020 (Ives), and cultivated chicken more recently passing a blind taste test (Baker), a future where meat grown in laboratories line grocery aisles and fill restaurant plates no

longer seems far off from reality. However, while the industry has come a long way from the first, \$330,000, cultivated burger made in 2013 (“World’s First”), it is still very much in its infancy. As of 2021, the industry consists of a little more than 100 startups, and has received \$1.36 billion dollars in investment (Cohen et al. 9, 22). To make up just 1% of the global protein market, tens of billions of dollars will have to be spent to increase its commercial viability. Projections of where the market will reach in 2030 vary wildly, and depend heavily on consumer acceptance; if cultivated meat is able to replace a wide variety of meats, and can be sold in countries with larger meat markets, the market size has the potential to reach 25 billion USD (Brennan et al.).

This paper will provide a brief overview of cultivated meat’s production process and the current state of art, which will provide context for a discussion on the following question: How can barriers for cultivated meat on the consumer market such as cost and taste be addressed to increase consumer acceptance?

Section 1 - Cultivated Meat

Cultivated meat separates itself from other forms of alternative proteins by being “real” meat produced in a different way, rather than just being an imitation: on the cellular level, cultivated meat is genuine animal tissue. This also means that if produced properly, cultivated meat has the potential to fully replicate the sensorial and nutritional aspects of conventional meat. To achieve this, stem cells are harvested from an animal, placed in a bioreactor, and finally constructed depending on the type of meat it seeks to mimic (Kadim et al. 223).

Acquiring the Cells:

As different cell types have different qualities, effectively culturing cells starts with identifying and isolating a specific cell type. On average, around 90% of meat is composed of muscle fibers, or myocytes, which a variety of different stem cells have the ability to differentiate into (Listrat et al. 2). When deciding on which cell line to use, two variables come into play: its proliferative and differentiation capacity. An ideal cell line would be both immortal and easy to control, meaning that an indefinite amount of meat can be produced from a single harvest, without much risk of it differentiating into something undesirable. However, existing cell lines come with trade offs. Myosatellite cells, being a unipotent stem cell which can only differentiate

into myoblasts, which in turn forms muscle fibers, are currently the most promising cell type (Kadim et al. 223), and are already being used by a few companies, such as Aleph Farms and Mosa Meat. However, they are limited to about 20 divisions, whereas the industrial scale production of cultivated meat is estimated to require at least 30-50. Another cell type that has gained a fair share of attention is the induced pluripotent stem cell (iPSC), which can theoretically proliferate indefinitely. They are differentiated cells altered to be pluripotent – stem cells with the ability to differentiate into most other cell types – by forcing the expression of certain transcription factors, making them more accessible and easier to isolate than other pluripotent stem cells. However, it is difficult to keep their proliferative capacity high without triggering unwanted differentiation (Chen et al. 8). The other 10% of meat is a combination of fat and connective tissues, as well as a small fraction of blood, both of which contribute to the taste and texture of the product (Listrat et al. 2). Thus, cell lines which can undergo adipogenesis or angiogenesis are also being explored, with similar criteria as the muscle cells. These other components can either be co-cultured alongside the muscle cells, or manually introduced later.

Cell Culturing:

For them to grow into usable muscle fibre, cells go through proliferation stages, during which they may be moved into larger and larger bioreactors, before being placed on scaffolding to mature and differentiate, by which further growth is limited. The entire process can take up to an estimated 40 days, though companies have cited times closer to 2-3 weeks (Specht 16-17). The cells are grown either in aggregates (free floating clumps), or on microcarriers (spheres that cells can adhere to), which are more expensive, but easier to control (Chen et al. 8). In order to mimic *in vivo* conditions, the cells are suspended in cell culture media, a mixture of essential nutrients and added factors which help promote and maintain stable growth (Kadim et al. 226). There are currently many different formulas commercially available, and can be optimized for different cell lines, though all share basic components (Specht 6-7; Arora). The bioreactors themselves have to maintain a controlled environment and cycle out waste products as would a live organism (Chen et al. 11).

The scaffolding mentioned above refers to a food grade, biodegradable structure which the cells can attach themselves to. The purpose of a scaffold is to help the cells mature and differentiate in a specified manner, giving them a structure similar to real tissue, and allowing for

the perfusion of cell culture media in lieu of a proper vascular system (Pajčin et al.). Conventional scaffolding, or the top-down approach, involves seeding, or directly inserting cells onto a premade scaffold, but limits sizes to a few hundred micrometers, as it is not as effective at recreating tissue structure (Chen et al. 6). Other approaches such as the bottom-up approach seek to tackle this issue by creating smaller building blocks which can later be assembled into more complex tissues (Nichol and Khademhosseini 1-2).

Section 2 - Current State

As mentioned above, the industry currently comprises over a little over 100 startups (116 recorded). Most are still in early stages of development, with plants slated to begin production in a few years. Individual startups either focus on a topic of uncertainty, or focus on a particular meat, with beef being by far the most common, though a handful are looking into cultivating seafood (both fish and shellfish), pork, chicken, or other more unconventional meats. The bias towards beef in the wider scientific community is also quite apparent, with most research being conducted on beef and bovine cell lines (“Alternative”).

The majority of cultivated meat being produced right now is in the form of ground meat – burgers, deep fried patties etc – as it avoids the challenge of assembling the tissue fragments in a proper structure (Fraeye et al. 2). However, companies are seeking to introduce a wider variety of products into the market. Eat Just, the company approved for commercial sale in Singapore, has since been approved for the sale of chicken breast on top of their initial nuggets (Buxton). In December 2021, MeaTech3D unveiled a 110 gram steak, the largest so far, made with 3D bioprinting technology, though it is still a way off from the typical 200+ gram conventional steak (Carrington, *Lab-Grown Steak*).

The ability to create better, and more faithful cuts of meat heavily rely on more research on several factors. First, determining and deriving optimal cell lines, especially as cell lines of livestock species are not as well researched as others, takes anywhere from months to years. As with iPSCs, genetic engineering can help achieve desirable qualities. In addition, livestock cell lines are not stored (Ramani et al. 686), leading to a lack of cell lines suited for the purpose of cultivated meat readily available to researchers and developers (Soice and Johnston 2), which can greatly hinder progress. Increasing accessibility, possibly through the formation of a livestock cell bank, then, is a priority. Afterwards, cell culture media formulas, scaffold and

bioreactor design can be optimized as well, as they vary from cell line to cell line (Chen et al. 5-7). The creation of a vascular system is another, ongoing challenge, as previously mentioned, relying on diffusion alone to deliver nutrients severely limits how large a piece of meat can be.

In the meantime, however, the cultivation of meat itself seems to be scaling up at a rapid pace, with Future Meat Technologies opening the self proclaimed “first industrial cellular meat facility” in 2021, with the ability to produce 500 kg of meat per day in the form of chicken, pork, and lamb (de Sousa). A second, even larger plant is currently being planned by Eat Just, which reportedly will have 10 bioreactors, each with a capacity of 250,000 L, an entire order of magnitude larger than current ones in use (Carrington, *Largest Vats*). Whether they will succeed in designing bioreactors suitable for cultivating animal muscle cells on such a scale, though, is still uncertain, as there is severely limited data (Chen et al. 8).

Current consumer attitudes towards cultivated meat also leave something to be desired: a large majority of those surveyed tend to have limited to no knowledge on cultivated meat (Zhang et al.; Verbeke et al, *Challenges and Prospects*), and initial reactions upon learning about its premise often invoked feelings of disgust and perceived unnaturalness (Verbeke et al, *Would You Eat*). While perceptions improved significantly when those surveyed were exposed to more in depth explanations of the technology involved, and most were at least willing to try cultivated meat (Zhang et al.; Szejda et al.), further concerns were brought up regarding food safety, price, and taste (Verbeke et al, *Challenges and Prospects*; Szejda et al.; Bryant and Barnett 18).

Section 3.1 - Cost

In the United States, the average wholesale price of beef in 2021 was 9.3 USD per kilogram, which would be comparable to its production cost. Other meat products, such as pork and chicken, come in at \$4.4 and \$1.76 respectively (US Department of Agriculture). Studies examining the production costs of conventional meat have used \$2 per kg as a baseline (Risner) (Vergeer 27). Comparatively, estimates of the current production costs of cultivated meat average at around \$1,700, but range from \$150 all the way up to \$22,500, depending on how efficiently ingredients are used (Vergeer 17; Specht 22). However, even in the most optimistic scenario, these costs are orders of magnitude higher than their conventional counterparts. Surveys have found that not all consumers are willing to pay this premium, which poses a major roadblock to widespread adoption of cultivated meat (Bryant and Barnett 18). Thus, lowering production

costs, and subsequently, retail prices, of cultivated meat is essential for increasing consumer acceptance.

While the cost of cultivated meat most likely will not reach levels comparable to conventional meat in the near future, more optimistic estimates show that it is possible with the technology currently available. This following section will overview potential methods to reach these lower costs.

The vast majority, anywhere from 55% to 95%, of the production cost arises from the raw materials used to create cell culture media (Specht 6), which explains the high variability in cost purely based on how efficiently it is used. However, as previously established, costs still remain a hundred times higher than the target even with low-medium use, thus, either the price of these ingredients themselves must lower, or cheaper alternatives must be found.

An examination of the widely used medium Essential 8 found that growth factors, molecules which trigger the growth of cells, are estimated to account for more than 99% of this high price. Ignoring bulk pricing, the medium costs around \$400 per liter, or \$8 million per 20,000 L, roughly the amount a large bioreactor will contain. Two growth factors in particular, FGF2 and TGF- β , cost up to 2 million and 80 million per gram respectively. While they exist in very low concentrations, it still translates to a total of \$7,246,000 per 20,000L. The proteins insulin and transferrin contribute another \$220,000 (Specht 8). Albumin is another protein that can be a primary cost driver in other formulas (Vergeer 17).

There are two immediate options to decrease the price of growth factors. First, is to simply decrease the amount required in formulas. Through a combination of various existing methods, it is feasible to cut this amount down by 90%, effectively dropping the price by tenfold. These methods can be as simple as gradually allowing cells to adapt to low growth factor conditions, though more complex ones involve engineering the cells and proteins themselves. Second is to lower production costs of FGF 2 and TGF- β , both of which are structurally similar, if not less complex than insulin and transferrin, with the main difference being the latter two are produced at a much larger scale. If the production cost of all four are lowered to that of enzymes used in larger industries alongside lowering growth factor concentration, the price per liter can be reduced by another 10 fold (Specht 11-12). Once again, these enzymes are more complex than the growth factors, the only difference being they are in much higher demand.

The main component of cell culture media is the basal medium, a mixture of various salts, vitamins, and other nutrients to enable cell growth, and is what becomes the major cost driver once prices for growth factors are down. It is important to note that while hundreds of cell culture media formulas are already commercially available, they are bought in quantities of milliliters, and use refined ingredients more suited for pharmaceutical purposes, rather than food production. This means that prices listed so far do not account for bulk pricing. Basal medium uses large amounts of common ingredients such as table salt or baking soda, which could be bought for significantly cheaper prices than what is currently being used in these mediums. Similarly, the other expensive ingredients could be replaced by food-grade counterparts. This lowers the price per liter to a few cents. Based on average cell density and cell volume, assuming that the process is efficient enough to only need 20,000 L of medium, would be able to produce approximately 3,500 kg of meat per batch. This equates to around a little more than a dollar per kg, comparable to that of conventional meat (Specht 13-14, 22).

Studies also note the potential cost reductions in more efficient perfusion reactors (Vergeer 4). Improved reactors not only can significantly increase cell density and cell performance, which in turn increases the yield, but also affect how much medium is required per batch (Chen et al. 8). Proper waste management and medium recycling systems are necessary to keep medium usage to the assumed 20,000 L, as cell culture media is typically changed every 2 days during bench-scale applications to remove metabolic waste products and replenish nutrients (Specht 20). How much of the media can be recycled, and whether keeping usage to under 20,000 L per batch is feasible, requires further research and analysis on the topic.

The price of cell culture media, and in turn, cultivated meat can potentially be greatly reduced, as the primary barrier for cost is that the process has not been industrialized. It stands to reason that these cost reductions would come naturally as the cultivated meat industry continues to gain traction. Even if all these cost reductions were not met, cultivated meat could find a niche with more expensive meats, such as bluefin tuna.

Section 3.2 - Taste

Across multiple surveys, consumers tended to expect that cultivated meat would be less palatable than conventional meat, an expectation which was found to be true in some cases (Bryant and Barnett 19). While on one hand, this expectation can be used to positively surprise

consumers, if cultivated meat were to differentiate itself from other alternative meats as, practically speaking, equivalent to conventional meat, there are improvements to be made in regards to its taste and texture.

The signature “meat flavor” is created during the cooking process, as heat triggers an array of interactions which turn non-volatile compounds into hundreds of different volatiles. However, many of these non-volatile compounds are formed during post-mortem metabolism, as pH levels drop due to lack of oxygen, and muscles contract (Kosowska et al. 2). After slaughter, meat is typically aged to take advantage of this process, tenderizing the meat and allowing these flavor precursors to form. It is not clear how this process translates to cultivated meat (Fraeye et al. 2).

What is known, however, is that intramuscular fat (IMF) plays a large role in palatability, which is something cultivated meat lacks. One study found a positive correlation between the percentage of IMF, and palatability scores for beef, plateauing at an ideal 15% (Thompson). This is because phospholipids are responsible for the formation of many volatiles. While heating lean meat just gives a general "meat flavor", heating of meat containing fat is what gives different meats their distinctive taste (Kosowska et al. 2).

Texture also plays a large role in determining palatability, possibly even more so than taste. There are three things which give full cuts of meat their texture: the composition of muscle fibers, connective tissue, and fat (Fraeye et al. 2). There are four distinct types of muscle fibers in skeletal muscle, the proportions of which have an effect on the overall texture. However, once again, these proportions are thought to be dependent upon the post-mortem metabolic processes. (Arshad et al. 7; Listrat et al. 6).

Connective tissue and fat, on the other hand, can be added. This can be done through co-culturing, or introduced later on when constructing the final product. Co-culturing involves cultivating different cell types in one batch. While effective, there are significant challenges, such as deriving a media formula which can work for both cell types, and controlling the proportions. Cells also interact with each other, sometimes in unexpected or detrimental ways: for example, one study found that adipocytes may suppress the differentiation of myocytes (Seo et al.).

An alternative would be the use of 3D bioprinting technology, which had seen some success in creating the first steaks. It functions the same way as typical 3D printing, except it

uses bioink, a mixture of cells and some other biological substance similar to that of scaffolding, instead of plastic to construct tissue layer by layer (Kang et al. 2). This way, cultivated meat can be precisely constructed with specific cell types to mirror the structure of a cut of meat from a live animal.

Conclusion

Despite making significant progress since its first venture in 2013, cultivated meat still has several obstacles to overcome before it is able to establish a significant presence in the market. One of these obstacles is consumer acceptance, as the mixed, and mostly hesitant attitude toward cultivated meat prevents it from reaching any sort of consumer base outside of a small, elite niche. The two major deciding factors of consumer acceptance are price and taste. As cultivated meat is most similar to conventional meat among the different forms of alternative protein, to increase consumer acceptance, cultivated meat should emulate, or even surpass, conventional meat in both these fields, allowing consumers to more readily pick a potentially healthier, and more sustainable option. The high production costs of cultivated meat is mostly attributed to the unsuitability of current cell culture media, and to a lesser extent, bioreactors, for industrial scale production. Meanwhile, cultivated meat's palatability relies on the ability to replicate the structure and proportion of muscle, fat, and connective tissue in conventional meat, as well as a deeper understanding of how post-mortem processes, which shape much of the sensorial aspects of conventional meat, apply to cultivated meat.

In both cases, current technology should be enough to address these shortcomings – we have the capability to produce proteins, such as those which are currently the largest cost drivers in cell culture media, for 10 cents per gram. 3D bioprinting technology has already produced whole cuts of steak. What needs to happen next is refinement, and research. Ideas on how to lower media costs are ineffective if they remain as untested ideas. However, if cultivated meat manages to overcome these barriers, and reduce the consumption of conventional meat, it can aid in alleviating a major health and environmental crisis.

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How Has COVID Affected the Chinese Economy? by Rachelle Wendy Qin

Introduction

Throughout the last few decades, China's economy has been booming since its reforms in the 1970s. Its leader, Deng Xiaoping, transformed China into a capitalist country. China went from being relatively poor to the second-largest economy in the world in a matter of a few decades. As a capitalist country, China's markets were opened to foreigners, and the economy has grown rapidly, largely due to China's ability to massively increase its exports to other countries and attract investment inflows. Trading and technology have allowed China to become a modern superpower. However, due to COVID, the world's growth, especially China's economic growth, has been slowing down. Its economy suffered badly due to tensions with the U.S. and other countries, their lockdown policy, and the crashing real estate market. However, as China eases its lockdown policies, its affected industries will start to recover.

COVID Policy of China

The Chinese zero-COVID policy was implemented to prevent the spread of COVID. This meant major cities such as Shanghai and Chengdu were on lockdown for months. No one was allowed to leave their homes, and mass testing was required daily. Almost 300 million people were affected by this system. While it was brutal for the people, China had one of the lowest death rates in the world at 5000, while 1 million Americans died from COVID.²⁸ However, the economic consequences of this were astronomical. Unemployment is a major issue, especially for young people and graduates. Youth unemployment went up to 19.3% in June 2022. China's private sectors usually provide the most jobs but are now firing people.

China's Economy Before and After the COVID

The following graph shows the recent history of China's GDP (measured in trillions of U.S. dollars per year). GDP stands for "Gross Domestic Product" and measures the total value of all goods and services produced within the economy during a given year. GDP is an important measure because standards of living rise when GDP increases.

²⁸ <https://asiatimes.com/2022/06/covid-death-toll-vs-chinas-puts-us-to-shame/>

China's economy continued to grow steadily during the COVID pandemic when GDP rose from about \$14.7 trillion to about \$17.7 trillion despite the economic hardships caused by the crisis. The growth rate of the Chinese economy would likely have been even stronger without the COVID. The continued strength of the economy is likely due to many factors, such as China's ability to earn trade surpluses with many countries throughout the world, which has helped minimize the impact of the COVID. China also has a relatively low inflation rate and a stable currency, which have helped maintain the economy's strength.

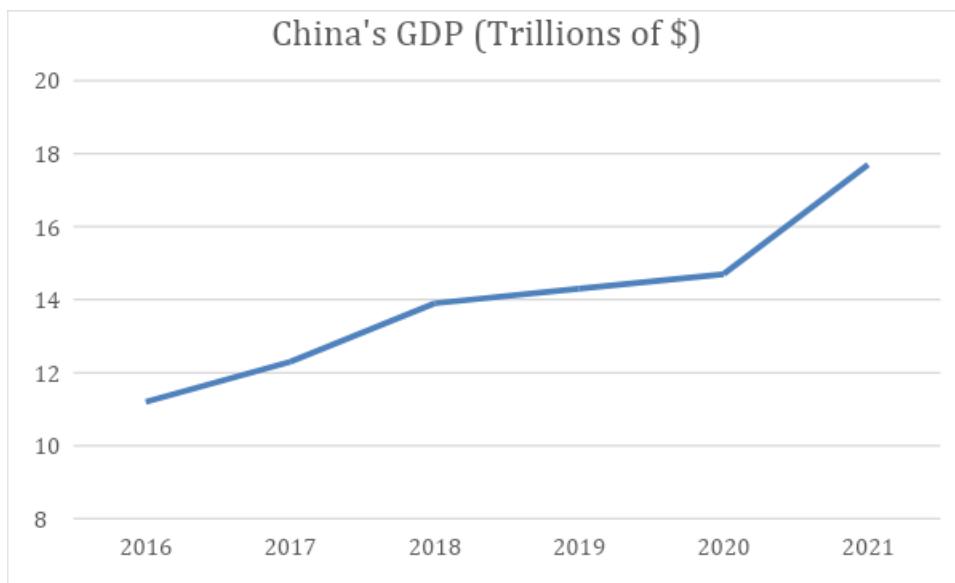


Figure 1: China's GDP

Chinese Labor Markets

The following graph shows that overall Chinese unemployment rose from 4.9% to a peak of 6.1% in April 2022, largely due to the ongoing lockdowns; since then, unemployment has fallen steadily to 5.4% as of July 2022.

Although the overall unemployment rate remains very low, youth unemployment has increased during the recent years, reach a peak of 19.3% in June 2022, an increase of 3.9% since June 2021.²⁹ This crisis did not start during the COVID but was made worse by the reduction in economic activity caused by lockdowns. Other factors have contributed to this crisis, such as

²⁹ <https://china.ucsd.edu/opinion/post/youth-unemployment-crisis-looms-large.html>

demographic changes, an imbalance between the education of young people and the skills needed by the labor market, etc. Unfortunately, this problem may continue well after the economy recovers from the COVID pandemic.

China's Inflation Rate

The following graph shows the recent history of China's inflation rate.



Figure 3: China's Inflation Rate

The graph shows that China's inflation rate has ranged from a low of about 1% in 2021 to a high of 2.9% in 2019, just before the outbreak of the COVID. Even at 2.9%, the inflation rate was lower than the Bank of China's official target of 3%.³⁰

The data reflects the slowdown of economic activity due to the lockdowns during the outbreak of the COVID pandemic. As the economy recovers, the inflation rate will likely increase again, possibly leading to a tightening monetary policy by the Bank of China.

The following graph shows real estate prices in China from 2016 – 2022; the graph is based on an index that equals 100 in 2010. Since the index is currently near 110, Chinese real estate prices are about 10% higher than in 2010.

³⁰ <https://www.chinadaily.com.cn/a/202208/29/WS630c6236a310fd2b29e74cc6.html>

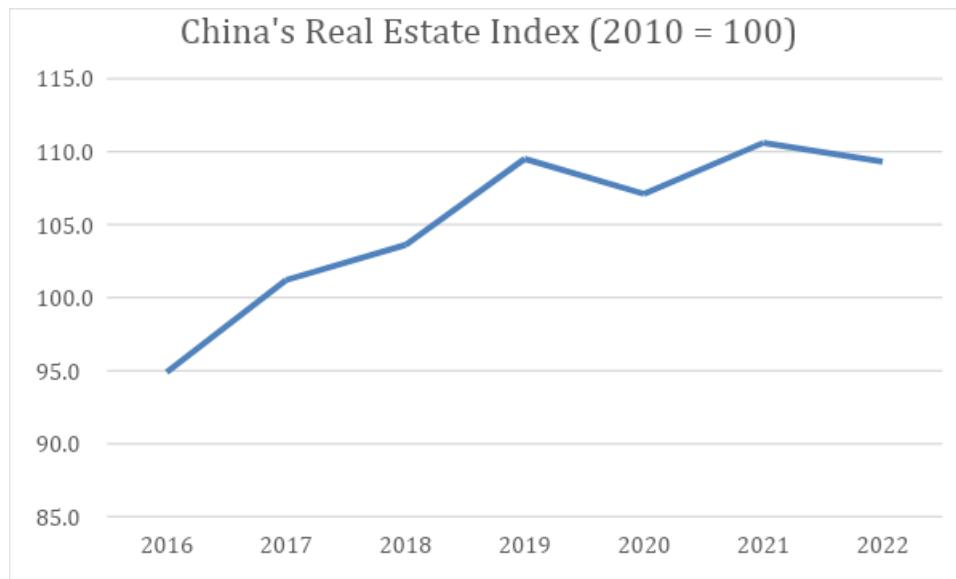


Figure 4: China's Real Estate Market Index

The graph shows that the rapid increase in real estate prices prior to the outbreak of the COVID slowed down significantly, with the index reaching a peak of 110.6 in 2021. This shows that the COVID substantially reduced the demand for housing and real estate due to the sharp reduction in economic activity. This is reflected in the following graph, which shows the percentage changes in China's real estate index from 2017-2022:



The graph shows that before the COVID, Chinese real estate prices were rising faster than the rate of inflation, reaching 6.64% in 2017 while increasing by 5.69% in 2019. Since the outbreak of the COVID, real estate prices have been either falling or rising very slowly. This is a result of the reduction in demand for new housing during the lockdowns caused by the COVID pandemic. Once the lockdowns have ended, the demand for housing is likely to rebound so that real estate prices will likely bounce back again.

Interest Rates in China

Interest rates in China have remained stable since the fall of 2015, when they were at 2.90%, and have remained at this level ever since. This is somewhat surprising since central banks often lower interest rates during a crisis such as the COVID pandemic. It appears that the Bank of China has decided to prop up the banking system with other methods, such as lowering the required reserve ratio, making it easier for banks to lend money to customers. Possibly the Bank of China is concerned that lowering rates would increase inflation too much and has resisted lowering rates further since 2.90% is very close to the Bank of China's inflation target of 3.0%.



Figure 6: China's Interest Rates

As the economy recovers from the COVID crisis, it may be necessary for the Bank of China to raise rates again to ensure that inflation does not rise above the Bank of China's target.

The following graph shows the recent history of China's exchange rate (Yuan/\$):

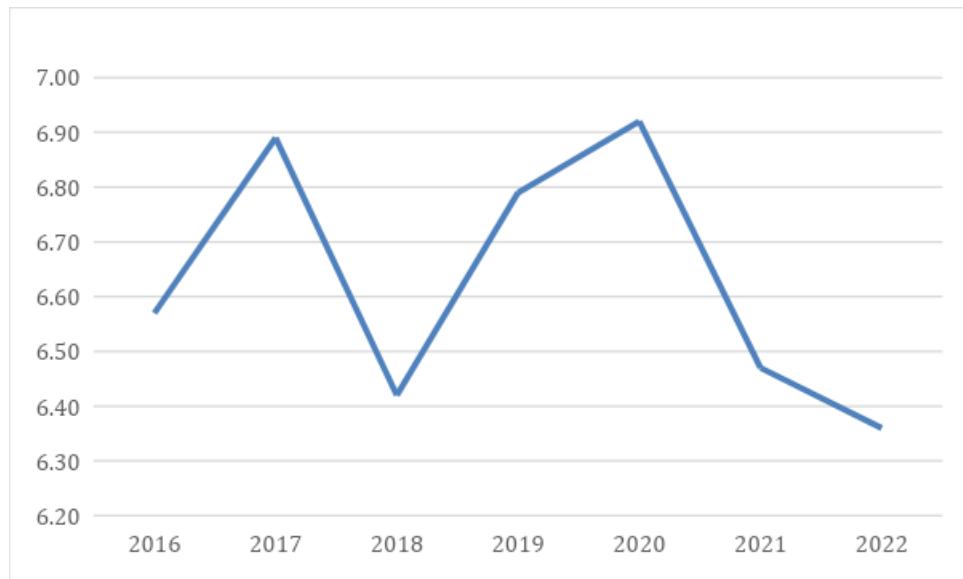


Figure 7: China's Exchange Rate (Yuan per Dollar)

The Chinese yuan is pegged to a basket of currencies of its major trading partners so it can fluctuate somewhat but is relatively stable over time³¹. This means that the yuan's value is kept at a fixed rate by the Bank of China, which intervenes in foreign exchange markets as needed to maintain the fixed rate. This policy encourages trade and investment in China as it greatly reduces foreign exchange risk and increases confidence in the stability of the yuan.

The yuan reached a high level of 6.92 yuan/dollar early in 2020 before rebounding to 6.36 yuan/dollar in 2022. This means that it took 6.92 yuan to buy one U.S. dollar in 2020, and now takes only 6.36 yuan to buy one dollar so the yuan has appreciated (strengthened) against the dollar. This reflects the continuing strength of the Chinese economy during the COVID as well as the weakness in the economies of its major trading partners. The strength of the yuan can be attributed in part to China's ability to maintain exports as well as inflows of investment capital during the crisis.

³¹ <https://www.investopedia.com/articles/forex/030616/why-chinese-yuan-pegged.asp>

The Bank of China has not changed its exchange rate policy during the COVID pandemic; it continues to maintain a peg to a basket of the currencies of its major trade partners without devaluing or revaluing the yuan.

As the economy recovers from the COVID crisis, the yuan will likely appreciate against the dollar and other major currencies as exports rebound due to a recovery in the economies of China's major trading partners.

China's Current Account Balance

The following graph shows the recent history of China's current account balance. The current account includes imports, exports, and international income flows such as stock dividends, wages, interest income, etc. If the current account balance is positive, this indicates that a country is exporting more than it is importing, which is known as a trade surplus. A trade surplus increases GDP and increases the incomes of the citizens of a country.

The graph shows that China has been able to maintain a current account surplus with the rest of the world throughout the pandemic, although it did decline steadily during this period. The current account balance fell from \$147.71 billion in 2019 to \$113.17 billion in 2022.

The falling current account balance is likely a reflection of economic weakness in China's trading partners due to the COVID, which reduced their ability to buy Chinese goods. China's current account balance will likely continue to improve as the world recovers from the impact of the COVID pandemic.

Conclusion

The COVID crisis was an unprecedented event that damaged economies throughout the world. In particular, the sharp reduction in economic activity throughout the world led to a reduction in China's exports, which had fueled its growth since the introduction of capitalism in the 1970s. Domestically, the COVID led to a reduction in real estate prices, higher unemployment, and slowing GDP growth.

Fortunately, the current account balance remained positive throughout the crisis, enabling the economy to avoid a massive slowdown. GDP continued to grow, although more slowly, while unemployment increased sharply but then returned to more normal levels during 2022. Inflation fell during this period, making it possible to keep interest rates at a steady level. The

yuan lost a significant amount of value but then rebounded to its strongest level in over five years, making it unnecessary for the Bank of China to adjust its exchange rate policy.

On balance, policy responses to the COVID were very cautious, unlike most of China's trading partners, where interest rates needed to be reduced sharply to avoid a major recession or depression. The continuing strength of China's exports acted as a stabilizer during this period, preventing a dramatic decline in GDP or a huge increase in unemployment. China should be in a strong position to recover from the COVID crisis as its exports rebound and the rest of the world recovers as well.

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Analyzing Performance of Meta Stock with CAPM Model by Yanchen Li

Introduction

This paper primarily focuses on the correlation between risk and return of investments and specifically on the company Meta's historical stock prices. The paper will include and discuss risk and return based on the CAPM (Capital Asset Pricing Model) and various factors vital to a stock's risk and return. This paper introduces and analyzes the factors including two financial ratios, the Debt-to-Equity ratio and the Price-to-Earnings ratio, respectively; earnings growth and macroeconomic elements. This paper explains what the relationship between risk and return of a potential investment and provides an analysis of this relationship. The concept of beta and its role in the valuation is also presented in the paper. The company to be analyzed is Meta, which just changed its name from Facebook a few months ago.³² This is what this paper will be looking at. Its stocks, recently-made investments, and its evaluation by most investors in the U.S will also be mentioned.

Meta Platforms, Inc.

Meta, previously known as Facebook, is an American multinational technology conglomerate based in California. This company owns well-known Apps, including Instagram, WhatsApp, Facebook, etc. It is one of the most developed and advanced technology firms in the U.S as well as the whole world. Meta's stock has had a mediocre performance in recent periods, as it has dramatically dropped from \$382.18 each share on September 7, 2021, to \$183.83 per share on July 24, 2022. The following discussion will provide an analysis based on the CAPM model.

CAPM Model

The Capital Asset Pricing Model (CAPM)³³ is a model that describes the relationship between the expected return and the risk of investing in a security.

³²<https://www.inc.com/justin-bariso/facebook-meta-mark-zuckerberg-innovators-dilemma-why-did-facebook-change-its-name.html#:~:text=Which%20is%20why%20Zuckerberg%20and,world%20built%20in%20virtual%20reality>

³³<https://corporatefinanceinstitute.com/resources/knowledge/finance/what-is-capm-formula/>

The model was invented by Jan Mossin, Jack Treynor, William Sharpe, and John Lintner in the 1960s. Based on this model, we use a variable named Beta³⁴ to measure the risk of a particular investment. This variable is a measure of the volatility or systematic risk of a security or a portfolio compared to the market as a whole.

The CAPM model is based on several assumptions, including: investors holding a set of diversified portfolios, there is a single-period transaction horizon, investors can borrow and lend at a risk-free rate of return, and there is a perfect capital market with no taxes or transactions costs.

The calculation of the CAPM model is based on the following equation:³⁵

$$R_i = R_f + \beta_i * (R_m - R_f)$$

Equation 1: The Capital Asset Pricing Model (CAPM) Equation

R_i is the expected return on the investment.

R_f is the risk-free rate.

β_i is the beta of the investment

R_m is the expected return of the market.

R_i: The expected return is the investment's intended yield or the discount rate we can use to calculate the present value of its future cash flows; this is obtained when we sum up all the variables in the equation.

R_f: The risk-free rate stands mainly for government-issued bonds. It has no risk for buyers since the issuer is the government.

β_i: Beta is the measurement of the overall risk for a portfolio or security compared to the whole market. Beta is evaluated according to the number 1.0. The investment is considered riskier than the market average if the beta value exceeds 1.0. The risk of our portfolio will be reduced overall if the asset has a beta below 1.0, which is a lower risk than the market average.

³⁴ <https://www.investopedia.com/terms/b/beta.asp>

³⁵ <https://www.accaglobal.com/uk/en/student/exam-support-resources/fundamentals-exams-study-resources/f9/technical-articles/CAPM-theory.html>

Additionally, the projected return is the same as the market return when the beta is 1.0. The beta is calculated as follows determined by the equation:

$$\beta_i = \frac{\text{Cov}(R_i, R_m)}{\text{Var}(R_m)}$$

Equation 2: The definition of beta

The beta measures how closely a stock tracks the overall market relative to the risk of the overall market. A risk-free asset, such as a Treasury security, has a beta of zero. The overall market has a beta of one. The beta measures how much “systematic” or market-wide risk a stock contains; “unsystematic” risk is risk that is unique to single stock.

R_m: The expected return of the market is what investors would potentially hope for based on the amount of return they will receive after buying security.

Advantages and Disadvantages

Investors worldwide use the CAPM model since its availability and precision have been acknowledged. But there are some inaccuracies in the model when it is calculated.

Advantages

All investors around the globe have praised the advantages of the CAPM model. First, the convenience of using it is desirable to market participants. The CAPM model is a very condensed calculation capable of calculating the value investors need in a concise amount of time. It can also generate various potential outcomes and give assurance regarding the necessary rates of return. Second of all, the model measures a variety of portfolios. Unsystematic risk is eliminated because investors are assumed to maintain a diversified portfolio similar to the market portfolio. Since the unsystematic risk is not included, the systematic risk is the only measured risk. This, in turn, reflects the fact that most investors have diversified portfolios where unsystematic risk has been eliminated.

Disadvantages

Just like all models, the CAPM model also has defective parts. The primary problem that exists in this model is the assumptions made in the calculations. There are, in total, four premises of the CAPM model, which can make the value computed from the model be criticized as

unrealistic and imprecise. For example, the model automatically hypothesizes that the buyers can borrow and lend at a risk-free rate of return. Generally, only national securities governments own are risk-free because they do not usually run out of money. On balance, though, the value of a model is based on the accuracy of its predictions rather than the realism of its assumptions. This is why the CAPM model continues to be used 60 years after its creation.

Another limitation is the measure of beta. Betas are only available for publicly traded companies; for other companies, betas must be calculated on a case-by-case basis. Another issue with the beta is that it is based on past data and may not reflect current market conditions. Furthermore, it is challenging to compute the beta coefficient for businesses that operate in various markets or segments because it measures the systematic risk of a company for a specific need. An example of this would be Samsung³⁶, a firm that sells insurance, smartphones, and even ship buildings; it would be a very complex situation for the CAPM model to handle, mainly when calculating a company's beta.

The beta measure is also based on several very restrictive assumptions that are not likely to hold in practice. For example,

- investors are assumed to be able to borrow or lend unlimited amounts of money at the risk-free rate of interest (the yield on a Treasury security)
- it is assumed that there are no taxes or transactions costs and that financial markets are perfectly efficient
- it is assumed that all investors have the same investment horizon

In each of these cases, the assumptions are intended to simplify the CAPM model without affecting the realism of its results. Even with these unrealistic assumptions, the CAPM has performed very well since its introduction in the early 1960s.

Applying the CAPM Model to Meta

In the following section, research that primarily concentrates on the correlation of Meta's stock price returns (from August 19, 2021, to August 18, 2022) and the Standard & Poor's 500 is illustrated, with a scatter plot that shows how closely the returns to Meta stock follow those of the Standard and Poor's 500.

³⁶ <https://en.wikipedia.org/wiki/Samsung>

Computing Beta for the CAPM Model

The data for this study consists of the daily stock price of Meta over the past year (August 19, 2021 – August 18, 2022).

The first stage of the research was to extract data from the internet. The data of the Meta stock is taken from Yahoo³⁷; the Standard & Poor's 500 data came from FRED (Federal Reserve Economic Database)³⁸. During the year between August 19, 2021, to August 18, 2022, the beta is estimated to be 1.7853. This number means Meta stock during that period is riskier than the overall market. The beta is calculated using a statistical technique called “regression analysis.” With this data a scatter plot was created with a trend line that demonstrated the correlation between the returns to Meta stock and the returns to the Standard and Poor's 500:

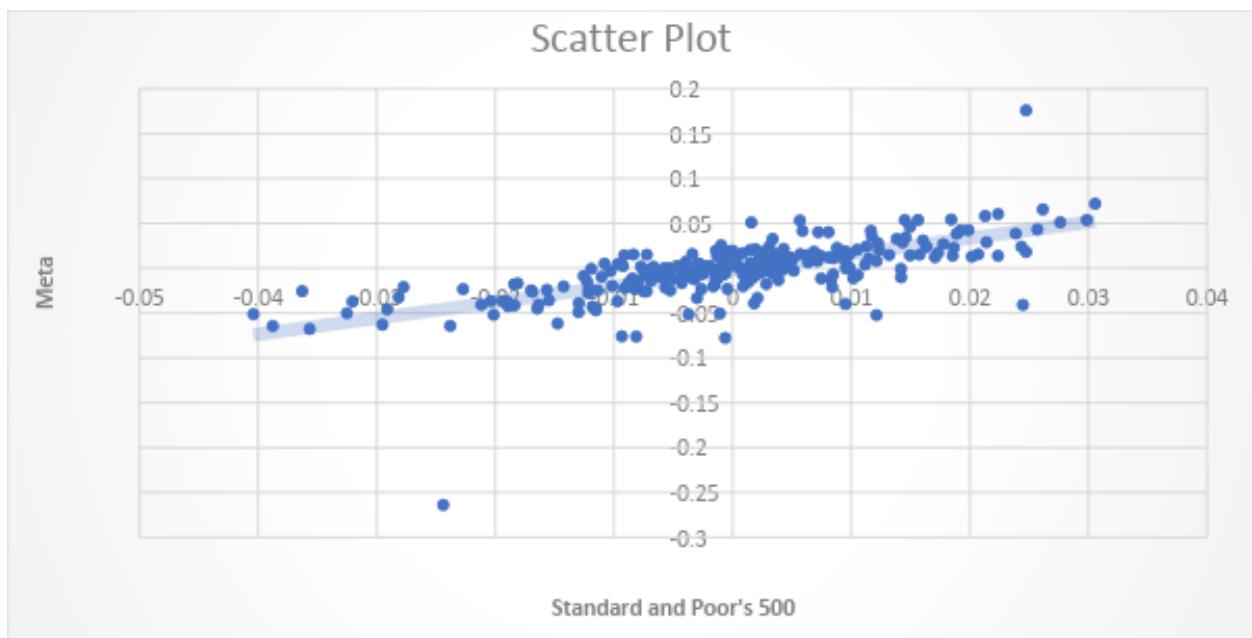


Figure 1: Scatter Plot of Meta stock returns versus Standard and Poor's 500 returns

³⁷ <https://finance.yahoo.com/quote/META?p=META&.tsrc=fin-srch>

³⁸ <https://fred.stlouisfed.org/series/SP500>

The Excel scatter plot shows the trend line that best explains the relationship between the returns to the Standard and Poor's 500 and Meta stock. The slope of the trend line is the estimated beta for Meta stock.

The graph shows a positive relationship between Meta stock and S&P 500, with a slope of 1.785. It means that on an average basis, if the S&P 500's price rises by one percent, the price of Meta stock will increase by 1.785 percent. This proves that Meta's stock, between August 19, 2021, to August 18, 2022 is a relatively risky stock because its beta is well above one, as shown in the evaluation method mentioned above.

Apart from beta, the line intercept (negative 0.0022) is the stock's "alpha," a measure demonstrating whether a particular stock outperforms the market. A positive alpha means that the stock outperformed the overall market, while a negative number of alpha shows that a particular stock failed to outperform the market. Therefore, an alpha of negative 0.0022 means that the Meta stock during the time measured has been unable to outperform the market.

With the S&P 500 and Meta data, we can also calculate the correlation between their returns. The value calculated is 0.68060055. This is a very strong positive correlation since the highest possible correlation is 1. Since the S&P 500 is a market-capitalization-weighted index of the five hundred leading publicly traded companies in the U.S,³⁹ the higher the correlation between a stock and S&P 500, the higher is the stock's beta. A correlation of approximately 0.68 shows a strong positive correlation, showing that the returns to Meta have a strong tendency to follow the returns to the S&P 500. This helps explain why Meta has a very high and risky beta during the measured period.

Predicted Beta versus Actual Performance of Meta

The following graph shows the relationship between the actual returns to Meta stock and the returns predicted by the CAPM model from August 19, 2021, to August 18, 2022:

³⁹ <https://www.investopedia.com/terms/s/sp500.asp>

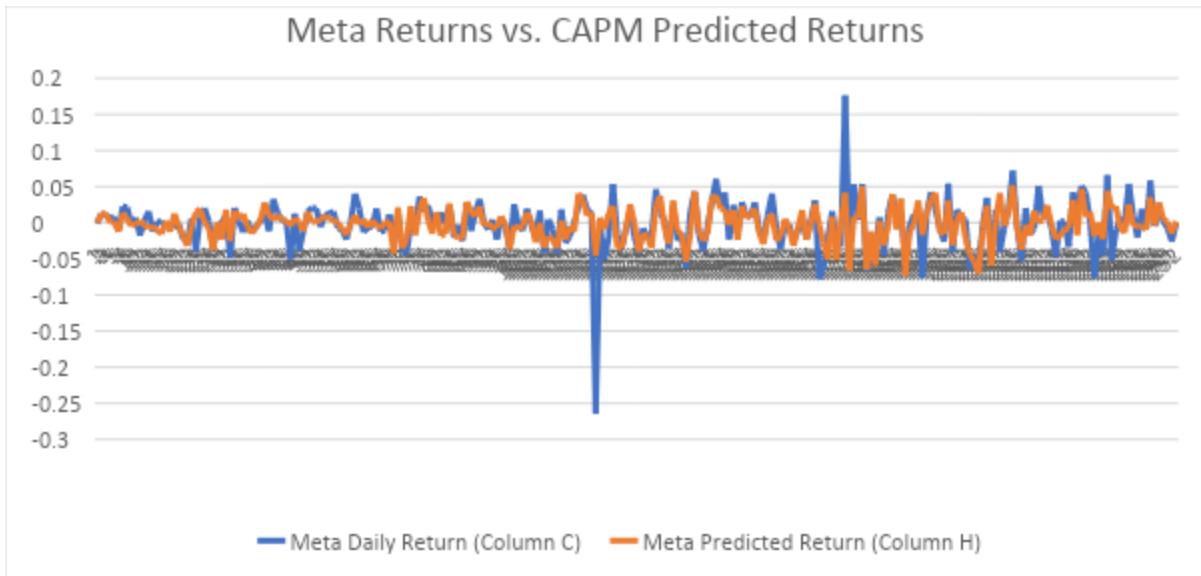


Figure 2: Comparison of actual returns to Meta stock and returns predicted by the CAPM

During this period there were two dates on which the performance of Meta stock was radically different than that predicted by the CAPM model: February 3, 2022 and April 28, 2022.

The plunge⁴⁰: Shares of Facebook (Meta) owner Meta plummeted 26% on Thursday, February 3, 2022, a giant single-day slide in market value for a U.S. company after the social media giant issued a dismal forecast. Facebook attributed its slide to Apple Inc's privacy changes and increased competition from platforms like ByteDance's TikTok.

The surge⁴¹: This rebound happened after Facebook (Meta) announced that it had exceeded its expectations for profits and experienced a rebound in the number of users. Its CEO mentioned that this is an indication that Meta is working on its long-term objectives to develop the metaverse, that the firm would reduce costs and was investing in artificial intelligence capabilities to improve recommendations and advertisements.

Aside from these two dates, the actual returns to Meta follow closely the predictions of the CAPM model, as shown in Figure 2.

⁴⁰ <https://www.reuters.com/business/nasdaq-futures-sink-2-after-facebooks-dour-forecast-2022-02-03/>

⁴¹ <https://www.reuters.com/business/nasdaq-futures-jump-2-after-meta-earnings-beat-2022-04-28/>

According to the evidence that is demonstrated in the graph and the data, the CAPM model does serve as a practical calculation that can effectively approximate and measure the return of a stock. As for the plunge and the surge, which the CAPM model did not predict correctly for Meta's stock price, these situations could not be anticipated because they are very irregular events. They are coincidental and happened randomly, as a result, the CAPM model couldn't possibly predict the accurate value of Meta's stock price on those dates. This error does not mean that the CAPM model is unable to provide correct and precise predictions of stocks. Overall the CAPM predicted returns to Meta closely followed the actual returns during the period under consideration.

Valuing Meta Stock with Financial Ratios

The financial condition of a corporation can be analyzed with a series of financial ratios. These are taken from the corporation's financial statements, mainly the income statement and balance sheet. The income statement shows how a corporation's earnings (net income) are calculated. The balance sheet shows a breakdown of the corporation's assets, liabilities and equity. Financial ratios make it easy to directly compare the performance of different corporations to each other, and to also compare a corporation's current performance to its performance in past years.

Two of the more commonly used financial ratios are the debt-equity ratio, which is a measure of how much the corporation has borrowed, and the price-earnings (P/E) ratio, which can be used as an indication of whether a stock is overpriced or underpriced in the market.

The Debt-Equity Ratio⁴²

A corporation's debt-equity ratio shows the relationship between the value of a corporation's bond and its stocks. Bonds are a type of debt, meaning all bondholders have lent money to the corporation. Stocks are a form of equity, which means that all stockholders own a piece of the corporation and are entitled to share in its profits.

Issuing debt (bonds) has several advantages over issuing equity (stocks). The return paid to bondholders is typically lower than the return paid to stockholders, and the interest payments on debt are tax-deductible to a corporation. The main drawback to debt is that the interest must

⁴² Source: finance.yahoo.com

be paid each year, regardless of how well the corporation is doing; failure to pay the interest would result in bankruptcy.

The debt-equity ratio is seen as a measure of how much credit risk a corporation has. The higher is this ratio, the greater is the risk of bankruptcy. For 2021, Meta had debt worth \$13,783,000,000 and equity worth \$124,879,000,000. This means that the debt-equity ratio for 2021 is $\$13,783,000,000 / \$124,879,000,000 = 0.11$. This compares with⁴³ debt-equity ratio = $\$124,179,000,000 / \$63,090,000,000 = 1.976$. The debt-to-equity ratio of Meta, which is 0.11, is the lowest compared with Apple and Microsoft. This means their stock price should be relatively higher than for these two companies. Because Meta has the least debt, it is more trustworthy than Microsoft and Apple for investors since they would tend to believe that Meta has a better capability of earning money back.

The Price-Earnings (P/E) Ratio⁴⁴

A corporation's price-earnings (P/E) ratio shows how much investors are willing to pay for \$1 of the corporation's earnings or net income. It is calculated as the ratio of the stock price to the corporation's earnings per share (EPS). EPS shows how much the company has earned per outstanding share of stock. As of August 22, 2022, the EPS and P/E ratios for Meta, Apple and Microsoft are:

Meta: Price = 162.94 EPS = 11.58 P/E Ratio = $162.94 / 11.58 = 14.07$

Apple: Price = 169.01 EPS = 6.05 P/E Ratio = $169.01 / 6.05 = 27.94$

Microsoft: Price = 279.53 EPS = 9.65 P/E Ratio = $279.53 / 9.65 = 28.97$

This may be interpreted to mean that Meta stock is underpriced relative to Apple and Microsoft and could be a good investment.

Earnings Growth⁴⁵

Earnings represent the difference between a corporation's income and its expenses. Earnings are another name for "net income."

Meta's earnings over the past few years have been:

⁴³ Source: finance.yahoo.com

⁴⁴ Source: finance.yahoo.com

⁴⁵ Source: finance.yahoo.com

2021	\$39,370,000,000
2020	\$29,146,000,000
2019	\$18,485,000,000
2018	\$22,112,000,000

This pattern shows that the company's earnings are rebounding very firmly from the pandemic and are now substantially higher than just a few years ago. This indicates that the company is headed in the right direction, and its stock price should continue to rise to reflect this earnings growth.

Macroeconomic Variables and their Effect on MetaStock

The U.S. economy has experienced many challenges in the past few years; the outbreak of COVID in 2020 slowed the economy dramatically, and in 2022 the U.S. slipped into recession while experiencing accelerating inflation. The following table⁴⁶ shows quarterly GDP growth dating back to the third quarter of 2019:

Quarter	GDP Growth (year-over-year)
2019 Q3	2.8%
2019 Q4	1.9%
2020 Q1	-5.1%
2020 Q2	-31.2%
2020 Q3	33.8%
2020 Q4	4.5%
2021 Q1	6.3%
2021 Q2	6.7%
2021 Q3	2.3%
2021 Q4	6.9%
2022 Q1	-1.6%

⁴⁶<https://tradingeconomics.com/united-states/gdp-growth#:~:text=GDP%20Growth%20Rate%20in%20the,the%20second%20quarter%20of%202020>

2022 Q2	-0.9%
---------	-------

The table shows that the economy was experiencing relatively slow growth over the last half of 2019, and then became sharply negative due to the pandemic. The economy began to rebound from the COVID crisis in the second half of 2020 throughout 2021; in 2022, the economy fell back into recession. Although the pandemic harmed Meta's earnings, the company successfully increased its profits in 2020 and 2021 despite the slowdown of the U.S. economy. Meta's revenues appear to be somewhat independent of the business cycle, making the stock more attractive to investors. Meta's revenues come primarily from advertising on its platforms; although these revenues would normally slow down during periods of economic turmoil, Meta has been able to diversify its revenues by expanding its operations into new areas such as virtual reality.⁴⁷

Interest rates remained at historically low levels throughout the pandemic; the Federal Reserve found it necessary to raise rates again in 2022 in response to soaring inflation, which reached levels not seen since the late 1970s.

The following table⁴⁸ shows the federal funds rate target (the main policy instrument of the Federal Reserve System) going back to the second half of 2019:

Time	Federal Funds Rate Target
July 31, 2019	2.00% - 2.25%
September 18, 2019	1.75% - 2.00%
October 30, 2019	1.50% - 1.75%
March 3, 2020	1.00% - 1.25%
March 15, 2020	0.00% – 0.25%

⁴⁷ <https://www.nytimes.com/2022/01/31/technology/facebook-meta-change.html>

⁴⁸ http://www.fedprimerate.com/fedfundrate/federal_funds_rate_history.htm

March 16, 2022	0.25% - 0.50%
May 4, 2022	0.75% - 1.00%
June 15, 2022	1.50% - 1.75%
July 27, 2022	2.25% - 2.50%

The table shows that the Fed lowered the federal funds rate target steadily during the second half of 2019 through the first half of 2020, keeping rates at essentially zero for two years as COVID heavily impacted the economy. By May of 2022, it became clear that inflationary pressures were rising rapidly, so the Fed raised rates by 2.25% through July 2022.

The following table⁴⁹ shows the inflation rate (measured as the percentage change in the Consumer Price Index (CPI)) from the second half of 2019 to 2022:

Month	Annual Inflation Rate
Jul-19	1.82%
Aug-19	1.81%
Sep-19	1.83%
Oct-19	1.94%
Nov-19	1.71%
Dec-19	1.96%
Jan-20	2.68%
Feb-20	2.77%
Mar-20	2.11%
Apr-20	0.86%
May-20	0.33%
Jun-20	0.67%
Jul-20	1.15%
Aug-20	1.30%
Sep-20	1.45%

⁴⁹ <https://data.bls.gov/cgi-bin/surveymost>

Oct-20	1.41%
Nov-20	1.12%
Dec-20	1.27%
Jan-21	1.79%
Feb-21	1.95%
Mar-21	2.40%
Apr-21	3.46%
May-21	4.99%
Jun-21	5.97%
Jul-21	5.90%
Aug-21	5.58%
Sep-21	5.54%
Oct-21	6.27%
Nov-21	6.74%
Dec-21	7.14%
Jan-22	7.94%
Feb-22	8.46%
Mar-22	9.31%
Apr-22	9.15%
May-22	9.45%
Jun-22	10.07%
Jul-22	9.05%

The table shows that inflation began rising over the second half of 2021 as the economy started to recover from the pandemic. In 2022 inflation rose above 7% for the first time since the 1970s and continued to grow to over 10% before slowing down slightly. This triggered a series of interest rate increases by the Fed which can potentially move the economy deeper into its current recession. This is a cause for concern for all U.S. stocks. Despite this, Meta has continued to increase its earnings so that Meta stock could be seen as an inflation hedge for investors.

Conclusion

This paper uses the Capital Asset Pricing Model (CAPM) to discuss the relationship between risk and stock returns. It discusses the impact of financial ratios on stock valuation and examines the impact of macroeconomic variables on stock valuation. The analysis is applied to the stock of Meta (formerly known as Facebook).

According to the CAPM model, risk can be measured through a stock's beta; this reflects how much systematic risk a stock contributes to an investor's portfolio. The paper shows how the beta is computed from the relationship between a stock's returns and the returns to a market index such as the Standard and Poor's 500. The estimated beta of Meta is 1.758 during the period from August 2021 to August 2022 shows that Meta is significantly riskier than the average stock in the U.S. economy. The returns to Meta were compared with the predictions of the CAPM during this period, and with two significant exceptions, the CAPM predicted returns followed the actual returns to Meta stock very closely.

The paper also uses critical financial ratios to analyze Meta stock and compare its performance with its direct competitors: Microsoft and Apple. The debt-equity ratio and price-earnings ratios were explained and applied to Meta; the results show that Meta has far less debt than its competitors and that Meta stock may be undervalued compared to its competitors.

Finally, the paper shows the impact of three key macroeconomic variables on stock valuation: GDP growth, interest rates, and inflation. The paper shows that despite the effect on the U.S. economy of COVID and the recent recession, along with rapidly rising inflation, Meta has been able to consistently increase its earnings during this period which shows a significant amount of strength for the corporation. On balance, Meta stock appears to be a good choice for investors.

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Risk and Return for Apple Bonds by Yanjun Li

Introduction

Bonds, which are one of the most popular instruments used for debt, expose investors to a significant amount of risk. However, the higher the risk is, the higher the return you will have in the future, on average. Based on this, the paper analyzes the relationship between risk and return for bonds in general and focuses specifically on Apple bonds. In the following passages, I will discuss the bond from different perspectives to provide a comprehensive understanding.

The paper begins with the key features of bonds, including face value, coupon rate, maturity, and special features such as a call provision. After that, the focus shifts to various bond issuers, including corporate bonds and Treasury bonds. Bond pricing models are then used to compute the present value of a bond's future cash flows. From this information, the risk and return for bonds finally come into the discussion. The factors considered in this paper are: yield to maturity, credit risk and ratings agencies (Standard and Poor's and Moody's), interest rate risk, duration, and macroeconomic variables that affect bond risk and return.

Apple

The first business in history with a \$1 trillion valuation is Apple, Inc. Two individuals named Steve Jobs and Steve Wozniak were the pioneers of creating personal computers. Jobs was regarded as a marketing guru, and Wozniak contributed his technological know-how.

How They Met

A common acquaintance, Bill Fernandez, met the two in the early 1970s, while Steve Jobs was still in high school and Steve Wozniak was enrolled at UC Berkley. Fernandez believed that because of their shared interest in technology and practical jokes, they would quickly become friends.

In order to work on the circuit board for a project named Game Breakout, Jobs solicited the aid of his pal Wozniak when he was employed with Atari. In 1975, and they reconnected when they joined the Homebrew Computer Club.

The Beginning of Apple

Wozniak started working on the ordinary home PC shortly after that meeting. His ideas were promptly rejected when he submitted his work to his company, Hewlett Packard, but Jobs recognized the merit of the finished device. Together, Wozniak, Jobs and Ronald Wayne, an associate of Jobs from Atari, founded Apple Computers.

Origin of the Name

Some people hypothesize that the name Apple was selected in honor of an apple seed. An apple seed will develop into a large, robust fruit if it is given the proper amount of water, care, and fertilizer. Steve Jobs had a far more obvious explanation. When asked, he responded that he liked apples and that they are listed in the phone book before Atari, his old company.

Measuring Interest Rate Risk: Duration⁵⁰

When investing in bonds and bond funds, it's important to be mindful of interest rate risk. In this context, the word "duration" refers to more than just a "period" or "measure of time." Instead, duration indicates how much your bond investment's price is expected to change in response to changes in interest rates, whether they are up or down. Your bond investment will be more susceptible to fluctuations in interest rates the longer the duration number is. Therefore, duration risk refers to how much an interest rate change affects the price of a bond.

An economist must be cited when discussing the bond's duration. The term "duration" of the bond was first used in 1938 by Canadian economist Frederick Robertson Macaulay⁵¹, who invented the Macaulay's duration formula. He previously recommended that in such a circumstance, the duration be determined as the time-weighted average of the present values of the bond's cash flows relative to the bond's price.

Macaulay's duration formula defined is as follows:

$$D = \frac{\sum_{i=1}^T \frac{t*C}{(1+r)^t} + \frac{T*F}{(1+r)^t}}{\sum_{i=1}^T \frac{C}{(1+r)^t} + \frac{F}{(1+r)^t}}$$

⁵⁰

⁵¹

Figure1: The formula for computing Macaulay Duration

where:

D=The bond's Macaulay duration

T=the number of periods until maturity

i=the i th time period

C=the periodic coupon payment

r=the periodic yield to maturity

F=the face value

Numerical Example

The following table (created using Microsoft Excel) shows how duration is calculated for a five-year bond with a face value of \$1,000, coupon rate of 6% and yield of 4%:

Yield		4%		
Year	Cash Flow	Present Value	Time *	Present Value
1	60	57.69		57.69
2	60	55.47		110.95
3	60	53.34		160.02
4	60	51.29		205.15
5	1060	871.24		4356.21
SUM		1089.04		4890.03
DURATION				4.49

Figure 2: Calculation of Duration for a 5-year bond

For simplicity, it is assumed here that the coupon payments are made on an annual basis; in practice, most U.S. bonds pay coupons on a semi-annual basis.

Note that the investor receives a coupon of \$60 each year for five years; this is the product of the coupon rate (6%) and the face value (\$1,000). In the fifth year, when the bond matures, the investor also receives the face value of \$1,000.

The present value of each cash flow is computed based on a yield of 4% with annual compounding. For example, the present value of the \$60 coupon received in 3 years is determined as: $60/(1.04)^3 = 53.34$

In the last column, the time at which each cash flow is received is multiplied by the present value of the cash flow. The results are known as “time-weighted” present values. For example, the time-weighted present value of the \$60 coupon received in 3 years equals: $53.34(3) = 160.02$

The sum of the present values of the bond’s cash flows equals the price of the bond, which in this case is \$1089.04. The duration equals the sum of the time-weighted present values (4890.03) divided by the price of the bond (1089.04), or: $4890.03/1089.04 = 4.49$

Macaulay duration is measured in years, so this result is interpreted as 4.49 years. This means that it will take approximately 4.49 years to recover the initial investment in the bond. This measure also shows that if the bond’s yield rises by 1%, the price will fall by approximately 4.49%; if the bond’s yield falls by 1%, the price will rise by approximately 4.49%.

Example of an Apple Bond

The following table⁵² shows the key features of an Apple bond that matures on May 4, 2043 and has a coupon rate of 3.850%.

Last Updated: 08/22/2022

Bond Detail

Lookup Symbol: AAPL400181 [GO](#)

APPLE INC

[+ ADD TO WATCHLIST](#)

Coupon Rate
3.850%

Maturity Date
05/04/2043

Symbol
AAPL4001810 CUSIP
037833AL4

Next Call Date
— Callable
Yes

Last Trade
Price
\$93.56
[Trade History](#)

Last Trade
Yield
4.324%
[Prospectus](#)

Price/Yield Chart

[Price Chart](#) [Yield Chart](#)

08/22/2017 - 08/19/2022 Zoom: 5D 1M 3M YTD 1Y 3Y **5Y** 10Y Max
— Price



Classification Elements

Bond Type	US Corporate Debentures
Debt Type	Senior Unsecured Note
Industry Group	Industrial
Industry Sub Group	Manufacturing
Sub-Product Asset	CORP
Sub-Product Asset Type	Corporate Bond
State	—
Use of Proceeds	—
Security Code	—

Special Characteristics

Medium Term Note	N
------------------	---

Issue Elements

Offering Date	04/30/2013
Dated Date	05/03/2013

The remaining details are shown in the next table:

Computing the Duration of an Apple Bond

The duration of the bond in Figure 3 is calculated in the same way as the example used in Figure 2 with one major change. In practice bonds typically make coupon payments semi-annually (twice per year) instead of annually. It is therefore necessary to compute the present value of these semi-annual coupons using a semi-annual yield to maturity. The sum of the time-weighted present values using this approach produce a semi-annual duration number, which must be divided in half to compute the annual duration measure. In this case, the duration turns out to be 14.04 years. This shows that a 1% increase in the bond's yield will lower the price by approximately 14.04%; similarly, a 1% decrease in the bond's yield will increase the price by approximately 14.04%. Note that the larger the change in yield, the less accurate will be the estimated price change using the Duration measure.

Other Types of Risk

In addition to interest rate risk, there are several other risk factors associated with bond investments, including refunding risk⁵³, call risk⁵⁴, reinvestment risk⁵⁵ and credit risk. Refunding risk refers to the issuer of a bond periodically withdrawing a certain number of bonds. This can be done in several ways, including through secondary market purchases. A bond issuer may redeem bonds early in order to improve its own credit rating and reduce the coupon it pays to bondholders. For example, suppose that a corporation issues \$100,000,000 in new bonds and then retires \$5,000,000 of these bonds at the end of each year for twenty years. This setup is known as a “sinking fund.” Typically, the company redeems the bonds by paying each investor the principal and a small redemption premium and may then issue new bonds to replace the retired bonds. The investor can then reinvest the proceeds in a new bond. The risk facing the investor is that the new bond may have a lower coupon rate than the original bond.

Another interesting risk is call risk, which is what is known when the principal of a bond is redeemed early but the investor cannot find a similar bond with an equally attractive yield. For example, if Company X issues bonds at a 10% coupon rate and market rates drop so that the company can now borrow at a lower rate by issuing new bonds with a 5% coupon rate, it will do so by “calling” the outstanding bonds. This means that the bondholders must sell the bonds back to the company. Although the bondholders will receive a small premium, there is a strong chance that they will be forced to reinvest the proceeds at a lower coupon rate.

As another example, a callable bond with a coupon rate of 5% and a maturity of 10 years is being issued. The protection period is four years, and the issuer cannot call the bonds during the first four years, regardless of interest rate trends. After the protection period, bondholders are exposed to the risk of having their bonds recalled if interest rates fall below 5%.

While most corporate bonds contain call risk, government bonds do not. U.S. Treasury securities do not contain a call provision. Having a call provision would reduce the attractiveness of U.S. Treasuries to investors and would make it more difficult for the U.S. Government to borrow money.

⁵³ <https://www.investopedia.com/terms/r/reinvestmentrisk.asp>

⁵⁴ <https://www.investopedia.com/terms/c/callrisk.asp>

⁵⁵ <https://www.investopedia.com/terms/r/reinvestmentrisk.asp#:~:text=Reinvestment%20risk%20is%20the%20likelihood,their%20current%20rate%20of%20return.>

Reinvestment risk refers to the possibility that reinvestment income from a bond's coupons will fall in the future due to lower interest rates.

Credit Risk⁵⁶

Credit risk arises when a lender extends credit to a borrower, since there is a chance that the loan may not be repaid, which is known as a "default." Based on the borrower's or the business's capacity to meet future obligations, loans may be granted. Lenders go to tremendous pains to comprehend a borrower's financial situation and to determine the likelihood that the borrower would eventually cause a default.

Lenders evaluate credit risk using their own unique risk evaluation systems, which vary depending on the company or region and are based upon whether the borrower is a consumer or a commercial borrower.

Credit risk is based on many variables. For example, the state of the economy is a major determinant of credit risk; when the economy experiences slow growth or a recession this increases the likelihood that borrowers will not be able to repay their loans on time, so that overall credit risk increases. In addition, increases in interest rates increase the cost of borrowing which can increase overall credit risk. For an individual corporation, credit risk depends on several key factors, such as the growth and stability of its earnings, the amount of outstanding debt that the corporation has relative to its equity, the amount of competition that the corporation faces, the cost of producing the corporation's products, etc.

In order to make a personal loan, creditors will need to know the borrower's financial condition, including their income (in relation to all their responsibilities), other assets, and liabilities. They will also want to know how their credit history looks. Personal guarantees and collateral are frequently used in personal financing.

Contrarily, commercial lending is considerably more complicated, and many company clients borrow bigger sums of money than do private customers. Several qualitative and quantitative methodologies are needed to rate the risk of a commercial borrower. These are some aspects of qualitative risk evaluation:

⁵⁶ Credit Risk - Overview, Risk Management, Credit Rating, 5 Cs (corporatefinanceinstitute.com)
<https://corporatefinanceinstitute.com/resources/knowledge/finance/credit-risk/>

1. Knowing what's happening in the corporate world and the larger economy
2. Examining the borrower's industry of operation assessing the company's strengths and weaknesses in the market as well as its growth plans
3. Examining and comprehending the ownership and management.
4. The examination will take management's reputation and the owner's personal credit scores into account.

Financial analysis makes up the quantitative portion of the credit risk assessment. To determine the borrower's overall financial health, lenders consider a number of performance and economic ratios, such as the debt-equity ratio. A borrower's credit evaluation will result in a score based on the lender's own analysis methods, models, and underwriting criteria more generally.

There are several names that may be given to the score. For instance, the ratings are known as credit rates or debt ratings for governmental debt instruments, and risk ratings for individual debtors (or something similar).

The chance that the borrower will cause a default event is indicated by the score itself. The likelihood of a borrower defaulting decreases with higher credit scores and ratings; it increases with lower scores and ratings.

Credit Ratings Agencies

There are two major credit rating agencies that provide ratings for bonds issued in the United States: Moody's and Standard and Poor's. These companies analyze all bonds for credit risk and the ratings that they apply to these bonds are used by market participants to determine how risky each bond is.

Moody's Ratings

American credit rating company Moody's Investors Service is a division of Moody's Corporation. The company uses a standardized rating system called Moody's ratings to determine a borrower's creditworthiness. With a \$2.1 billion annual revenue, Moody's employs 1,252 researchers and supervisors to evaluate the creditworthiness of its clients. Banks and other

financial institutions, risky assets, repaid funds, and other bond instruments including government, corporate, and municipal bonds are among the debt securities that Moody's rates.

Nine rating symbols are provided by Moody's in the increasing order of credit risk and serve as indicators of creditworthiness:

Aaa, Aa, A, Baa, Ba, B, Caa, Ca, C.

The number modifiers 1, 2, and 3 are used to further split the nine symbols. For example, among Aa bonds, Aa1 is the highest rating, Aa2 is the second highest rating and Aa3 is the lowest rating.

With this scale, bonds rated Baa3 or above are considered to be "investment grade" bonds while those rated below Baa3 are considered to be "junk bonds."

S&P Ratings

Another American credit rating organization, S&P (Standard & Poor's Financial Services), provides S&P ratings, a uniform rating system. The business is a division of S&P Global. S&P has recorded revenues of almost \$2.1 billion, although the business only has 1,416 analysts and managers working for it. Numerous commercial and public enterprises, along with other governmental agencies, are given credit ratings by S&P.

S&P publishes credit ratings for both long-term and short-term debt. The following list determines the order of S&P's credit rating symbols. As with Moody's, each rating is a set of letters:

AAA, AA, A, BBB, BB, B, CCC, CC, C, D

In addition, the + and - symbols are used as modifiers. For example, among all AA bonds, AA+ are the most highly rated, AA are the next most highly rated and AA- are the lowest rated. With this scale, bonds rated BBB+ or above are considered to be "investment grade" bonds while those rated below BBB+ are considered to be "junk bonds."

Example: Apple Bonds

Figure 3 shows that Apple's credit rating is AA+ on the Standard and Poor's scale and

Aaa on the Moody's scale. Aaa is the highest possible rating on the Moody's scale, while AA+ is the second highest rating on the Standard and Poor's scale. This shows that Apple is extremely creditworthy although the two agencies have slightly different options about the financial condition of Apple.

Summary of Moody's Ratings and S&P Ratings⁵⁷

The organization being rated is a major determinant of how Moody's and S&P ratings can differ from one another. It is simpler to discern between the two sorts of ratings because both have unique rating symbols. Following careful study, businesses seeking credit ratings may choose either Moody's or S&P. Although critical in determining creditworthiness, these ratings do not guarantee borrowers' capacity to pay back debts in the future because they are based on information from the past and should not be the only consideration in investing decisions.

Conclusion

This paper discusses the relationship between the risk and return to bonds, which are debt instruments issued mainly by corporations and governments to raise funds. Bonds expose investors to several types of risk, including: interest rate risk, refunding risk, call risk, reinvestment risk, and credit risk. Interest rate risk refers to the possibility that a bond holder could suffer losses due to rising interest rates. Refunding risk is the risk that a bond holder will be required to sell a bond back to the issuer prior to maturity due to a sinking fund and then earn a lower coupon rate from a new bond as a result. Call risk is the risk that a bond will be called in the future by the issuer, reducing the rate of return to the bond holders. Reinvestment risk refers to the chance that a bond holder's reinvestment income from bond coupons could fall if interest rates fall in the future. Credit risk refers to the possibility that a bond holder could suffer losses if a bond issuer fails to make all promised payments in a timely manner.

The measure Macaulay duration was developed to measure the interest rate risk of bonds; it is based on the time-weighted present values of a bond's cash flows and the bond's price. Macaulay duration shows that the longer the maturity of a bond, the greater is its sensitivity to interest rate changes.

Credit risk can be measured by the ratings assigned by organizations such as Moody's

⁵⁷

and Standard and Poor's. The credit ratings of Standard and Poor's and Moody's shows that the more highly rated a bond is, the lower will be its yield (rate of return) and vice versa.

Appendix: The Use of Excel

Excel is a very powerful statistical software program from Microsoft with many functions. In my paper, Excel plays two main roles. The first role is to categorize and analyze the different risks, as shown below. In order to make the calculations and examples easier, Excel's own formulas and the ability to change the results as the numbers in each row or column change are of great help.

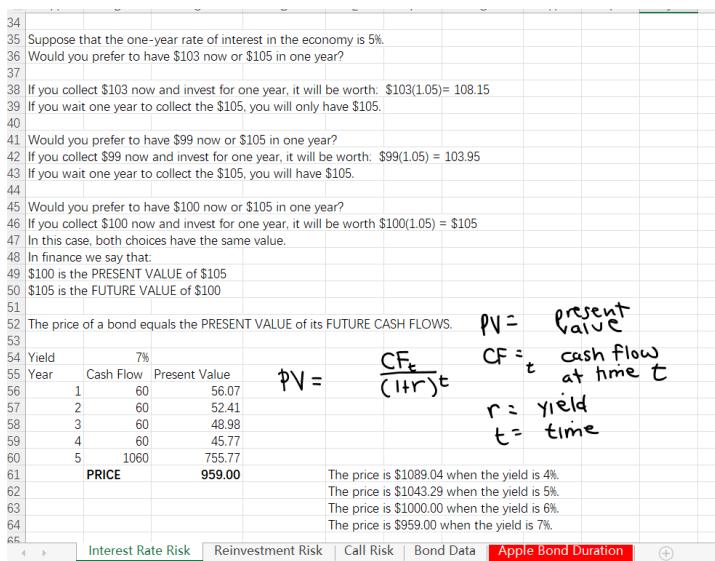


Figure4: An example of use of excel

Another function was to arrange the Apple bond I chose and then calculate its Macaulay duration as follows:

1	Annual Yield	4.324%	Semi-Annual Yield	2.162%							
2	Date	Time (Years)	Time (Semi-Annual Period)	Cash Flow	Present Value	Time * Present Value					
3	2022/11/4	0.20	0.40	\$19.25	\$19.09	7.63	Maturity Date	2043/5/4			
4	2023/5/4	0.70	1.39	\$19.25	\$18.69	26.01	Coupon Rate	3.85%			
5	2023/11/4	1.20	2.40	\$19.25	\$18.29	43.89	Face Value	\$1,000			
6	2024/5/4	1.70	3.40	\$19.25	\$17.90	60.91	Yield	4.324%			
7	2024/11/4	2.20	4.41	\$19.25	\$17.52	77.18	Next Coupon	2022/11/4			
8	2025/5/4	2.70	5.40	\$19.25	\$17.15	92.57	Today	2022/8/23			
9	2025/11/4	3.20	6.41	\$19.25	\$16.79	107.52					
10	2026/5/4	3.70	7.40	\$19.25	\$16.43	121.56	Semi-Annual Coupon Rate	1.93%			
11	2026/11/4	4.20	8.41	\$19.25	\$16.08	135.18	Semi-Annual Coupon	\$19.25			
12	2027/5/4	4.70	9.40	\$19.25	\$15.74	147.96					
13	2027/11/4	5.20	10.41	\$19.25	\$15.41	160.34					
14	2028/5/4	5.70	11.40	\$19.25	\$15.08	171.99					
15	2028/11/4	6.21	12.41	\$19.25	\$14.76	183.21					
16	2029/5/4	6.70	13.40	\$19.25	\$14.45	193.70					
17	2029/11/4	7.21	14.41	\$19.25	\$14.14	203.82					
18	2030/5/4	7.70	15.40	\$19.25	\$13.85	213.28					
19	2030/11/4	8.21	16.41	\$19.25	\$13.55	222.39					
20	2031/5/4	8.70	17.40	\$19.25	\$13.27	230.88					
21	2031/11/4	9.21	18.41	\$19.25	\$12.98	239.05					
22	2032/5/4	9.70	19.41	\$19.25	\$12.71	246.68					
23	2032/11/4	10.21	20.42	\$19.25	\$12.44	253.95					
24	2033/5/4	10.70	21.41	\$19.25	\$12.18	260.70					
25	2033/11/4	11.21	22.42	\$19.25	\$11.92	267.15					
26	2034/5/4	11.70	23.41	\$19.25	\$11.67	273.12					
27	2034/11/4	12.21	24.42	\$19.25	\$11.42	278.80					
28	2035/5/4	12.70	25.41	\$19.25	\$11.18	284.04					
29	2035/11/4	13.21	26.42	\$19.25	\$10.94	289.01					
30	2036/5/4	13.71	27.41	\$19.25	\$10.71	293.59					
31	2036/11/4	14.21	28.42	\$19.25	\$10.48	297.89					
32	2037/5/4	14.71	29.41	\$19.25	\$10.25	301.92					

Figure 5: Using Excel to compute Macaulay duration.

Excel saved me a great deal of time by making it possible to organize the data and then enter formulas only once; they were then copied to all necessary cells.

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The Creation of False and Real Memory by Jiwon Lee

Abstract

False memory is remembering incidents differently or remembering something that did not even happen. It can be caused by the influence of the environment or naturally. Although many people can have some kind of false memory, it can be brutal when it comes to incarceration. There have been cases where a person remembering that he or she is the victim of a crime or remembering that he or she is the perpetrator by interrogations. To prevent these situations, it is critical to consider the situation of the creation of a false memory by knowing its different causes. Therefore, this review broadly focuses on factors that affect memories, such as the formation of a false memory, by reviewing environmental or biological factors that might affect the formation of a false memory and reviewing real memory formation and decay. This review will also go through how the criminal justice system's environment influences the memory to help prevent wrongful incarceration. Lastly, it will discuss potential future research topics that can expand knowledge about false memories.

Introduction

A false memory is a psychological phenomenon whereby a person remembers an event that never occurred or does not remember something correctly. False memories are created when memory is not encoded properly and suggestions from others are combined with actual memory. False memories happen to almost everyone, which includes minor events etc. However, in terms of crime, false memory can be brutal. Sometimes, it happens by a victim remembering differently of the perpetrator or the events or a suspect remembering a false event by thinking he or she committed the crime.

False memories can happen both environmentally (remembering differently by interrogation) or by biological/cognitive factors (aging, lesions, etc.). Therefore, it is critical to learn about the formation of false memories, especially in crime investigations, so that investigators can regulate the interrogation environment more neutrally and consider potential factors that can lead to wrongful incarceration.

To know more about false memories, it is also important to know about the creation of a real memory, which is a memory when someone remembers the events that happened earlier.

Real memories go through the process of memory decay, and as time passes by, it might lead to creation of a false memory. Lastly, since the legal system can give the most influence to a person who is suffering from a false memory, it is also important to know the legal system structures that affect memory.

Therefore, by knowing these facts about legal systems, false memories, and real memories, investigators can suspect if a memory is a false memory judging by a person's environmental or genetic factors. In addition, by knowing the legal system that can affect memory, it might create regulations that are more fair to suspects.

False Memories

Like many things, false memories are caused by both environmental and biological factors. Although there are a lot of reasons why false memories can occur, this section will discuss the environmental and biological reasons. There are particular environmental settings that can make a person more susceptible to false memories, such as witnessing those scenes and the environment they are in.

Remembering negative events – such as witnessing a murder scene – are shown to positively correlate with the creation of false memories. The impact of the negative event on the creation of false memories has been examined by Alan W. Kersten, et al. (2021). Kersten and colleagues conducted an experiment to examine which event participants would remember better. They prepared two scenarios where the actors do neutral events, such as making an oatmeal, and negative events, where actors kill roaches. Although participants remembered the negative event more clearly than the neutral event, they had a hard time remembering which actor performed the negative act. Therefore, this shows that, when a person witnesses a stressful event, it is more likely to create false memories about the perpetrator.

Another factor that can contribute to false confessions is the way in which police interact with their suspects. For example, the police can brainwash, control, and bully the people that they interact with. This makes the suspects unable to fully understand the process or the information that is shown and limits their ability to reason. This is called a “persuaded false confession” and it comes from a specific series of events:

First, interrogators accuse suspects of committing the crime. The suspects, who are often confused at first, think that the interrogators are mistaken and try to persuade them that they are innocent by giving logical reasons. However, when they realize that their explanations are not working, the suspects often become confused by their belief of their own innocence.

After that, the suspects usually use their last memory of not committing the crime, and the police respond by showing the cases where the criminals cannot remember the scene when they commit a crime. When the suspect is exposed to this interrogation tactic, they often fall into the police's manipulation.

Therefore, it follows that the negative environment of the interrogation room, or even just simply being pointed out as suspect, can contribute to false memory creation, which can lead to false confessions.

However, the police are not the only actors who can contribute to false memory creation. On the contrary, therapists have the ability to convince those who enter treatment that they have forgotten childhood trauma or abuse. Therapists might try to help people by remembering their negative childhood memories, which has the potential to create false memories from their external influence.

Additionally, psychotherapy techniques such as hypnosis and guided meditation are often used to discover repressed memories, which are often traumatic, like childhood sexual abuse. These memories are often dependent on the emotions the person has felt that day and helps them identify their relationship. Therefore, this can cause false memory syndrome, which is the creation of a memory that is not true. Lindsay and colleagues (2004) have studied one of the factors that can create a false memory in therapy: photos. In an initial interview, the experimenter read 3 narratives aloud to each participant, two of which were true and one of which was false. Additionally, half of the participants were shown their childhood class group photo. They found that false memories were significantly greater in the photo condition (when participants were shown a childhood photo) compared to the no-photo condition. Moreover, participants' ratings of the strength of their memory for true events were equal to the strength of false memories.

To sum up, negative events, police coercion, and suggestive therapeutic techniques are some key reasons why false memories are created.

Biological and Cognitive factors

Although environmental factors greatly affect false memories, biological factors also affect false memories. This section will discuss the neurological predispositions and personal characteristics that can affect one's memory. The hippocampus is the main part of the brain that is implicated in learning and memory. Therefore, when the hippocampus is damaged, it can affect a person's memory and memory formation. The type of memory that is most affected by damage in the hippocampus is recognition memory, which determines one's ability to recognize previously encountered events, objects, or people. Damage in the hippocampus can be created by trauma, strokes, or Alzheimer's disease.

The prefrontal cortex also plays a central role in cognitive functions, and damage in the prefrontal cortex can produce negative emotions, which contributes to false memory formation. Additionally, problems with the prefrontal cortex can lead to issues with working memory, processing in the hippocampus, and long-term memory. Damage in the prefrontal cortex can be caused by an injury, stroke, or infection. Finally, the perirhinal cortex plays the role of object recognition and memory. Damage in the perirhinal cortex can lead to exacerbated memory impairment following lesions to the hippocampal formation. People who have trauma in their past are more likely to produce false memories. When a person experiences a traumatic event, their brain is more likely to block the memory from fully encoding or unconsciously alter one's behavior into an unusual one. Episodic memory is memory about events, such as remembering buying water in a certain grocery store on a certain street. However, with trauma, a person can shut down their episodic memory and fragment the sequence of the events. Therefore, this can lead to false memories.

In addition to trauma, People who are suffering from OCD have a higher risk of producing false memories since they do not have confidence in their own memory. Obsessive-compulsive disorder (OCD) is a disorder where people have the urge to be obsessed with thoughts or behaviors and repeat certain behaviors. Finally, aging can influence memory. After people reach a particular age, it is common for them to become more forgetful of details, which can create false memories as well. Therefore, neurological problems in the hippocampus, prefrontal cortex, and perirhinal cortex increase the possibility of getting false memories. In addition, factors like OCD, trauma, and aging can create false memories.

Real Memories

Real memory pertains to memories that are encoded and recalled correctly. However, like false memory, real memories are also affected by biological and environmental factors. Memory formation happens through encoding via chemical and electrical impulses within the brain. There are four types of encoding: (1) visual, (2) acoustic, (3) elaborative, and (4) semantic. First, visual encoding is a process where people remember visual images. This type of memory is known to be stored in the iconic memory and then move to the long-term memory. The amygdala is known to have a large role in this process. Second, acoustic encoding is the process of memorization through hearing. For this process to happen, a phonological loop is needed, in which sounds are played repeatedly. Third, elaborative encoding connects previous learned information to new information. This is the process that typically contributes to long-term memory retention. Last, semantic encoding is the encoding of something that has meaning inside it, like words, phrases, pictures, places, etc.

Real Memory Decay

Like false memory creation, real memory decay also has environmental and biological factors. However, whereas false memory is mostly affected by the outer environment, real memory decay is mostly affected by changes on an individual level.

There are many different theories of forgetting. For instance, trace decay theory is the theory that memory will naturally decay as time progresses. According to this theory, one needs to use stored information to prevent it from being forgotten. This process starts right after a memory is encoded. Another theory is interference theory. This theory maintains that long term memory cannot be retrieved from the short term memory because both of the memories interfere with each other. The way that this happens is through proactive interference: this is when a new memory cannot be encoded because the old memory that is already encoded is disrupted when the new memory enters. Another way that this can happen is through retroactive interference. This is when the old memory is affected by the new memory. When the new facts are presented, the old memory is also not used. Therefore, it decreases the use of the memory and the memory is forgotten. Finally, cue-dependent forgetting is the forgetting process because of the effect of emotion. For example, this can happen when collecting a memory that aligns with the mood they are currently in. The criminal justice system places both victims and perpetrators of crimes

through a long process (i.e., investigation, arrest, prosecution, indictment, arraignment, pre-trial detention, plea bargaining, trial/adjudication of guilt, sentencing, appeal, and punishment), which can taint real memories and lead to the formation of false memories.

For example, in the investigation process, evidence from eyewitnesses lineups can affect the memories of victims and perpetrators of crimes. First, it is possible that the eyewitnesses can be mistaken. According to the National Registry of Exonerations, there are hundreds of cases of mistaken eyewitness identification. This can happen when the witness cannot properly view the crime. Second, it is evident from cases of mistaken identification that police ask witnesses to attempt identifications even when there is little evidence connecting the suspect to the crime. Aside from this process, victims and witnesses are often called to the police station for more investigation, such as interviews about the crime. In this process, the interviewer must prepare a comfortable environment, give acknowledgement for the victim's rights, and ensure the victim's safety. Otherwise, it may cause someone to incorrectly remember information

The suspect may also go through an interrogation which sometimes includes coercion and can lead to false confessions. This happens because in poorly conducted interrogations, the police can trick suspects into confessing by feeding false evidence.

Discussion

False memories are created for a variety of reasons, both environmental and biological. These reasons vary as a product of whether the person creating those memories is a victim of a crime or a perpetrator of a crime. Thus far, I have discussed how false memories are created, how these contrast with the formation of real memories, and the role that the criminal justice system plays in affecting the way that both victims and perpetrators remember events. This review demonstrates that there is room for future research on this topic.

For instance, a question becomes, are there differences in how false memories are created for victims vs. perpetrators? The literature on the formation of false memory for perpetrators shows that false memory is formed when a person is falsely accused and was forced by environmental factors. In contrast, when victims form false memories, it is typically because various actors attempt to “bring back” repressed memories, like in suggestive therapy sessions. Therefore, it can be reasonably concluded that the type of false memory is determined by the situation the person is in. Future research could benefit from a close examination of this topic.

Another question that is important to future research concerns how quickly a false memory can be formed. The speed of false memory formation can be determined by the person's current emotion and/or the person's biological factors. For example, a problem in a person's hippocampus might result from forgetting the previous memories and eventually accepting the hypothesis of police and the creation of a false memory. Yet again, this would be an interesting question for empirical examination.

Finally, I wonder if victims with false memories and defendants with false memories are equally likely to testify/confess to legal actors about what happened. It is likely the case that this is an individual difference variable. Since every person has different biological predispositions, the possibility of testifying about a false memory would likely vary by how much a person thinks the false memory is real as well as their personality factors. Future researchers might examine the differences between victims and defendants in this regard.

Conclusion

This is a paper about false memories which mostly focused on potential factors that may foster false memories. In addition to potential factors, I suggested future research questions which includes "what are the differences in how false memories are created for victims vs. perpetrators," "how quickly can a false memory be formed," and "are victims with false memories and defendants with false memories are equally likely to testify/confess to legal actors about what happened?" It is crucial to learn more about false memories since this can prevent wrongful arrest in the future and also prevent unwanted mental health issues.

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**Can a Bird Kill a Plane: Analyzing Destructive Collision Testing in Aircraft Turbofan Blades using ANSYS Simulation Software by Dev Patel ¹, Devansh Saini ², Linping Zhao ³,
Lee Alkureishi ³, Pravin Patel ³**

Introduction

Incidents must be minimized to maximize the safety of the passengers and integrity of the aircraft in the aerospace Industry. However, a common incident in the aerospace industry, especially commercially, is bird strike.¹ Bird strikes are very dangerous since a single collision at the wrong spot of an aircraft can be incredibly dangerous. The purpose of this paper is to outline the tests performed on a single turbofan compressor blade that is standard to most commercial aircraft.

Methods

Using the ANSYS simulation software, a software utilized to test the toughness, strength, elasticity, temperature distribution, and other attributes of various computer models.² Also used was the GrabCad website, which is a website for online part files that can be used in computer simulations.³ Multiple tests were run to observe how a turbofan blade may respond to a strike of a bird that weighs approximately 0.5kg. Assumptions such as the plane moving at the speed of 102.889 m/s and that the simulated force was akin to that of a Canadian Goose striking the specific fan blade were made to see how the blade (made of structural steel) would react to a bird strike in different locations, and if there was sufficient deformation that could force a harm to the engine, the aircraft, and the passengers. The test consisted of applying a ramped force over the period of one second onto various points of the part. This force was simulating the impact of a bird hitting a planes turbofan at a relatively low level (2000 ft), such as just after takeoff or on landing, since most bird strikes occur at these times. The blade itself was fixed and supported on one side by the compressor shaft.

Results

Assuming the constant variables, the bird would cause significant damage if the blade was hit in certain spots. The most deformation occurred at the top of the fan blade, which indicates that the highest risk of breakage would be at the top of the fan blade. However the most

stress occurred at the base of the blade, where it would connect to the main compressor shaft and hub. A bird strike of 2500N is a force strong enough to result in catastrophic failure of the compressor blade if it is hit in certain locations (ex. The top and bottom) because the deformation of the blade would result in failure, or the continued stress at the base of the shaft after impact could result in the blade snapping because of undue stress placed upon it. However, assuming the blade was hit in the center, it may be able to survive a bird strike, although there would still be considerable deformation and stress placed on the blade itself, resulting in the need for repairs and stress tests before flight recertification. The results indicate that the most deformation occurs near the top of the blade because it is not connected to a supporting surface. Also the most stress is concentrated on the fixed surface where the blade itself is attached to the compressor shaft. Overall, assuming a constant size of bird, the results indicate that, the compressor blade may be able to withstand certain collisions and protect the integrity

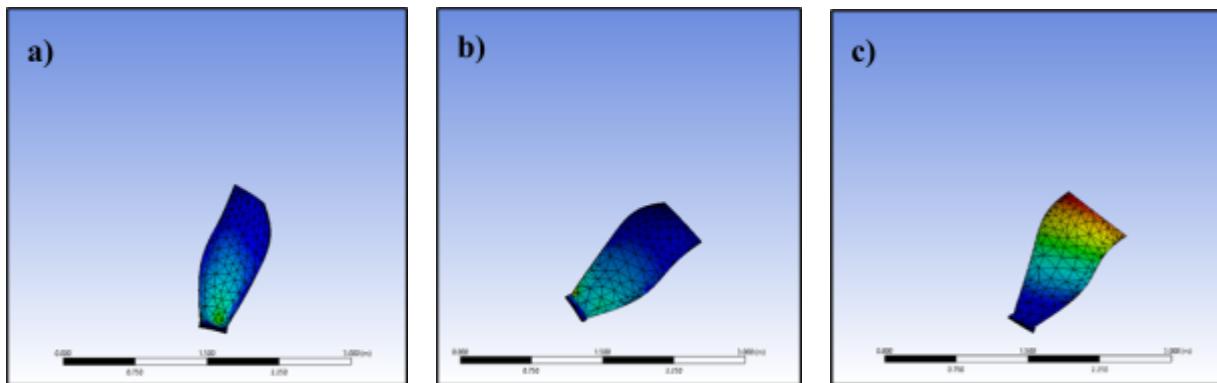


Fig. 1. a) and b) The simulated stress level of the turbofan upon impact of the bird. c) shows the deformation of the fan blade upon impact. In all of the above images, the level of stress and deformation is represented by color, where red is the extreme and blue is the least amount of stress or deformation.

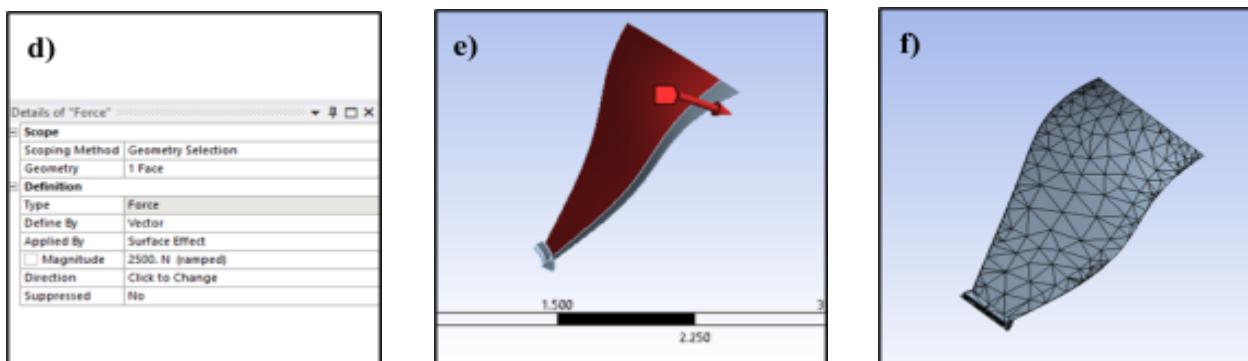


Fig. 2. d) specifics of the force applied are indicated. e) shows the face where the force (bird) is applied. f) shows the meshing process for the part. It is a custom mesh to ensure proper coverage and proper display of results.

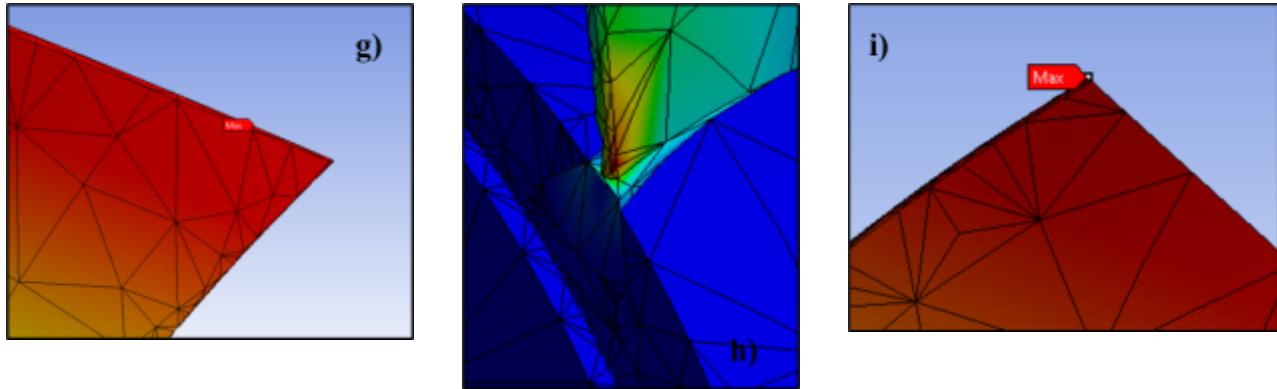


Fig. 3. g) The point of maximum directional deformation is shown, and it occurs at the upper right corner of the blade. The maximum directional deformation is 0.015862 meters. h) shows the point of maximum stress. It is located at the point where the fan blade is joined to the compressor hub. The maximum stress is 1.497e8 Pascals. i) the point of maximum total deformation occurs at the upper left corner of the fan blade. The maximum total deformation is 0.019349 meters.

Conclusion

From this research, it can be concluded that a bird can in fact cause serious damage to a plane in the event of a midair strike. The collision between a bird and a turbofan blade can severely deform and stress the blade and the compressor hub, which can lead to inflight failure of multiple engine components.

Limitations

Although analysis of this part was done well in depth, there are various limitations to these results that need to be acknowledged. The testing was only performed on the compressor shaft, hub, and a singular blade, therefore inferences were generalized from the way one blade performed. However, in most engine strikes, 2 or more blades come into contact with the foreign

object traveling, resulting in a varied distribution of force highly different to these results. The main limitation present was the lack of processing power available to run simulations that could accurately represent the collision. Another limitation is that the analysis only involves the 3 main parts, and not other blades or engine parts, therefore inferences made from this information may not accurately reflect a real life situation. Furthermore, the only force that was tested was 2500 N (force of a Canadian goose hitting a plane on takeoff/landing), therefore, the results are not representative of bird strikes from larger or smaller birds, however 2500 N provides a strong benchmark to test the overall durability of the fan blade itself. The results of the study are comprehensive and can provide an accurate simulation of a foreign object strike in an airplane.

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Assessment of Bicep Muscle Fatigue Using a Low-Cost Microcontroller-based EMG System

by Miles Davy^{1*}, Omar Tawakol^{2,3}

Abstract

The world of sports medicine is constantly advancing with new treatments and studies to help athletes stay healthy and perform better. One way we can prevent injury is by monitoring the electrical signal of athletes' muscles. A known effect of muscle fatigue is associated with a change in electrical signaling and activity. By using an electromyography (EMG) sensor this change in activity can be measured and is used to show the current state of fatigue in the muscle. In this study, muscle-fatigue of the bicep from 3 subjects (2 male, 1 female), was measured using a low cost EMG-sensor. I utilized the Root-mean-square (RMS) and the average-rectified-value (ARV) to quantify the results of this experiment and assess the degree of fatigue of the muscle. Using this procedure, I was able to identify the state of fatigue in the bicep muscle.

Introduction

Muscle fatigue is defined as a decrease in maximal force or power production in response to contractile activity. During a fatiguing contraction, biological changes happen, such as an increase in metabolite concentrations, changes in muscle fiber conduction velocity, and alterations in the number of motor units recruited.

Muscle fatigue is a prevalent problem in sports. When doing almost any everyday activity you use some sort of muscle. When a muscle is overworked it can be more prone to injury. One way to prevent such injuries is by testing which exercises lead to muscle fatigue. By using an EMG sensor, the frequency components of the acquired EMG signal can be used to determine whether the muscle is in a normal or fatigued state. The results of these tests could benefit a multitude of fields, but specifically; athlete performance and sports medicine.

By using electrodes and a myosensor, we can measure the EMG signal of a muscle to determine when the muscle is fatigued and which exercises lead to muscle fatigue.

Muscle fatigue can be divided into 2 categories: Fatigued and non-fatigued. When a muscle is in the non-fatigued state, it is able to apply its maximum force, but as the muscle starts the transition to the fatigued state, it begins to "recruit" new muscle fibers. Other authors classify this process as a third level called the "transition to fatigue." When the muscle enters this stage

of “transition to fatigue” there is a dip in the myoelectric power from the muscle due to the loss in muscle conduction velocity. The EMG sensor detects this dip in frequency which is how we know when the muscle is fatigued.

In this project, the EMG signal will be acquired by non-invasive methods by placing electrodes on the surface of the bicep muscle; using surface electrodes is preferred as it's less invasive when compared to intramuscular electrodes. The electrical activity of muscle fibers during contractions generates the sEMG signals, and the electrodes attached to the skin record these signals in a non-invasive manner. This project will utilize a low-cost system to collect EMG signal from the quadricep muscle to help prevent sports related injuries. Using a low-cost system greatly expands the application of this project which will further help prevent injury.

It is important to highlight that most researchers on sEMG are focused on isometric contractions [1]. A muscle contraction is defined as isometric when the joint angle is constrained to be fixed and there are no changes in muscle length. This project experiments on only the isometric contraction of the bicep muscle.

Learning more about how to prevent and identify when muscle fatigue occurs can provide many socio-economic benefits. With the use of a low-cost system, this project can be applied to a wide variety of places.

Methods

A. Participants

Participate No.	Male/Female	Age	Height (inches)	Weight (lbs)	Physical Active (Y/N)	Previous injuries or neurological conditions (Y/N)
1	Male	16	73	159.2	Y	N
2	Female	46	64	130.4	Y	N
3	Male	49	75	215.1	Y	N

B. Recording EMG signal

- a. All participants were informed of the general process of the procedure and gave consent to be part of the experiment.
- b. The skin where the electrode was to be applied was prepared by wiping thoroughly with 75% alcohol disinfecting wipes to get rid of any natural oils or anything else that might interfere with the reading of the EMG frequency.
- c. 2 surface electrodes attached to the myoware muscle sensor were placed along the bicep muscle with the first electrode placed at the head of the muscle. A third electrode attached to the sensor was placed away from the bicep muscle. The electrode placement was kept the same for all participants and trials in order to decrease the variance in the results.

C. Onsetting Fatigue

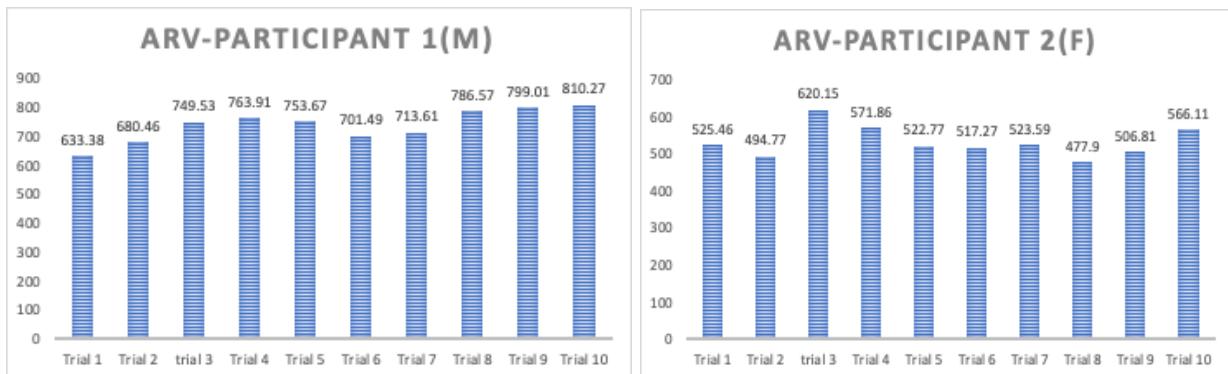
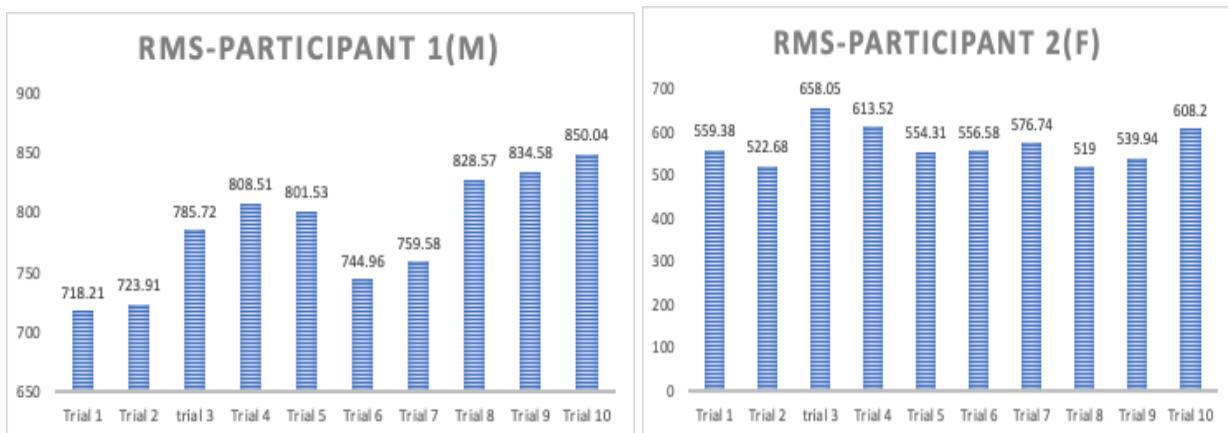
- a. All participants held a 15 lbs. dumbbell in their right arm for 20 seconds. The participants did their best to keep a 90° angle. Over the course of the 20 seconds the myoware muscle sensor recorded the frequency of the EMG signal.
- b. Participants did this same protocol for 10 trials each in order to reach 30 trials total.

Results

The RMS for participant 1 ranged from 718.21 to 850.04. The ARV of participant 1 ranged from 633.38 to 810.27. The RMS of participant 2 ranged from 519 to 658.05. The ARV of participant 2 ranged from 477.9 to 620.15. The RMS of participant 3 ranged from 642.06 to 842.77. The ARV of participant 3 ranged from 604.01 to 808.36. For this experiment, I used 2 techniques to analyze the data collected by the myoware muscle sensor. The first technique I used was finding the RMS of a data set of EMG frequency. RMS was used as an indicator for this amplitude modulation, and the change of RMS values with time Δ RMS was a parameter for fatigue assessment [2]. RMS shows the average power of a constantly varying data set over a period of time, in this case it was the EMG signal recorded over a period of 20 seconds. Using RMS allowed me to determine the average power of the electrical signals in the muscle to help determine the state of fatigue of the muscle. Essentially, the higher the RMS, the more fatigued the muscle is.

The second technique I used was to find the ARV of a data set of EMG frequency. The ARV of a quantity is the average of the absolute value of each unit in a data set. Using the ARV allowed me to find the average EMG frequency in hertz of each data set. This also helped me understand the state of fatigue the muscle is in. The first participant's ARV value ranged from 633.38 to 810.27. The second participant's ARV value ranged from 477.9 to 620.15. The third participant's ARV value ranged from 604.01 to 808.36

In addition to using both of these techniques to measure EMG frequency, I also used a t-test to determine whether the difference in both of these tests were reliable. The t-test provides a “p-value” or probability number. If the p number is below 0.05, then the data is considered to be reliably different. In this experiment the p number of the 10 trials of the RMS and ARV values for the first participant was 0.029097432. This shows that RMS and ARV are reliable ways of measuring EMG signals because they correspond to each other in a predictable and reliable manner. The X axis of the graphs represents the trial number, and the Y axis of the graphs represents the average RMS value for each trial.



Discussion

Analysis of the results and critique of the work, including limitations and how other researchers can improve on your work. One important aspect of this data that can be discussed is the difference between the maximum and minimum RMS and ARV values for each of the participants, and how this relates to the participants' physical characteristics such as their sex, age, height, and weight. Partially explained earlier, the large difference between the maximum RMS and ARV between the male participants and the female participant can be traced to the size of the bicep muscle. The larger the muscle, the more muscle fibers there are, the more reactions there are at any given moment, causing more electricity to be produced at any given period in time. Age seems to also have played another factor because the minimum values for both RMS and ARV were much greater in the younger subject (16 yo.) versus the two older subjects (49 & 46 yo.) . As we age, less electricity is produced because the biological processes within the muscle become less effective and efficient. One point of further research to look into would be to see how height and weight affect the production of electrical signals by our muscles.

One thing I would've changed in this experiment is the amount of weight the participant's were holding. It would've been interesting to see if holding a heavier or lighter weight made a difference in the electrical activity of the muscle.

One limitation this experiment had is that every part of this experiment was wired. This limits the range of motion of participant's and it also makes the device that is used to capture the EMG signal less applicable in real life. If I could have, I would have used a wireless myo sensor to capture the EMG instead of the wired myoware sensor that had to be connected to the arduino uno which was then connected to a laptop.

A topic I would further research is the other ways EMG can be measured/displayed. This experiment used RMS and ARV, but what other ways are there to measure EMG signals? This experiment could also be done in different muscles in different parts of the body. It would be interesting to see how the results varied from muscle to muscle.

Conclusion

In conclusion, differences in sex and age played a major role in the difference of the average RMS and ARV values that the EMG sensor recorded. The results of the experiment

show that the low cost EMG-sensor reliably measured the electrical activity of the muscle in a way that can be widely applied to sports medicine.

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Applications of Stem Cell Therapy for ACL Surgery and Recovery by Sidharth Surapaneni

Abstract

The ACL is a ligament in the knee responsible for cutting and changing directions. Excessive force or improper biomechanics can cause injury to this ligament, and this is one of the most common injuries currently, especially among athletes. This paper will first review the anatomy of the knee and the ACL, and how it is commonly injured. Then, we will review the current treatments for this injury, and the main drawbacks to these treatments. From here we will transition to looking at what stem cells are, and the use of stem cells as an aid or alternative to surgery in ACL reconstruction. This includes a multitude of ways of using stem cells to recover from ACL injuries, from aiding graft strengthening to muscle growth. Finally, we will look at the current issues with stem cell treatments, and how these can be addressed in the future.

Introduction

The anterior cruciate ligament (ACL) runs diagonally, medially, and anteriorly across the knee. Its primary purpose is to stabilize the knee joint, and most importantly during movements that require changing direction quickly (Shimokochi et al., 2008). These movements are common during sports. Excess force, compared to strength, of the knee joint is a leading cause for knee injuries, with around 250,000 ACL injuries per year (Gulick, 2020; Mollis, 1991). There are three grades of ACL injuries, and the recovery pathway depends on severity, lifestyle, and knee functionality (Table 1.).

Table 1. ACL Injury and Recovery

ACL Injury Grade	Meaning	Common Recovery Pathway
Grade 1	Minor Stretching of Ligament	Physical therapy
Grade 2	Major stretching or partial tearing of ligament	Physical therapy and sometimes surgery
Grade 3	Full tear of ligament	Surgery followed by physical therapy

Patients who suffer from an ACL injury currently have two recovery options: (1)surgical reconstruction or (2) non-surgical rehabilitation. These decisions are based on the severity of the tear, age, and expected future lifestyle demands (Table 1). There are multiple options for ACL reconstruction, with each having their own unique pros and cons. There are many different types of surgical ACL reconstructions, such as with the patellar tendon, hamstring, or cadaver tissue, but every method requires at least a week of complete rest followed by extensive rehabilitation to regain strength and stability in the affected knee for a total recovery time of six to twelve months(Nyland et al., 2016). Patients who undergo surgery often need to endure lengthy recovery periods where they must stay off their feet followed by extensive physical therapy regimens. Patients who undergo ACL reconstruction have a significant re-injury rate, highlighting the need for alternative methods of ACL rehabilitation. Furthermore, most athletes never return to the same level of activity or regain their original knee strength (Arden et al., 2012).

Stem cells are cells that have the ability to self-renew and differentiate into specialized cells. Stem cells have been used to provide skin grafts to help facilitate the regrowth of epithelial cells (An et al., 2021). It has been shown that stem cells can successfully integrate into many different types of tissues, such as specific kinds of muscle and epithelial tissue (Yin et al., 2013). The promise of stem cells has gained traction as a potential alternative to help facilitate recovery after ACL reconstruction. Can stem cell therapy be a viable option for patients who have an ACL injury? How can we apply stem cells/regenerative medicine to better understand and treat ACL injuries? Currently, stem cells have not been approved for widespread use as a tool for ACL rehabilitation, either as an alternative to ACL reconstruction or along with ACL reconstruction to speed up and improve graft healing. However, these methods are currently being investigated. This review will highlight current research and advancements of stem cells in relation to the field of ACL reconstruction and recovery.

Biology of the Knee and ACL

The knee is a joint that connects the femur, patella, and tibia. The main muscle groups surrounding the knee are the quadriceps and hamstring, which are located above the knee, with the calf and soleus muscle groups below the knee. Within the knee, many different tendons, ligaments, and cartilage maintain the knee joint function. There are four main ligaments that

provide stability and support. The ACL and PCL form a cross at the center of the knee, with the LCL running along the outside of the knee and the MCL along the inside of the knee (Hassebrock et al., 2020).

The ACL is of utmost importance, as it is responsible for protecting against anterior tibial translation, also known as “knees over toes” (Yoo et al., 2021). The ACL is also responsible for protection against internal rotation and even external rotation in certain weight bearing scenarios (Fleming et al., 2001). The ligament connects to the femur, running diagonally across the knee before fanning out and connecting to the tibia.

It is generally accepted that the ACL is composed of two parts, the anteromedial bundle (AMB), and the posterolateral bundle (PLB). Each part experiences different lengthening when subject to mechanical stress, as the AMB lengthens significantly more (Hollis et al., 1991). The ACL is composed of the proximal, middle, and distal sections. The proximal portion is the less solid portion and composed of type II collagen and glycoproteins. Fibroblasts and fibrocartilage make up the middle portion, and chondroblasts and some fibroblast make up the distal portion of the ACL. The distal portion is the most solid and consists of chondroblasts and some fibroblast (Duthon et al., 2006).

ACL Injuries and Treatments

ACL injuries are given a grade based on the severity of the damage - Grade 1, Grade 2, and Grade 3 injuries. Each injury has its own unique properties and specific rehabilitation protocols to make full recovery (Rodriguez et al., 2021).

Following a grade 1 injury, swelling and inflammation may require a short period of rest. This is followed by 1-4 months of physical therapy, depending on severity of sprain and activity level goals post injury. Physical therapy here focuses on strength of the quadriceps, hamstrings, hips, and other muscles surrounding the knee. Afterwards, more movement-based exercises are implemented, and physical therapy is then completed.

The rehab plan for grade 2 injuries often depends on whether the patient opts for the non-surgical or surgical path. The recovery process for the non-surgical path is similar to a grade 1 injury and the time of recovery for the surgical path is similar to a grade 3 injury which is as follows.

Grade 3 injuries require a short period of rest for post injury swelling to subside, followed by preliminary strengthening around the knee if possible and then surgery. Rehab following surgery will first focus on regaining range of motion and controlling swelling (Cavanaugh, Powers, 2017). This is then followed by strengthening the muscles surrounding the knee, but especially on the quadriceps because ACL reconstruction often leads to severe muscle atrophy (Thomas et al., 2016). Movement-based exercises begin with running and jumping, followed by changing directions at high speeds (Kvist, 2004). From a strength perspective, return to sport is only allowed if the difference in thigh circumference is below 10%-20%. This whole process takes 6-12 months depending on activity level goals and surgery type.

Along with post-surgery muscle atrophy, this rehabilitation creates psychological barriers related to the patient's confidence in the function of their knee, hindering the patient's ability to make a full recovery (Sonesson et al., 2017). Furthermore, the surgery and recovery process are painful, with patients becoming prone to injuries due to the graft being weak during the healing stage (Samitier et al., 2015).

There are a few common kinds of ACL reconstruction, and each has its pros and cons. The patellar tendon graft involves harvesting the middle third of the patellar tendon to replace the damaged ACL (Lidén et al., 2007) The tendon is attached to drilled tunnels in the femur and tibia, allowing for the gradual ligamentization, or the process where the composition and structure of the tendon compositionally and structurally changes into a ligament (Claes et al., 2011). The patellar tendon is sutured together, but inflammation in this area does persist for months post-surgery.

The hamstring autograft follows a similar principle, but instead, the semitendinosus tendon in the hamstring is harvested to create an ACL graft (Suydam et al., 2017). Some hamstring weakness will be seen for a few months post-surgery, but this can be overcome with proper rehabilitation.

The final option is the cadaver allograft, which is when a tendon from a donor is harvested and used as an ACL graft. The patellar tendon, hamstring, and cadaver grafts take between 6-12 months to fully recover, but the cadaver graft is often on the shorter end of the recovery timeline. This is partially due to the lack of "donor site morbidity," or weakness of the tissue from where the autograft was harvested (Kartus et al., 2001).

However, the patellar tendon graft is the gold standard because of its strong bone to graft strength (Carmichael, Cross, 2009). Cadaver grafts also have high re-tear rates among younger individuals, making autografts the best option for this patient group (Kaeding et al., 2017). However, the long recovery time, high reinjury rates and physiological and physical pain has led to the need to search for alternatives for ACL reconstruction or treatments.

Stem Cells

Tissue specific adult stem cells (ASCs) are a specific type of multipotent stem cell with the ability to self-renew and differentiate into mature cell types. They are found in the human body in small numbers. Some examples include hematopoietic, muscle, and mesenchymal stem cells. They also can be created through the de-differentiation of a somatic cell using Yamanaka factors. Yamanaka factors are a specific set of transcription factors that are expressed early. These types of cells are called *induced* tissue specific stem cells, or iTSCs. They are more specialized than induced pluripotent stem cells (iPSCs), which are pluripotent stem cells that have been fully de-differentiated from somatic cells (Saitoh et al. 2021). These cells have greater differentiation capabilities in comparison to ASCs, which are more tissue-specific. Mesenchymal stem cells are a tissue specific adult stem cell and have been shown to regenerate damaged bone and cartilage. This is facilitated by niche factors and signals in the microenvironment surrounding these cells (Hwang et al., 2009). Mesenchymal stem cells can also be derived from the adipose fat tissue, as this tissue often has a higher stem cell concentration (Kanaya et al., 2007). These mesenchymal stem cells can then differentiate into different progenitor cells such as myoblasts and osteoblasts progenitors depending on their microenvironment (Ciufredda et al., 2016).

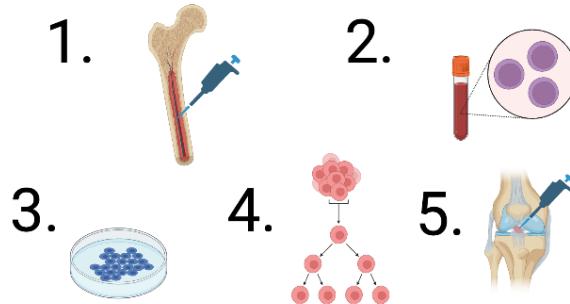
Muscle stem cells are another type of multipotent stem cell that has regenerative function and also rely on their microenvironment for proper stem cell function. (Yu et al., 2021). Different signals and factors can determine whether these muscle stem cells differentiate into a skeletal or smooth muscle cell, or the specific composition of the cell.

Applying Stem Cells to Improve ACL Recovery

For ACL regeneration, mesenchymal stem cells are being heavily researched because of their ability to differentiate into the connective tissue of the ACL (Wang et al., 2021). These cells

are first derived from the bone marrow, and are then expanded in vitro(multiplied in a culture) to increase cell count. They would then be directed down to the proper lineage before transplantation (Figure 1).

Figure 1. Autologous MSC Transplantation



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It has been shown in rat models that mesenchymal stem cells secrete growth factors that can aid in proliferation of ACL cells for partial tears (Kanaya et al., 2007). This has been observed in humans during the early stages of rehabilitation, as tendon to bone healing was significantly higher when inserting mesenchymal stem cells in one study within the first two weeks compared to an absence of stem cell insertion (Ju et al., 2008).

Another novel use of ASCs that is being explored is the use of muscle stem cells to strengthen the atrophied muscles surrounding the knee joint. ACL reconstructions often lead to a period of complete immobilization of the knee joint for almost a week, followed by a slow ramp-up in activity of the joint. This leads to the quadriceps often heavily shrinking in size, and this often continues for months even with the patient receiving physical therapy. For example, patients who have an ACL injury have 30% weaker quadriceps muscles six months post-operation, which is the earliest point that athletes often return to sport (Thomas et al., 2016). This is often seen in muscles with slower twitch muscles, like the quadriceps (Brocca et al., 2012). Muscle weakness is one of the reasons for the higher reinjury rate and lower performance level post ACL surgery. This has led to research investigating the potential of muscle stem cells and how they can be used to regenerate muscles non-invasively and aid in muscle strengthening.

Gene modification in these kinds of cellular therapy has also been explored in order to improve outcomes in ACL rehabilitation. In order to determine the specific lineage a stem cell will differentiate into, certain genes and pathways must be activated. For example, the Runx2 gene plays an essential role in osteogenesis in the human body. Activating this gene to adipose-derived stem cells allowed for greater cartilage and bone formation along with formation of the muscle and fibrous tissue. This allowed for stronger tendon graft integration in the ACL as compared to adipose-derived stem cells without the gene insertion (Zhang et al., 2016). Stem cells can also be used in complications arising from traumatic knee injuries such as Osteoarthritis. Native mesenchymal stem cells in patients with osteoarthritis often have lower proliferation and differentiation rates, even in response to injury. We can improve these cells' proliferation rates however with epidermal growth factors (EGF), allowing for greater regeneration rates (Barry, Murphy, 2013).

Drawbacks

However, there are drawbacks and hurdles to overcome when utilizing stem cell therapy. The main problem is the lack of research and knowledge regarding cell fate of these inserted stem cells. This leads to lower sample sizes and a lack of solid, agreed upon conclusions of the effectiveness of stem cell therapy. These unanswered questions on why some stem cell treatments are not as effective need to be answered before these treatments are put into widespread use. For example, some cells such as adipose-derived stem cells have been shown to differentiate into adipocytes rather than the collagen rich cells needed for the ACL (Tsuiji et al., 2014) Furthermore, many studies with mesenchymal stem cells have shown no significant improvement in tendon-bone healing in the long run. Again, these questions could be answered with more research and data-gathering.

There are also questions regarding cost and availability. One study on a number of clinics across the country showed that in same day stem cell injections, primarily to treat knee osteoarthritis, the average treatment cost was \$5156. Along with the fact that insurance companies generally do not cover the cost of the treatment due to the relative lack of research on the topic, stem cell therapy may not be an economically feasible option for many people in the short-term. This could change in the future however as there is more infrastructure and trained scientists in the stem cell industry.

Conclusion

ACL injuries are among the most common injuries that take place annually in the United States. Even as it is a prevalent problem, there are many issues associated with patient rehabilitation of these injuries in terms of time and chance of recovering to full strength. Physical therapy is often used to recover from these injuries, and for tears affecting functionality, surgery is often recommended. Stem cells have the potential to provide an interesting alternative or aid to surgery, as it can either entirely circumvent the need for surgery for partial tears or be used to help in the healing process of the graft post-surgery. Tissue specific stem cells such as mesenchymal and muscle stem cells, may be able to do this in the future by providing a non-invasive method to help the native or grafted ACL heal, reduce pain, muscle atrophy and prolonged recovery period associated with surgery. However, research still must be done to measure the true effectiveness of these stem cell-based treatments.

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Biomedical Ethics by Zaid Shehryar

In his seminal work “A Theory of Justice,” John Rawls uses a hypothetical device known as the “original position” to frame specific interpretations of the idea that citizens are free and equal individuals and that society should be equitable. In this paper, I will describe Rawls’s defense of egalitarianism, explain the difference between “extreme” and “moderate” egalitarianism, discuss the main strengths and weaknesses of his argument, and explore how his position relates to the issue of medical ethics.

Rawls begins by making an indirect reference to the utilitarian argument, which holds that society should strive to achieve the greatest good for the greatest number of people. However, he is opposed to this traditional philosophical perspective and proposes his own theory of justice for a liberal society: justice as fairness. For Rawls, the central task of government is to preserve and promote the liberty and welfare of individuals. As such, principles of justice are needed to serve as standards for the design and ongoing evaluation of social institutions and practices. Yet Rawls wonders how we could formulate these principles of justice, and in answer he devises the thought experiment of the original position.

We are to imagine ourselves as free and equal individuals who have collectively agreed upon and committed ourselves to the principles of both political and social justice. In doing so we stand behind “the veil of ignorance.” Because rational judgment must be impartial on pain of inconsistency, each person must imagine themselves without knowledge of their personal, social, and historical circumstances. In this way, people can still cooperate with one another and adhere to standards of rational decision-making, but they are to be impartial. To deal with the uncertainty of the original position, Rawls proposes a strategy known as “maximin,” which requires us to choose from all alternatives the one whose worst outcome would be the least bad. For instance, consider slavery. Not knowing whether one would be a slave, the risk of permitting slavery is simply too great.

As such, Rawls believes that the most rational choice for individuals in the original position would be his two principles of justice. The first ensures that each person has an equal right to the most extensive total system of equal basic liberties compatible with a similar system of liberty for all. The second states that social and economic inequalities are to be arranged so

that they are both (a) to the greatest benefit of the least advantaged and (b) attached to offices and positions open to all under conditions of fair equality of opportunity.

According to Rawls, these two principles can govern the distribution of all social goods. However, because the first principle guarantees a system of equal liberty for all, it has priority. The second principle governs the distribution of social goods other than liberty. Although society can take measures to organize itself in a way that would eliminate differences in wealth, Rawls argues that individuals in the original position would not choose this form of egalitarianism. Instead, they would follow the maximin strategy. As a result, in a just society, differences in wealth and social position can be tolerated only when they benefit those who are least advantaged. In addition, there must be an equality of opportunity for access to the best social benefits. For example, admission to medical school should not be limited by irrelevant factors, such as race or gender, and those who face financial challenges in pursuing their education could claim a right to compensatory assistance.

Rawls's theory of egalitarianism is significantly different from some extreme versions. Namely, for Rawls, any inequality can be justified if it causes no harm, or if it is to the benefit of those worst off. By contrast, extreme versions of egalitarianism sometimes reject all forms of inequality. Some forms of socialism entail the political pursuit of a classless, moneyless society. Under these conditions, in contrast to Rawls, no inequality could be justified.

Rawls' argument has various strengths and weaknesses. One strength is the wide-ranging relevance of the original position. This brilliant thought experiment is easy to understand and apply in a variety of contexts. On the other hand, a potential drawback of Rawls's theory is his reliance on subjectivity. To justify the principles that will govern society, a person is invited to imagine herself behind a veil of ignorance, engaging in a rational but selfish calculus for her own benefit. Yet not all reasons are subjective. In other words, there may be reasons to choose principles that are not grounded in self-interest. It is conceivable that even from behind a veil of ignorance, people would make decisions against their own best interests. They may well prefer a society with enormous inequality, either because they believe it is more fair, or on the off-chance that they happen to be wealthy.

One way to extend Rawls's theory of justice is to see how it could apply to a field like bioethics. Rawls endorses the legitimacy of paternalism, and although he does not attempt to justify individual cases, he does tell us that we should consider the preferences of others when

we are in a situation whereby we must act on their behalf. For instance, suppose we know that a person believes in the efficacy of electroconvulsive therapy (ECT) for the treatment of severe depression. If that person should become so depressed as to be unable to reach a decision about his own treatment, then we might be justified, according to Rawls's paternalism, in seeing that this person receives ECT.

The scope of Rawls's contribution to political and ethical thought is difficult to overstate. The original position with its veil of ignorance is one of the most ingenious thought experiments ever devised, and it would certainly be worth considering at the crossroads of a difficult decision.

The Chinese Economic Climate and Future Under the Xi Administration by Qitian Huang

Abstract

The Xi administration increasingly faces challenges against the economic climate in China. The dwindling population growth rate, an inefficient state employment strategy and many other factors have forced the Xi administration to act upon these issues rapidly and efficiently in order to save the Chinese economy. This essay discusses how the Xi administration has reacted to these changes while also trying to analyze the motives behind such revisions. Overall, this essay is split into three sections. The first section looks at the Chinese economic environment inherited by the Xi administration including the reformist era economic climate and policies and current problems faced by the Xi administration. The second section looks at exercising increasing control over the market. The final section looks at the rationale of the policies including Mao's Cultural Revolution and the lack of long-term effectiveness of "Opening up."

Introduction

For the majority of the world, the Covid-19 pandemic seems to be something of the past. With most nations lifting quarantines and travel suspensions, international trade and enterprise/business operations appear to function once more. Interestingly, the People's Republic of China seems to be an exception to this. As of 2022, the PRC is one of the only nations that is still executing city-wide quarantines and a strict travel ban. Pursuing a "zero-covid" policy, the war against covid still rages on. Naturally, the zero-covid policy has taken a heavy toll on the Chinese economy. However, looking deeper into the economic situation in the PRC, economic decline has been a trend in contemporary China since the election of Xi. Long-term economic issues such as the decline of population growth, brain drain, population aging, and the loss of foreign direct investments have put the PRC in a challenging situation. This essay will try to analyze how the Xi administration is using the Covid-19 pandemic as a justification for policies that aim to establish more legitimacy for the Xi administration both with the masses and in the Communist Party of China in exchange for the ongoing economic decline.

Chinese Economic Environment inherited by the Xi Administration

The reformist era describes the period of time from the late 1970s to the 2010s when economic freedom in the People's Republic of China (PRC) drastically increased. Deng's "Reform and Opening Up" policies allowed for a significantly greater amount of economic freedom, including the creation of private enterprises and allowing foreign investments in the PRC. Between 1980 and 2014, the PRC's annual GDP growth (in percentage) was 9.85, with an all-time high of 15.2 (GDP Growth % - China). During the reformist era, controlling the unemployment rate was regarded as a major strategy for both social stability and economic development, paying "great attention to exploiting its advantage in labor resources, and actively developed labor-intensive industries and enterprises that have relative advantages and whose products enjoy market demands" (DI 5-6). Furthermore, the state encouraged:

- a. Unemployed individuals to start their own businesses/self-employment
- b. Private enterprises (mainly in the tertiary sector/service sector) to hire more unemployed individuals with tax reductions, subsidies, and loans at a discounted interest rate
- c. Artificially creating new public sector posts for individuals over a certain age (50 for men, 40 for women) that is unemployed.

The "quantity-over-quality" strategy utilized by the PRC poses one underlying issue in the long run: the limitation of labor productivity growth. Using factors in the production possibility curve, it could be argued that the PRC during the reformist era focused mainly on labor for the growth of efficiency, but in exchange, neglected the importance of technological improvements, as the improvement of technology will ultimately decrease the employment in one sector in exchange for a higher output per laborer. The labor productivity growth showed that in 1990, the growth skyrocketed from -11% all the way to 13% in a span of just one year, with it then slowly decreasing until reaching 8% in the 2000s and increasing back to around 13 in 2005 before showing a constant decrease all the way to 2016 –the beginning of the Xi era– (Labour Productivity Growth % - China).

Current Problems faced by the Xi administration

For Xi, the previous employment strategy will have significantly less impact on the Chinese economy. Since the 1990s, the PRC's annual population growth rate was already in decline, from 1.6 percent in 1990 to 0.1 percent in 2021 (Population Growth % - China). This, combined with the rapid population aging issue (the percentage of the population over the age of

65 doubled from 1990 to 2021), will undoubtedly threaten the current Chinese employment strategy (Population ages 65+ % - China). Furthermore, the data has already confirmed this hypothesis given the labor productivity growth statistics (Labour Productivity Growth % - China). Overall, rapid aging and the trend of decreased population growth rate will severely limit the available Chinese labor force, leading to more expensive labor costs for foreign and domestic enterprises.

Some might suggest that in order to increase labor productivity, the Xi administration could simply import or develop newer technology, thus increasing the amount of productivity per capita. However, this solution would be flawed in one major aspect: an increase in efficiency would mean unemployment. Any form of an increase in efficiency would certainly bring down the employment rate in China, as the supply would simply exceed the amount of demand. This directly contrasts the goal of the Chinese government, which is to incite stability through mass employment and keep their comparative advantage of cheap labor. The government would have the luxury to call itself a provider for the people due to the CPC subsidizing and incentivizing private enterprises for more employment, while also providing large amounts of jobs for individuals, thus gaining legitimacy and stability.

Effects of a higher labor cost could already be seen, as since the election of Xi, foreign direct investment has dropped from three percent of the total GDP to 1.5 in 2020 compared to 3.5 to 4.5 percent between the 2000s to the 2010s (Foreign Direct Investment % - China). The constant decline of foreign investments would also have a positive association with the number of technological goods imported from other nations, leading to a decrease in technological advancements compared to a nation with a higher amount of foreign investment. In addition to the lack of foreign direct investments, China is currently also suffering from a brain drain. As the Talent Tracker project from the University of Chicago showed, around 29 percent of the top-tier researchers in the artificial intelligence field came from the PRC, the highest percentage in the world (AI Talent Tracker). Here is the problem though, the United States currently houses around 60 percent of the total AI researchers in the world, meaning that “88 percent of Chinese PhDs in artificial intelligence end up working in the U.S.; China retains only 10 percent” (Morales and Ethans). Besides the brain drain, a large amount of wealthy Chinese businessmen are also seeking paths out of the country. According to the *Hurun Chinese Luxury Consumer Survey* from the Hurun Research Institute in 2018, around 37 percent of high-net-worth individuals from

China expressed their desire to leave, the United States being their top desired destination (Xu and Pinkle). Furthermore, as of 2022, an estimation of 10,000 high-net-worth individuals have been “seeking to pull \$48 billion from China this year - the second-largest predicted wealth and people outflow for a country after Russia” (Bloomberg News).

Looking at the economic climate more closely, the cost of living in the PRC does not seem that great either. From a 2018 survey conducted by Beijing Normal University (Cai and Dong), the percentage of households that have an annual disposable income that exceeds 120,000 yuan is around 0.61, and households that have an annual disposable income of around 60,000-12,000 yuan is around 4.52, and those with an annual disposable income of 6,000-18,000 yuan take up 40.71 percent of the total population. For example, the annual living expense for a household of three (one child) in Xi'an, a city with 12,952,907 residents as of 2020, is around 197,607 yuan with schooling and rent included (Cost of Living in Xi'an). It should be mentioned at this point that on average, the cost of raising one child until 18 in China is around 485,000 yuan, with those in urban areas costing 484,000 yuan more (Stanaway). This means that on average, Chinese parents spend 20% of their income on childcare and education, “much higher than many countries including the US, France, Germany and Japan” (Hui). Even though Xi'an has a higher average annual disposable income than mentioned above, only 6.5 percent of individuals have an annual disposable income higher than 120,000 yuan (Xi'an 2022 Salary Report). However, the average annual living expense for an individual is only 48,722 yuan (Numbeo, rent), although official statistics show only 20,388 yuan; the individual annual disposable income is around 48,000 yuan in Xi'an (Xi'an 2022 Salary Report). Looking at these statistics, it would be clear why individuals would not want to have children, even though the nation has abandoned its “one-child policy,” the cost of raising a child successfully would seem impossible for the average family to afford. Furthermore, the lack of economic success would further threaten the party’s legitimacy, as the quality of life and living costs rise up. In turn, the Xi administration would need to look for another way to regain legitimacy: politically.

Interestingly, when diving deeper into these statistics, it would seem that the official PRC statements had vastly underestimated certain component costs. For example, the official data stated that the annual cost per household for housing rent was 263 yuan, though looking through certain housing rental websites, it would seem that a minimum of 300 yuan was needed for even a one-room apartment. Repeating the same process for different cities in the Shaanxi province, it

would seem that this statement still holds true. Due to this discovery, from here on official statements and statistics should be analyzed with extreme care.

Increasing Control on the Market

In early 2018, the United States imposed safeguard tariffs against certain Chinese-made products after the US International Trade Commission “determined that imports of these products had injured domestic producers [...] China retaliated over several tariff waves, targeting about \$100 billion of US exports” (Fajgelbaum and Khandelwal). Although both sides agreed to stop imposing further tariffs in early 2020, the effects of these tariffs on China were around 5.5 percent of its GDP. Soon, with the rise of Covid-19, US President Donald Trump repeatedly blamed the Chinese government for their inability to control and contain the virus, stating “[i]t’s China’s fault, it should have never have happened” (Trump Blame China). US support for Ukraine in the Russo-Ukrainian crisis further soiled relationships between the two superpowers with “China’s tacit support for Russia’s invasion of Ukraine”, and with Nancy Pelosi’s recent visit to Taiwan being viewed by the Xi administration as “them recognizing [Taiwan’s] sovereignty” (Knickmeyer). It would not be difficult to understand how the Xi administration could exploit the current US hostility as a justification for his own political gains and current economic decline. Soon after the Sino-American trade war, China developed regulations for controlling exports, official investment screenings, and visa sanctions (Hass). In addition to tightening economic controls, the Xi administration also utilized this opportunity to secure extra authority in Hong Kong with the 2019 Hong Kong Extradition Bill.

Covid-19

Since the start of the Covid-19 pandemic, Chinese economic growth has seemingly been abandoned for exerting control over the nation. Lockdowns, mandatory nucleic acid tests, and limited travel to and from mainland China have severely damaged its citizens’ abilities to conduct business activities both internationally and domestically. As an example, the recent two-month-lockdown in Shanghai, which has the biggest economic output in the PRC, reduced its gross industrial output by 61 percent, and foreign trade import and export were down by 36.5 percent compared to last year’s statistics, and the city’s total social consumption dropped by 48.3 percent (He and SMCEI). It was also due to the Zero-Covid policies that issues mentioned in the

previous sections became prevalent, such as the migration of high-net-worth individuals. However, despite these economic impacts, the Xi administration still shows no signs of discarding the zero-covid policy while the majority of the world has already done so. Under these circumstances, it would seem inexplicable why the CPC is so adamant about wiping out Covid in China without alternative motives.

Long-term economic success in China is tremendously difficult to achieve, as the problems of the increase in the cost of living, a decline in population growth, and rising population aging (both of which lead to the lack of foreign investments and trade due to a higher labor cost and loss of Chinese comparative advantage). Importing more advanced technology would solve the problem of efficiency and economic output, but at the same time would cause large-scale unemployment, further decreasing the party's legitimacy in China.

However, with the introduction of the pandemic, the Xi administration has tightened security to increase its legitimacy: it has done this largely through political repression. Even though the Chinese economy would be sacrificed in turn, it would seem to be worth the gamble. In May of this year, China's National Immigration Administration announced a ban on all nonessential departures of its citizens, with reports of limiting passport issuances and invalidating certain passports by clipping off the corners for citizens returning to China (Barrett), though state-approved media has denounced these accusations from "anti-Chinese communities"(huanqiu). No matter the truth of these accusations, the already declining foreign investments due to the Chinese labor costs, the brain drain, the loss of assets from fleeing high-net-worth individuals due to government crackdowns, and most importantly, the drop in population growth in China has led to instability not only from the masses but also from certain senior party members (Year of Instability), already providing an alternative motive for the Xi administration. The travel suspension imposed on foreigners remains valid (DFA), along with the ban on nonessential departures for all Chinese residents seems like a path to isolating the nation from economic and social exchanges. The masses, through these methods, would become dependent on the state, given there is no other alternative. They are left with no other choices, including consuming only state-controlled media, with other outlets prevented from spreading "misinformation" about the pandemic or unable to research due to the ban on travel and through the fear of Covid. This way the state can shape the narrative of the situation into whatever they

need, justifications for new policies, data, or denouncing any naysayers would be especially simple due to the monopoly on information.

The Rationale Behind the Policies

Current Chinese government choices are grounded in history. Around May of 1966, Mao launched an infamous nationwide movement, the “Cultural Revolution” to insight student rebellions across the country. These rebellions were often aimed at high-ranking party officials deemed to be “rightists” (defined as individuals who hold anti-socialist views, anti-proletarian views, support capitalistic reforms, and countless more anti-Maoist views). During this movement, certain “Red Guard student factions emerged with the sole goal of reasserting Mao’s legitimacy in the state, meanwhile harassing and denouncing individuals (mainly targeting certain high-ranking CPC officials, scholars, individuals with “capitalistic” and “imperialistic” pasts”, and others who have deemed to be a threat to the revolutionary cause). The Cultural Revolution, in short, was Mao’s plan to divert the people’s attention away from the failure caused by his previous economic campaign, The Great Leap Forward, which estimates indicate ended the lives of 23 million to 45 million individuals due to natural and manmade famines (Dikotter 324-325). During the Seven Thousand Cadres Conference, veteran party officials such as Liu Shaoqi openly alluded to Mao’s failures in the Great Leap Forward, calling the famine 70 percent manmade and 30 percent natural (Dikotter 10-11). Now, utilizing the Cultural Revolution, Mao could lure the public eye away from himself while also pinning the previous economic failures on “conspirators against the party.” Comparatively, it is not hard to draw a parallel between Mao’s Cultural Revolution and Xi’s nationalistic agenda. During the Reformist Era, the pursuit of globalization “reduced the intrusive power of the Communist state,” with Chairman Hu closely intertwining Chinese nationalistic views and greater globalization for economic development (Bhattacharya 247). But for the Xi administration, the luxury of utilizing economic development has ceased due to reasons mentioned previously. Taking a page from Mao’s method, it is only reasonable to assume Xi would be taking the public's attention away from domestic policies that led to the decline of the Chinese economy, and instead finding a scapegoat while at the same time pushing nationalistic agendas to justify the party’s increased political control further.

The failure of “Opening Up”

In order to understand the rationale of Xi’s current reforms, the economic system during the Reformist era (and earlier) must be utilized. This section will serve to analyze how the economic system during the reformist era was carried out, as well as how the globalization of the Chinese economy served to weaken the CPC’s bargaining power in the global sense.

Internally, China, as seen throughout its history, has adapted to a system named Regionally Decentralized Authoritarian regime (RDA), which is a combination of political centralization and economic regional decentralization (Xu 1077). In the context of the Chinese dynasties, this was mainly caused by the local patronage economy in combination with the local gentries. The central government, in this case, would approve certain merchant heads in the region, having a mutual agreement of “deliver[ing] tax revenues and controlling the action of the associates. In return, officials stood ready to utilize their power—either directly or by allowing authorized merchants or their agents to act as informal official deputies—to block initiatives that threatened the operations of the ‘legitimate’ or ‘insider’ merchants” (Brandt, et al. 75). In the context of the Reformist era, this system was operated not through local merchants nor gentries, but with regional officials, and with the regional economics being “relatively self-contained, and subnational government have overall responsibility for initiation and coordinating reforms” (Xu 1078). This does not mean the central government does not have any control over any economic activities though, the national government is still capable of setting initiatives for these regional officials. This could be done in two ways:

1. To reward certain regional head officials with more power or promotion when meeting a specific quota for a national economic goal or when one region trumps others in terms of meeting these quotas. This was also applied to testing out economic reforms, where subnational officials would test out a specific reform locally for political benefits.
2. To transfer or demote certain regional officials for another official that better fits the current economic incentives of the national government. Since the national government still holds absolute political power in the nation, if one regional head office was not meeting, or showing loyalty to the national government’s economic (or political) incentives, they could be traded for another office that would better suit this role.

Nevertheless, with the regional agents operating independently for their economic policies and decisions, the Xi administration could see this as a weakness in the stability and control of the

nation. The actions taken towards strengthening the economic control of the national government by the Xi administration will be discussed later in this section.

Externally, China's economic reforms coincided with a new era of globalization, which is defined as a “rapid adjustment in the structure of world trade in response to a more open cross-border flow of goods, capital, people, and technology” as well as a “reduction in transaction costs because of substantial improvements in transport, communication, and information technologies” (Hardwick and Drysdale 545). This presented greater opportunities for China to exploit its comparative advantage of cheap human labor. Furthermore, with the PRC’s accession to the World Trade Organization, a standardized and streamlined global trading system further enhanced the PRC’s ability to engage in global trade. As Drysdale and Hardwick put it,

“As Chinese policymakers struggled with building the domestic market economy in the first two decades of the reform period, the years after WTO accession served to entrench them nationally. Adhering to WTO principles not only made China’s trade regime more transparent, reliable, and efficient. More importantly, in complying with WTO requirements, Chinese institutions—economic, legal, and social and political—have also become more aligned with international practice” (Hardwich and Drysdale 550-551)

Now acquiring international recognition, more individuals, organizations, and nations would be more comfortable engaging in investments and trade with the PRC. Since this influx of trade and investment, the PRC experienced a mass migration from rural to urban areas, creating more labor, and with more labor comes more urbanization due to the influx of migration, as well as boosting productivity, rapid economic growth, and increasing shares of world production and trade (due to the reformist-era Chinese economic strategy focusing on employment).

However, engaging in trade globally does have its shortcomings. Foremost, foreign investments played a major role in the modernization of the Chinese economy, as well as in trade and income growth, with “the applications of which were in their infancy when China acceded to the WTO” (Drysdale and Hardwick 563). Furthermore, in the first few decades of reform, foreign-invested firms were the major source of Chinese trade and output growth. Secondly, when joining the WTO, the PRC had to abide by a set of rules that were “stricter than those that apply to other WTO members”, in addition, the PRC, as well as other nations now have a new tool when political disputes arise (Drysdale and Hardwich 561-562). For example, it was widely

reported that the PRC had stopped the exportation of certain rare earth metals to Japan after a Chinese captain was arrested by Japan in the East China Sea in 2010, or more significantly, when the United States officially recognized data filtering (censorship) as a trade barrier in 2016 (Drysdale, Hardwich 566). As well as those discussed in the “Western Hostility” section.

Conclusion

Looking at the issues closely, the Xi administration is trying hard to gain even more domestic political control in compensation for the loss of external economic control. Internally, under the zero-covid policy, there can be no doubt regional officials are highly discontented with their inability to exercise economic control in their region, and the RDA system is still giving these officials a highly autonomous state economically. However, with the Xi administration utilizing the anti-corruption campaign launched in 2014 as a weapon to clear out any or all dissidents against his regime, (ending the careers of nearly 1.5 million individuals), there is little room for dissent. In combination with the zero-covid policy, which has impacted the abilities of those officials to enact economic policies and freely interact with other nations, could certainly be viewed as Xi’s way of gaining political and economic power, directly counteracting the RDA system. Externally, the factors leading the PRC into economic decline are still an ongoing issue, as less and less FDI means less technological advancements, trade, and exports, while the PRC is already reliant on other nations to participate in trade for certain commodities. Furthermore, the brain drain issue increases the significance of technological staleness. In reaction to these issues, Xi has reasons to believe that a strong central control of the economy and a lesser reliance on foreign trade should be exercised to compensate for the loss of China’s comparative advantage. Thus, this would explain his actions against the local officials and their autonomous economic power; however, this may ultimately accentuate the long-term stagnation of Chinese economic growth

Analyzing the issue from a wider perspective, it is no doubt that the Xi administration is in dire need of political stability and sacrificing the economy in the process. The already declining economic climate in China is difficult to resolve due to the employment strategy utilized both for managing the economy and justification for the socialist aspect of the state. With China quickly losing its comparative advantage of labor due to the ongoing population aging crisis, the Xi administration is also losing its bargaining chip internationally. However, if

the Xi administration slowly isolates the PRC from the international trading scene and tightens the party's authority (propaganda, crackdown, censorship, etc) in the PRC (surrendering economic growth in the meantime), increased stability and the party's legitimacy might be achieved.

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Impact of Class Weights and Feature Importance in Automated Stroke Detection by

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Abstract

A stroke occurs when a blood vessel that carries oxygen and nutrients to the brain is either blocked by a clot or ruptures. Consequently, part of the brain is unable to obtain the blood (and oxygen) it needs, so brain cells die. This makes it important to be able to assess the probability of a stroke given features that are specific to patients so that they could take preventative measures in the future. Thus, the unpredictability and deadliness of strokes pose the following questions: Can we predict the occurrence of a stroke from few facts about the patient easily accessible by the doctor? What are the most important features for stroke prediction? In this project, we investigate the feasibility of using a supervised machine learning model to predict stroke occurrence. In practice, however, we faced challenges such as low prevalence and the imbalance in the available dataset, with many more negative than positive cases. In this research paper, we do a parametric study of class weighting as a way to tackle imbalance during training. We then infer the most important features that should be taken into consideration for stroke prediction. Assessing feature importance allows for patients to focus on two or three areas that may be contributing to their high probability for getting a stroke. The most significant result was that the most important feature that should be considered when determining the probability of an individual getting a stroke is age. However, there is no distinct second most important feature. Additionally, a non monotonic improvement with a class weight of 22.5 for positive cases in this dataset produces the most optimal results.

Introduction

There are several factors that can play a role in the chances of getting a stroke. As outlined in the McKinsey Analytics Online Hackathon Stroke Detection Dataset, some of these factors include gender, age, hypertension, glucose level, BMI, and smoking status. Symptoms of strokes include trouble walking, speaking, and understanding, as well as paralysis or numbness of the face, arm, or leg. The severity and unpredictability of strokes highlight the importance of prediction and preventative measures. Thus, automated methodology is crucial in this field as it provides a method for early detection. There are several challenges faced in the process of

creating a suitable model for stroke detection, one of which includes the severe imbalance present in the dataset with a larger number of negative test cases. In order to address this problem, we create class weights to balance the dataset and produce balanced results based on a variety of accuracy metrics. Additionally, to address the question of feature importance, we use mean decrease in impurity to determine which feature is the most significant in assessing the probability of an individual getting a stroke. In this research paper, we first discuss the dataset itself and preprocessing and encoding techniques utilized to create a favorable format of data to input into our model. We then discuss the methodology and models implemented, and the results that follow.

Background

Numerous studies centered around stroke detection have been recently conducted, two of which include “Identifying Stroke Indicators Using Rough Sets” by Pathan et al. (2020) [2] and “A predictive analytics approach for stroke prediction using machine learning and neural networks” by Dev et al. (2022) [3]. The former article focuses on rough sets in the data preprocessing stage through methods such as down-sampling of the dataset. A potential problem with this could be the fact that several good data points resulting in negative test cases are thrown away in an effort to balance the number of positive and negative test cases. Thus, an alternative method could be to assign weights to positive cases in order to balance the dataset in a manner which keeps all the relevant data while creating a balanced dataset, a key focus in this research project. The latter article focuses on creating the highest accuracy model with multi-layer perceptrons such as convolutional neural networks and neural networks in addition to balancing the dataset using sub-sampling techniques. While such models could potentially have higher accuracies, models such as CNNs are typically more suited for images rather than tabular data. In this sense, an alternative approach could be to use a classification Random Forest model. In this study, we aim to gain a thorough understanding of the impact of the weights assigned to each sample in the loss function used to optimize the model parameters. To this effect, we employ a tree-based model, Random Forest, and conduct a parametric study on the class weight assigned to positive samples. Contrary to other studies seeking state of the art accuracy, we instead focus on understanding the role played by critical parameters.

Dataset

The dataset used in this project was the McKinsey Analytics Online Hackathon Stroke Detection Dataset [1]. This dataset consists of tabular data with several possible features affecting the likelihood of a patient having a stroke, in addition to binary labels of either ‘1’ or ‘0’ to indicate whether or not the patient did have a stroke. A total of 5110 data points were used, and each data point or patient consisted of 10 total features. The 3 numerical features include age, BMI, and average glucose level while the 7 categorical features include gender, hypertension, heart disease, ever married, work type, residence type, and smoking status. Data preprocessing is required to encode all the features in order to implement a Random Forest model. In order to encode the categorical variables, we utilize the `get_dummies` function as a part of pandas, creating a usable format for the Random Forest Classifier. Two critical parameters include `dummy_na` and `drop_first`. We set `dummy_na` as false for all categorical variables since we verified during the data exploration phase that there were no missing values for any of the categorical variables. Additionally, we set `drop_first` as true for all binary variables but false for all variables with more than 2 categories to have a balanced representation of all possible feature values. Since we have missing values in one of the columns, BMI, we remove all the missing values. After preprocessing, we maintain a total of 16 features.

For the validation, we used a 90-10 train test split. We use stratified splitting to ensure that the validation sets have the same imbalance properties for uniform results. We also utilize cross-validation to get more robust estimates of our evaluation metrics.

	<code>id</code>	<code>gender</code>	<code>age</code>	<code>hypertension</code>	<code>heart_disease</code>	<code>ever_married</code>	<code>work_type</code>	<code>Residence_type</code>	<code>avg_glucose_level</code>	<code>bmi</code>	<code>smoking_status</code>	<code>stroke</code>
0	9046	Male	67.0	0	1	Yes	Private	Urban	228.69	36.6	formerly smoked	1
1	51676	Female	61.0	0	0	Yes	Self-employed	Rural	202.21	NaN	never smoked	1
2	31112	Male	80.0	0	1	Yes	Private	Rural	105.92	32.5	never smoked	1
3	60182	Female	49.0	0	0	Yes	Private	Urban	171.23	34.4	smokes	1
4	1665	Female	79.0	1	0	Yes	Self-employed	Rural	174.12	24.0	never smoked	1
...
5105	18234	Female	80.0	1	0	Yes	Private	Urban	83.75	NaN	never smoked	0
5106	44873	Female	81.0	0	0	Yes	Self-employed	Urban	125.20	40.0	never smoked	0
5107	19723	Female	35.0	0	0	Yes	Self-employed	Rural	82.99	30.6	never smoked	0
5108	37544	Male	51.0	0	0	Yes	Private	Rural	166.29	25.6	formerly smoked	0
5109	44679	Female	44.0	0	0	Yes	Govt_job	Urban	85.28	26.2	Unknown	0

5110 rows × 12 columns

Table 1: Initial tabular dataset with numerical and categorical variables.

	0	1	2	3	4	5	6	7	8	9	...	5100	5101	5102	5103	5104	5105	5106	5107	5108	5109
age	67.00	61.00	80.00	49.00	79.00	81.00	74.00	69.00	59.00	78.00	...	82.00	45.00	57.00	18.00	13.00	80.00	81.0	35.00	51.00	44.00
avg_glucose_level	228.69	202.21	105.92	171.23	174.12	186.21	70.09	94.39	76.15	58.57	...	71.97	97.95	77.93	82.85	103.08	83.75	125.2	82.99	166.29	85.28
bmi	36.60	NaN	32.50	34.40	24.00	29.00	27.40	22.80	NaN	24.20	...	28.30	24.50	21.70	46.90	18.60	NaN	40.0	30.60	25.60	26.20
stroke	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	...	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00
gender_Male	1.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	...	1.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	1.00	0.00
hypertension_1	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	...	1.00	0.00	0.00	0.00	0.00	1.00	0.0	0.00	0.00	0.00
heart_disease_1	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	...	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00
ever_married_Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	...	1.00	1.00	1.00	0.00	0.00	1.00	1.0	1.00	1.00	1.00
Residence_type_Urban	1.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	...	0.00	1.00	0.00	1.00	0.00	1.00	1.0	0.00	0.00	1.00
work_type_Never_worked	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00
work_type_Private	1.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	...	0.00	1.00	1.00	1.00	0.00	1.00	0.0	0.00	1.00	0.00
work_type_Self-employed	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	...	1.00	0.00	0.00	0.00	0.00	0.00	1.0	1.00	0.00	0.00
work_type_children	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	0.00	0.00	0.00	0.00	1.00	0.00	0.0	0.00	0.00	0.00
smoking_status_formerly_smoked	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	...	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	1.00	0.00
smoking_status_never smoked	0.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	...	1.00	0.00	1.00	0.00	0.00	1.00	1.0	1.00	0.00	0.00
smoking_status_smokes	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	...	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00

16 rows x 5109 columns

Table 2: Preprocessed sample of dataset, the table is transposed for visual clarity.

Methodology / Models

For the modeling portion of the research, we start by splitting the dataset into validation sets, with a 90-10 split using stratified cross validation. Then, we create our Random Forest model with default values from scikit-learn except for a max depth of 5 to avoid overfitting. After creating this model, we tackle the problem of creating weights. Due to a severe imbalance in the dataset (more negative than positive cases), we take a systematic approach to determining the relationship that different positive weights had towards different accuracy scores. We use the loss function Binary Crossentropy as our end goal for our model is binary classification. This in fact uses weights, and the focus of this study is to understand the role that the weights play. The model parameters are trained by optimizing the loss function. Thus, the choice of the loss function affects the choice of the parameters therein.

In order to determine the proper weight for positive cases, we create an alpha_range, an array storing powers of 2 from -2 to 10. We then loop through the values in alpha_range and assign each respective alpha to positive samples while keeping negative samples with a weight of 1. In doing so, we assign this class weight to the class weight parameter in the Random Forest model and based our results on the following 3 accuracy metrics: balanced accuracy, recall, and precision. These two accuracy metrics are absolutely critical because of the imbalance. However, the tradeoff between the two makes it hard to determine a specific alpha value. For example, a model that predicts every single patient as likely to get a stroke will attain perfect recall but poor

precision. At the same time, a model that predicts very few as likely to get a stroke can have better precision but poor recall. Thus, it is important to take the clinical implications into consideration when determining the right alpha value. For each of these values, we separately evaluate performance metrics using stratified cross validation.

After determining the proper weight for positive samples and the subsequent accuracy scores, we calculate the importance of each feature for stroke prediction through the use of the mean decrease in impurity.

Results and Discussion

After utilizing the range of alpha values in order to compare the different accuracy metrics such as balanced accuracy score, precision, and recall we determine the optimal alpha value to be 22.5, producing a balanced accuracy score, recall, and precision score of 71%, 65%, and 11% respectively. We achieve this by utilizing the ‘class_weight’ parameter in the Random Forest Classifier model. While there is no way to precisely determine which alpha value should be used, we approximate this value based on the importance of precision and recall in this scenario, and the priority of correctly diagnosing someone who is likely to get a stroke above all else. However, while keeping this in mind, it is still important to have some sort of balance between the three metrics, demonstrating why the chosen alpha value is not the highest possible value. The alpha value of 22.5 shown in relation to the three accuracy metrics can be seen below.

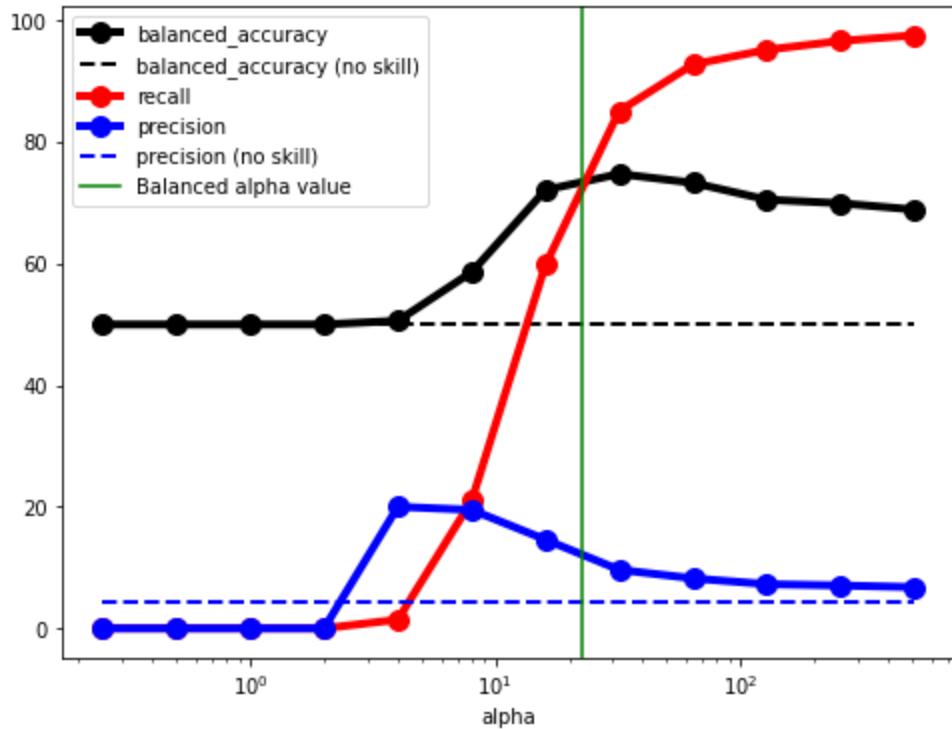


Figure 1: A precision, recall, balanced accuracy, and alpha graph displaying the relationship between a set of alpha values and the aforementioned accuracy metrics. An alpha value of 22.5 is shown in relation to the three accuracy metrics to present their respective accuracy scores.

As shown above, we create a baseline accuracy for the model, one that was determined by predicting the accuracy if the model only guessed ‘0’ or ‘1.’ By comparing the relationship of the different accuracy metrics to each other, the alpha values, and the baseline metrics, we determined that the most optimal alpha value was 22.5. This is also the natural ratio of negative to positive cases, so the alpha value of 22.5 equally balances the two classes. Looking at the accuracy metrics, we can see a non monotonic increase for recall and a somewhat monotonic increase for precision and balanced accuracy. Additionally, we plot the independent relationship between precision and recall, as shown below.

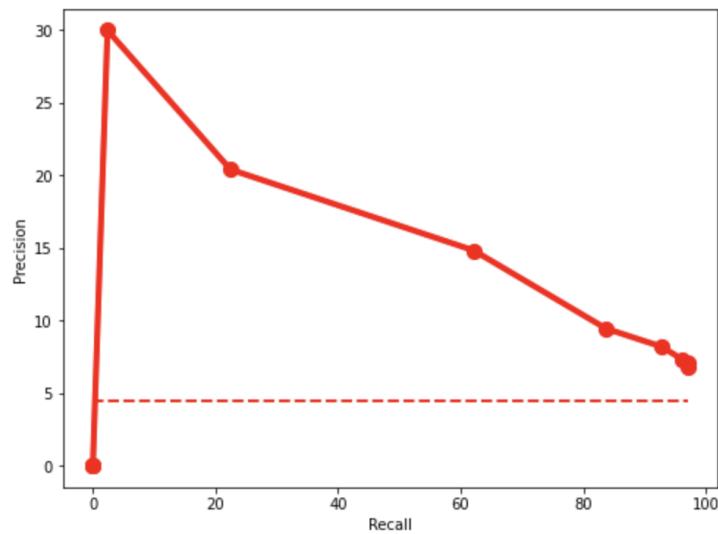


Figure 2: A precision vs recall graph displaying the tradeoff between accuracy scores for individual alpha values.

Finally, in an attempt to determine feature importance, we use scikit-learn's Random Classifier to determine the mean decrease in impurity (MDI), or the total decrease in node impurity averaged over the tree for a given feature. In doing so, we create the chart shown below for a given feature's mean decrease in impurity and how the importance compares in relation to each other.

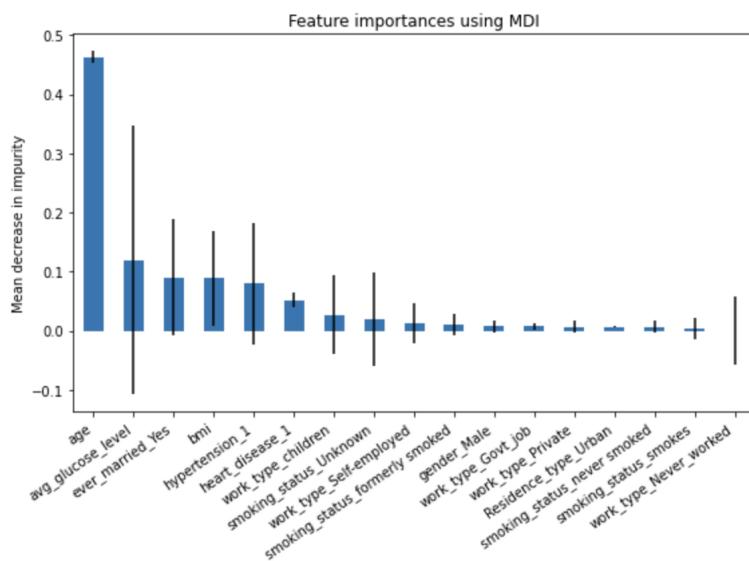


Figure 3: Bar graph displaying feature importance in descending order with confidence intervals using mean decrease in impurity.

Notably, the most important feature in stroke detection is age. Since there is an overlap in confidence intervals beyond the age feature, the subsequent most important features cannot be determined. However, age being the critical feature gives unique insight on which features should be considered first when determining the probability of an individual having a stroke in the future.

Conclusions

As stroke becomes more prevalent in our society today, the need for preventative measures becomes even more crucial in order to save those who may be more susceptible to strokes and the adverse consequences that follow. Thus, by using a Random Forest Classifier in order to isolate the most important feature that should be taken into consideration, age, we can help improve stroke detection. Additionally, we utilized class weights in order to balance a severely imbalanced dataset.

In the future, we can pursue more state of the art results with larger datasets and more tuned models. However, these steps will require a good understanding of the weights, preprocessing of the features, and choice of evaluation metrics. For instance, we could compare different models. Additionally, finding a bigger dataset can be helpful in increasing the accuracy of the model. Currently, only a fraction of the data points are available to be used but increasing this number will give the models a larger number of data points to evaluate.

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Third Party Candidates Participating in the American Presidential Process By Sisira Thumula, and Benjamin Schafer

Abstract

This research paper explores how third party candidates function in the American presidential election process. Throughout the paper I assess three distinct presidential elections – 1912, 1968 and 2000 – to back my assertion that third parties participating in the presidential election process create an uneven playing field for all candidates running in the election, and in some cases, they can produce an election outcome unrepresentative of voter preferences. The 1912 election, featuring Theodore Roosevelt as the third party candidate, exemplifies how simply splitting the partisan vote can lead to one political party's ultimate demise. During the 2000 presidential election, Ralph Nader's notorious campaign potentially acted as a spoiler to Democratic candidate Al Gore by siphoning away enough votes in a key swing state to tip the scale in Bush's favor, causing uproar from the entire Democratic Party. Finally, I will delve into third party candidate George Wallace's intentional interference in the 1968 election. Wallace planned to manipulate certain aspects of the presidential election process and the Electoral College to achieve his own political ambitions. All three points will reveal the Electoral College's liability to third party candidates, forcing us to consider whether third parties have a deleterious effect on American politics. I conclude that vulnerabilities in the Electoral College system render third party candidates a threat to democracy in America.

Introduction

A poll taken in July of 2022 shows a growth in Americans' frustrations with both Democrats and Republicans. Only 25% of people believe either dominant party governs well, while 60% wish for an alternative. As more people become frustrated with the government, the desire for a third party grows, from all sides of the political spectrum.⁵⁸ Voting for a third party, however, comes with consequences. On a national scale, third party voters can confidently vote for their preferred candidate, yet the likelihood of these candidates winning is slim to none. In

⁵⁸ David Paleologos, "Could a third-party candidate win the White House in 2024? Paleologos on the poll" [Could a third-party candidate win the White House in 2024? Paleologos on the poll], USA Today, last modified July 28, 2022, accessed September 12, 2022, <https://www.usatoday.com/story/news/politics/2022/07/28/third-party-candidate-white-house-2024/10166931002/>.

American politics only two parties have the political power and capability to win elections at a national level. By voting for an alternative party, voters risk squandering their vote, or worse, unintentionally assisting a mainstream candidate of the opposite political ideology. To that end, voters must decide between a tolerable candidate with a potential to win, or a third party politician they genuinely support. This occurrence has become common knowledge in American politics, but the issue lies deeper within the system.⁵⁹ In the current presidential elections process, third party candidates create an uneven playing field for candidates and, in some circumstances, a potentially unrepresentative election outcome. This paper investigates three distinct presidential elections – 1912, 1968, and 2000 – to evaluate third-party candidates in the presidential election process.

Literature Review

In an episode of The New York Times' podcast *The Daily* titled “A Particular Way to Pick a President,” Jesse Wegman analyzes how George Wallace’s 1968 campaign fueled a growing movement to abolish the Electoral College.⁶⁰ In the midst of the 2016 election, where former president Donald Trump lost the popular vote yet still won the election, the capability of the Electoral College is once again put into question. Wegman uses Wallace’s campaign and other historical evidence to prove his assertion that the abolition of the Electoral College should not be viewed as a partisan issue but an American issue. This paper highlights one specific flaw discussed by Wegman—that is, third parties.

One of the central claims of Edwards’s book, *Why the Electoral College Is Bad for America*, is the dangers of no candidate receiving a majority in the Electoral College. Edwards argues that in this scenario, politicians become incentivized to engage in dishonest behavior. In multiple instances in American history, during contingent elections, politicians bargained for endorsements, and in return, the corresponding party would receive some kind of political advantage or monetary incentive. The book explains how this took place in the election of 1825, where John Quincy Adams conspired with Henry Clay in order to become president. In return, Clay was promised to become Secretary of State after Adams was inaugurated. Edwards also argues contingent elections are especially dangerous for democracy because the American people

⁵⁹ See definition below in glossary (Page #14,15 &16)

⁶⁰ See definition below in glossary (Page #14,15 &16)

can't trust legislators to be ethical, especially when there are many opportunities to engage in corrupt behavior.⁶¹ This analysis creates an understanding for the peril that could have arisen in 1968 when George Wallace attempted to manipulate the Electoral College process by targeting these exact weaknesses in the system.

In their respective books, Shugart and Klarreich both fixate on the plurality system, though their argument do vary slightly Klarreich maintains that having more than two candidates in a plurality system dilutes voter preferences, increasing the chances of the spoiler effect and voter misrepresentation.⁶² Shugart's claim is slightly different because it argues that the plurality system can magnify the effect of third party candidates in individual states. The events that took shape during the 2000 election support this assertion. Shrgart's work is largely similar to my argument about Ralph Nader and the 2000 presidential election.

Theodore Roosevelt and the 1912 Presidential Election

The 1912 election is unique in that there were three viable presidential candidates, making it a prime example of how a third party can disrupt a presidential election. The 1910s began the rise of the Progressive era, which created a rift in the Republican Party. The Progressives, a splinter group of Republicans led by former president Theodore Roosevelt, began differentiating themselves from mainstream Republicanism. The Progressives believed in New Nationalism, an ideology that prioritized human rights and a more direct approach to democracy. As the 1912 primaries approached, many Americans predicted incumbent President William Howard Taft, Roosevelt's former Vice President, to be a shoe-in for the Republican nomination. However the Progressives, dissatisfied with Taft's conservative policies, appointed Teddy Roosevelt as their progressive candidate, making it unclear as to who would win the primaries. During the primaries, Taft and Roosevelt were polling nearly equally, but Taft ultimately won by a narrow margin, becoming the Republican nominee. Roosevelt then made the deeply controversial decision to run as a third party candidate, breaking his initial promise not to do so. Roosevelt and the Progressives created the Progressive Party and reentered the election.⁶³

⁶¹ See definition below in glossary (Page #14, 15 & 16)

⁶² See definition below in glossary (Page #14, 15 & 16)

⁶³ Lewis L. Gould, *Four Hats in the Ring* (n.p.: University Press of Kansas, 2008), [Page #45-75 & 122-151], <https://doi.org/10.2307/j.ctv2rsfczd>; Tichenor and Fuerstman, "Insurgency Campaigns," [Page #55-62];

If there are three or more candidates in the presidential election process, the two candidates most closely aligned hurt each other's chances of winning, while the candidate on the other side of the political spectrum stands to gain. After the progressive rift, the Republican Party and its voters became split between Roosevelt and Taft, clearing the way for Wilson, the Democratic nominee, to win the election. The 1912 election was unusual because of the multiplicity of strong candidates. In most elections, the spoiler effect does not have a consequence because there are only two major candidates; however, the 1912 election featured three prominent candidates, allowing the spoiler effect to propel Wilson to the presidency. Although both William Howard Taft and Theodore Roosevelt had different ideologies, they were on the same side of the political spectrum, so most, if not all, of their voters were Republican. The split in the Republican party paved the way for the Democrats, united under Woodrow Wilson, to win the election.⁶⁴ In the words of Ellen Axon Wilson, Woodrow Wilson's wife and former first lady, "it looks as if nothing but an accident can prevent Wilson's election, not because the country wants him especially, but because of Roosevelt's madness in splitting the G.O.P."⁶⁵ After the progressive rift, the Republican Party and its voters became split between Roosevelt and Taft, clearing the way for Wilson to win the election. There can be no definitive argument stating either Roosevelt or Taft would have become president in 1912 had the other not run, but the presence of two Republican candidates contributed to Wilson's victory. On those lines, the positioning of this election did the opposite for both Taft and Roosevelt. Allowing more than two candidates to be on the final ballot in a system where each candidate only receives one vote is fundamentally flawed because it fails to prevent them from indirectly affecting one another. The current system does not recognize preference as a factor in elections with more than two candidates. The results of an election may change when asking voters to choose the best of three candidates rather than choosing the better of two candidates. This small but significant difference can give certain parties the upper hand in elections.

⁶⁴ Erica Klarreich, "Election Selection," *Science News* 162, no. 18 (2002), <https://doi.org/10.2307/4014063>; Matthew Soberg Shugart, "Elections": The American Process of Selecting a President: A Comparative Perspective," *Presidential Studies Quarterly* 34, no. 3 (2004):, <http://www.jstor.org/stable/27552617>.

⁶⁵ Gould, *Four Hats*, [Page #124].

Ralph Nader and the 2000 Presidential Election

While the 1912 election explains how a third party candidate with nationwide support can disrupt an election, the 2000 election explains how an unpopular third party candidate can do the same. The 2000 presidential election between Democratic candidate and then-Vice President Al Gore and Republican candidate George Walker Bush is an infamous case of third party intervention in the presidential election process. Both candidates still had not received 270 votes, so the final determiner was left up to Florida. Due to claims of fraud, voter suppression, and the infamous “butterfly ballots,” (a mistake on the ballot causing over 2,000 democratic voters to vote for Pat Buchanan) the Florida court mandated a recount. The Supreme Court ruled the recount unconstitutional on the basis that it violated the Equal Protection Clause of the Fourteenth Amendment. Therefore the process was halted midway before counting the remaining votes. In the final Florida results, Bush won the election by mere 537 votes; to put this into context, there were around 6 million voters in Florida during the 2000 election. This ensued controversy all over America. Despite the fact that there were many issues with this election, there was one other player in the Florida election whom many Democrats blamed for Gore’s loss: the liberal-minded Green Party candidate, Ralph Nader. Nader received 97,421 votes in Florida, many of which Democrats speculated would have gone to Gore had Nader not run. Although this was not nearly enough to win the election, it may have been enough to tip the scale in Bush’s favor.

Due to the razor thin nature of swing state elections, a byproduct of the Electoral College and the winner-take-all system, third party candidates create a disadvantage to like-minded mainstream candidates, thereby potentially changing the outcome of elections.⁶⁶ In American presidential elections, it is not a rare occurrence for a few states to be the main determiners of election results. Politicians tend to ignore predominantly red or blue states because the distribution of electoral votes is not proportional to voter preferences in a winner-take-all election. As long as there is a majority of people who will consistently vote for a certain party, the state's electoral votes become almost a certainty, and politicians can disregard the minority of voters who may not vote for a state's predominant party. As long as a politician has a plurality of votes, they receive all of a state's electoral votes (this is with an exception for Nebraska and Maine). This condition further incentivizes politicians to target swing states, where there is no

⁶⁶ See definition below in glossary (Page #14,15 &16)

dominant political party and election results are more uncertain. As historically all presidential candidates campaign heavily in swing states, voting margins have grown even smaller, creating situations such as the 2000 election. Such narrow margins magnify the effect of third party candidates because the votes they receive can become enough to tip the scale into the opposition's favor. Out of the nearly ten thousand votes that Ralph Nader secured in Florida, researchers predicted 60% would go to Gore.⁶⁷ Because Bush won by a 537 vote margin, 6,000 votes could have easily changed who won Florida, thus changing the outcome of the election. The whole situation resembles a domino effect, with the winner-take-all system allowing for swing states to become the determiners of the election. The increased focus on swing states creates narrower margins, and those narrow margins then allow for third party candidates to change the state's popular vote winner, thereby potentially changing the whole election. The point of this argument is not to convince readers that the election of 2000 would have turned out differently had Nader not run—that is an unanswerable question; rather, the point is to show how vulnerable the presidential election process is to even the most minor third party candidates. After the election, millions of Americans felt outraged with Bush becoming president. Scholars throughout the country questioned the legitimacy of the election. Unlike the 1912 election, which showed a rare case in which there were three prominent candidates in the election, Ralph Nader didn't have nearly as much popularity on a national scale in comparison to Teddy Roosevelt in 1912. Nader received a mere 5% of the popular vote, and 0 electoral votes. The 2000 election shows even a candidate with no electoral votes can disturb the election under the current system. Similarly to the 1912 election, a split in Florida's liberal votes served as an advantage for the Republican candidate, however in this scenario, this advantage likely overturned the result of the 2000 election.⁶⁸

George Wallace and the 1968 Presidential Election

Whereas both 2000 and 1912 exemplifies how third parties can alter the results of an election, the 1968 election featuring George Wallace takes it one step further, showing how third

⁶⁷ Michael C. Herron and Jeffrey B. Lewis, "Did Ralph Nader Spoil a Gore Presidency? A Ballot-Level Study of Green and Reform Party Voters in the 2000 Presidential Election" [Did Ralph Nader Spoil a Gore Presidency? A Ballot-Level Study of Green and Reform Party Voters in the 2000 Presidential Election], *Quarterly Journal of Political Science*, 1-29, abstract in *Quarterly Journal of Political Science*, accessed September 6, 2022, <https://doi.org/10.1037/0002-9432.76.4.482>

⁶⁸ Herron and Lewis, "Did Ralph?"; Klarreich, "Election Selection," [Page #280]; Shugart, "Elections: The American," [Page #640-644].

parties can accomplish this through corrupt means. The 1960s, similar to the Progressive Era, was a decisive era in American history. This decade saw the peak of the Vietnam War, antiwar protests, and the Civil Rights Movement. Around this time George Wallace, the governor of Alabama, gained fame and notoriety in the South for his pro-segregation viewpoint. Wallace ended his inaugural speech with the infamous quote, “segregation now, segregation tomorrow, segregation forever!”⁶⁹ He became a champion for enraged Southern voters by feeding on their resentment towards marginalized groups (particularly African Americans) and the government. His tactical rhetoric got through to people all over the country, garnering support from almost half of the conservative Democratic voters in Wisconsin, Indiana, and Maryland.⁷⁰ With the 1968 presidential election approaching, Wallace announced his decision to run as a third party candidate against Republican candidate Richard Nixon and Democratic candidate Hubert Humphrey, but many Americans believed he was not running so that he could become president.⁷¹ Rather, they suspected George Wallace’s objective was to prevent both Nixon and Humphrey from receiving a majority of votes.

In an interview with the press, a reporter questioned Wallace’s intentions for entering the race, to which he responded, “Well, let me say this, that, yes, I’m in the race to spoil, but not to spoil in the sense that you’re talking about — [it] is to spoil the chances of both national parties electing a president.”⁷² Although he had a significant amount of support, Wallace knew – being an independent candidate and a segregationist radical – he wouldn’t have nearly enough to win the presidency. However, if Wallace received enough votes to prevent neither Hubert Humphrey nor Richard Nixon from getting a majority, then the House of Representatives would determine the president. In 1968, the Democrats overwhelmingly controlled the House of Representatives, so it was common belief that Hubert Humphrey would become president if the election was

⁶⁹ Biography.com Editors, ed., "George C. Wallace Biography" [George C. Wallace Biography], The Biography.com, last modified October 6, 2020, accessed July 12, 2022, <http://biography.com/political-figure/george-wallace>.

⁷⁰ Dan T. Carter, "Legacy of Rage: George Wallace and the Transformation of American Politics," *The Journal of Southern History* 62, no. 1 (1996): [Page #7-11 & 26], <https://doi.org/10.2307/2211204>.

⁷¹ Michael Barbaro, episode 889, "A Peculiar Way to Pick a President," October 22, 2020, in *The Daily*, narrated by Jesse Wegman, produced by Theo Balcomb, podcast, <https://www.nytimes.com/2020/10/22/podcasts/the-daily/electoral-college-trump-clinton-gore-bush.html?smid=url-share>, 34:46.

⁷² Reel America, "Face the Nation with George Wallace," hosted by Martin Agronsky, Nelson Benton, and Joseph Kraft, performed by George Wallace, aired April 12, 2018 (first broadcast July 21, 1968), on C-Span, accessed September 6, 2022, <https://www.c-span.org/video/?443769-2/face-nation-george-wallace>.

thrown to the House. In this scenario, people speculated Wallace would concede and convince his electors to support Nixon on the condition that Nixon would comply with Wallace's political demands.⁷³ When asked by a journalist, Wallace confirmed that he selected multiple electors who would either vote for him or whomever he approved of, with some even signing a pledge to do so. He stated that in the situation of a deadlock, "the chances are the [electoral] votes probably would have gone to Mr. Nixon."⁷⁴ When asked if he'd demand concessions in exchange for his support of Nixon, he replied, "we would probably have asked Mr. Nixon to reiterate some of his campaign statements he'd already made . . . just to restate what he had already said in substance."⁷⁵ His plan replicated what happened in 1877, when a few Democratic electors struck a deal with Republican candidate Rutherford B. Hayes. The electors agreed to vote for Hayes, and in exchange, Hayes agreed to halt Reconstruction in the South, a decision that led to decades of segregation and Jim Crow laws.⁷⁶

A third candidate running in the presidential election process can create a scenario in which the election is determined not by the voters, but by the corrupt interests of a few powerful political figures. The Electoral College has one defining factor that sets it apart from a plurality system: the winning candidate must receive the simple majority, not the plurality. In an election with two candidates, one candidate is guaranteed the majority; however in an election with three candidates, no one has a guaranteed majority. If this happens, all sorts of issues can arise. The potential of a corrupt bargain is more likely because mainstream candidates become incentivised to bargain with third parties for electoral votes. To make this situation plausible, all third party candidates need are a few loyal electors willing to comply with the demands of the third party candidate. Although it may sound far fetched, this is surprisingly likely considering the nature of the Electoral College. It's unlikely a third party candidate can control the votes of millions of Americans, however, in the College, a few electors represent millions of votes. For example, in 1968, George Wallace's staunch segregationist views were beginning to die out. Those who agreed with Wallace's politics supported Wallace simply to halt integration. In the case of 1968, Wallace had electors sign pledges so he could bargain with Nixon to prevent a contingent election. The 1968 election was an extreme case in which a candidate tried to exploit the

⁷³ Barbaro, "A Peculiar."

⁷⁴ George C. Edwards, *Why the Electoral College Is Bad for America* (n.p.: Yale University Press, 2019), [Page #93], <https://doi.org/10.2307/j.ctvmd868v>

⁷⁵ Edwards, *Why the Electoral*, [Page #93]

⁷⁶ Edwards, *Why the Electoral*, [Page #94].

electoral college, but one can only imagine what would transpire had George Wallace successfully deadlocked the election.⁷⁷

The fact that the presidential election process even allows for such occurrences should be enough to raise questions about its legitimacy, and in fact, it did. Although Wallace was not successful in spoiling the election due to a poorly managed campaign and overly radical ideas, his intentions were clear to millions of outraged Americans.⁷⁸ Wallace's campaign propelled the largest nationwide protest against the Electoral College, led by Birch Bayh, former three-term Democratic Senator from Indiana. Eighty percent of Americans, people and politicians from all sides of the political spectrum, supported abolishing the Electoral College. In 1969, the House voted overwhelmingly to abolish the Electoral College, with even then-Republican President Nixon on board. However, as soon as the bill got to the Senate, it was filibustered by Strom Thurmond, a Southern segregationist who was well aware that the Electoral College would be beneficial to his state. George Wallace's actions awoke many Americans to the Electoral College's vulnerabilities, starting one of the largest and most prominent campaigns to abolish the system. Although he failed in his original plan, he did make an impact on American history. George Wallace taught Americans the consequences of having a dangerous third party candidate in the Electoral College.⁷⁹

Alternative Perspectives

The American presidential election process has a vulnerability to third party candidates, therefore many would argue Americans should change the system. Some; However, supporters of the Electoral College and the current presidential process argue that the system should not be replaced because its benefits outweigh its flaws. The literature provides three primary reasons for this belief. One is that the Electoral College maintains federalism. The American government is built on the belief that no individual or group of people should hold all the political power. In the Electoral College, states have the right to choose their electors however they please. This gives them the power to determine how their electoral votes will be allocated. Furthermore, supporters

⁷⁷ Edwards, *Why the Electoral*, [Page #91-97]

⁷⁸ John Paul Hill, "A. B. 'Happy' Chandler, George C. Wallace, and the Presidential Election of 1968," *The Historian* 64, no. 3/4 (2002): [Page #667], <http://www.jstor.org/stable/24451026>.

⁷⁹ Jesse Wegman, "The Man Who Changed the Constitution, Twice" [The Man Who Changed the Constitution, Twice], *The New York Times*, last modified March 14, 2019, accessed September 6, 2022, <https://www.nytimes.com/2019/03/14/opinion/birch-bayh-constitution.html>.

of the College believe that the American government is more stable due to the two party system. Countries with more than two political parties sometimes have trouble agreeing upon government coalitions because there are many different ideologies. Also multi-partisianism encourages the rise of extreme, single-issue candidates who can potentially get voted into office. Lastly, eliminating the Electoral College would cause small states and regions with less population to lose their voice in government. Many scholars are concerned that politicians would begin targeting big cities and states all while forgetting about rural areas and small states.⁸⁰

Conclusion

The presidential election process has a vulnerability to third party candidates, but the solution cannot be to prohibit third parties from participating in presidential elections. America needs a multitude of voices and opinions to generate a consensus on how to operate government. The problem is not with third party candidates, but with the Electoral College itself. So if not the Electoral College, how does America elect a leader? One example is the runoff voting system currently used in France. This system allows for numerous candidates to run in the first election round, while the top two then advance into the final round. This ensures that voters have a chance to vote between a wide array of candidates in the first round, while in the final round, they can vote for the whomever they prefer out of the two finalists. In another instance, Sweden is just one of the many countries to use proportional representation, a system in which governing seats are assigned according to total vote proportions, not whoever receives the most amount of votes. Proportional representation ensures all voter's voices are heard, not just those who prefer a winning candidate. It is quite ironic that America, being a revolutionary in democracy, is not following the worldwide trend to better Democratic systems. It is time Americans abolish the Electoral College and find a more representative system.

Glossary

Electoral College- The Electoral College is an American electoral system that is a part of the presidential election process. The Framers of the US Constitution introduced this system to compromise between electing the president through the senate versus through the popular vote.

⁸⁰ Maria Lynn Mccollester, "COUNTERPOINT: PRESERVING THE ELECTORAL COLLEGE," *International Social Science Review* 82, no. 3/4 (2007); <http://www.jstor.org/stable/41887328>.

The Electoral College awards each state a certain number of electoral votes depending on its size and population. Electors, a group of state appointed officials, determined to whom to allocate their state's electoral votes. Although most electors vote according to their state's popular vote winner, they are not federally bound to do so. Once the majority of electors vote for a certain candidate, that candidate receives all of the state's electoral votes; a candidate who receives a majority of votes, wins the election.⁸¹

Contingent Election- A Contingent Election is when none of the candidates in an American presidential election receive a majority of the electoral votes. In this scenario, the members of House of Representatives vote between the top three candidates and whoever receives the plurality becomes president. A contingent election has only happened one time in American history, during the 1824-1825 election.⁸²

Winner-Take-All (Plurality) System: A system in which the winner with the most votes receives all the representation.⁸³ For example, in the Florida 2000 election, former president George W. Bush won 2,912,790 votes and former vice president Al Gore won 2,912,253 votes. Due to Florida's infamous 537 vote margin in the 2000 election, George Bush won all of Florida's 25 electoral votes.⁸⁴ 48 out of the 50 states use this method to allocate their electoral votes. Also it is important to note that plurality voting is not completely implemented in the final presidential election because the winning candidate needs 270 electoral votes, regardless of whoever receives the majority. If no candidate receives the majority, then the election is thrown to the House of Representatives where the plurality system is once again implemented.⁸⁵

⁸¹ Dave Roos, ed., "Why Was the Electoral College Created?" [Why Was the Electoral College Created?], History, last modified December 14, 2020, accessed August 26, 2022, <https://www.history.com/news/electoral-college-founding-fathers-constitutional-convention>; National Archives Editors, ed., "Electoral College Timeline of Events" [Electoral College Timeline of Events], National Archives, last modified July 24, 2020, accessed July 12, 2022, <https://www.archives.gov/electoral-college/key-dates>; National Archives Editors, ed., "Electoral College History" [Electoral College History], National Archives, last modified December 17, 2019, accessed July 12, 2022, <https://www.archives.gov/electoral-college/history#whyec>; National Archives Editors, ed., "Distribution of Electoral Votes" [Distribution of Electoral Votes], National Archives, last modified March 6, 2020, accessed July 12, 2022, <https://www.archives.gov/electoral-college/allocation>; Official Guide to Government Information and Services, "Presidential Election Process" [Presidential Election Process], USA Gov, last modified September 13, 2022, accessed September 14, 2022, <https://www.usa.gov/election#:~:text=The%20number%20of%20electors%20each,270%20votes%20or%20more%20wins>.

⁸² Edwards, *Why the Electoral*, [Page #78-80]

⁸³ Shugart, "Elections": The American," [Page #640].

⁸⁴ Herron and Lewis, "Did Ralph," abstract

⁸⁵ Official Guide to Government Information and Services, "Presidential Election Process" [Presidential Election Process], USA Gov, last modified September 13, 2022, accessed September 14, 2022,

Swing States: Swing states or battleground states, are states in which there are a relatively equal amount of Democratic and Republican voters. Politicians coined the term, “swing state” because the state can swing from red to blue or vice versa.⁸⁶

Spoiler Effect: The spoiler effect is likely to occur (in a plurality system especially) when a third party is on the same side of the political spectrum as a mainstream party. The existence of a third party splits the votes on one side of the political spectrum, stealing votes that would have otherwise gone to the mainstream party. This then gives leeway for the opposing mainstream party to win the election.⁸⁷

<https://www.usa.gov/election#:~:text=The%20number%20of%20electors%20each,270%20votes%20or%20more%20wins>.

⁸⁶ Shugart, "Elections': The American," [Page #640-644].

⁸⁷ Matthew Soberg Shugart, "Elections': The American Process of Selecting a President: A Comparative Perspective," *Presidential Studies Quarterly* 34, no. 3 (2004): [Page #640-644], <http://www.jstor.org/stable/27552617>.

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Personal Experiences of Modern-Age Christians from Europe and North America: A Case Study by Jiankun Peng

Abstract

Over the past 15 years, few research projects have covered the in-depth personal faith experiences of Christians from Europe and North America, as well as the misconceptions they experience. The current project intends to cover the gap through a preliminary survey and subsequent interviews online with Christians who fit this broad demographic. This study emphasizes detail by employing thematic analysis and a case study structure. Initially, a set of themes is identified through survey responses. Then, these themes are elaborated on and refined through the specific personal accounts of 6 people who participated in an interview. Based on the experiences shared by these interviewees, the results indicate the following. First, Christianity influences the participants' understanding of the meaning of life, shaping their actions and priorities depending on their interpretation of meaning and faith. Second, although obligations in Christianity are not immutable, obligations still conflict with the participants' desires, but the participants continue to find fulfillment in upholding their commitments. Despite disagreements from non-Christians, the participants hold Christian moral standards to non-Christians with good intent. Third, Christianity shapes the participants' daily lives by providing support through adversities, encouraging gratitude, and easing away anxieties. Finally, the participants reported experiencing a range of misunderstandings about their faith, including spreading false details about Christianity, believing that Christians are intentionally hostile toward people with different beliefs, assuming that Christianity and science are incompatible, and considering Christianity as a fixed set of rules. Overall, the present study helps deepen the understanding of the perspectives of modern-age Christians from Europe and North America by focusing on a few detailed, unique personal accounts.

Introduction

Despite this rapidly evolving 21st century, many older traditions remain, including religion and faith. This case study seeks to deepen the understanding of western Christianity in the last decade by inspecting the personal experiences of Christians from Europe and North America. Using in-depth interviews with individuals drawn from a survey sampling an online

Christian community, this study investigates how their faith interacts with their lives. Furthermore, the study examines the misconceptions and misunderstandings experienced by modern Christians themselves. In these ways, by focusing on the perspectives and lived experiences of modern Christians from Europe and North America, the study intends to learn more about Christians in the world today.

Literature Review

My goal for this project is to qualitatively examine the personal experiences and daily lives of modern Christians from Europe and North America. I reviewed literature with this topic in mind. The current literature review particularly focuses on studies of the past 12 years to ensure they are relevant to “modern Christians.”

Few literature matched the demographic and topic I have in mind. First, existing literature that explores personal experiences and daily lives of modern age Christians have different demographic focuses. Some research projects examined populations of specific age groups, such as college students and emerging adults (Guest et al., 2013; Baloch et al., 2014; Drovdaal & Keuss, 2020). Some recruited participants from particular geographic regions, including upper Midwest U.S. (Berg, 2012), North America Pacific Northwest (Guest et al., 2013), and Stockholm county, Sweden (Moberg, 2013). A few studies also recruited participants of particular ethnicities, such as Chinese immigrants in the U.S. (Lu, 2012). Second, the scope of the reviewed projects are either narrower or broader than Christianity itself as a religion, which is my intended area of study; these projects either focused on specific denominations of Christianity, such as Evangelicals (Polonyi et al., 2011), or on the influence of religiousness in general (Reuter, 2012; Koenig, 2012; Abbasi et al., 2013; Park et al., 2019). In summary, existing literature has studied the personal experiences and daily lives of modern age Christians through a variety of specific demographics based on age group, geographic region, ethnicity, and denomination of belief. Some studies are also conducted for religiousness in general, not specific to Christianity. Few studies, however, have examined this topic through Christians from Europe and North America, regardless of the above factors.

Other studies related to the relationship between modern lifestyle and Christian faith are based on quantitative methods, rather than qualitative, which is my intended method. For example, Abbasi et al. (2013) used quantitative analysis of survey and interview data to study the

effect of modern life on religious practices. Similarly, Koenig (2012) conducted a comprehensive review of studies regarding the relationship between religion and health, and strictly reviewed studies that used quantitative data. Likewise, Park et al. (2019) examined the relationship between religiousness and well-being through 22 prior studies that used quantitative data.

Evidently, there is little in-depth, qualitative research that studies how the faith of Christians from Europe and North America influence their everyday personal experiences in the modern age, regardless of their denominations, ethnicities, and age. To address this research gap, I utilize a case study approach and a comprehensive thematic analysis to examine the open-ended survey responses and interview data of self-identified Christians' personal experiences and general daily life. I sample participants on Reddit, a popular American social media platform available worldwide, and specifically in its sub categorical community "r/Christians." Initially, I surveyed participants without any demographic restrictions, in order to enroll as many participants as possible. However, in the interview stage, I only included participants who indicated they are from Europe or North America, and only performed case study research on them.

Moreover, there is little research over the last 12 years regarding what modern Christians themselves subjectively experience as misconceptions. There are, however, studies that cover objective biases against Christians, such as how they are viewed by professors as being less capable in fields of science (Barnes et al., 2020). This gap is identified and partly addressed through interviews and an open-ended survey question of the current study. I believe these topics are critical to set foot on because they help gain a better understanding of Christians nowadays and why they keep their faith in the contemporary context, in a personal and in-depth manner. This, in turn, may contribute to clarifying the identities of modern Christians from Europe and North America and mitigating misunderstandings due to stereotypes about them.

Methods

Rather than basing conclusions on general trends in large samples, case studies thoroughly examine a few individuals, events, or systems within a context (Bromley, 1986). This property makes case studies more effective for formulating intricate theories and hypotheses that require subtle details and makes it easier to determine the roles of particular variables in a phenomenon (Levy, 2014). The structure of a case study is suitable for the current project in the

following ways. First, the depth of case study analysis helps me to more easily identify causal relationships between specific variables that contribute to my core research question. In addition, performing comprehensive qualitative analysis on participants' responses allows me to more easily identify subtle connections and trends shared among different testimonies, which can further help me to accurately answer my research question and possibly formulate a broader theory about faith. Therefore, although I distributed a survey, the main focus of this study is on the survey's open-ended responses and the specific interviews conducted with a small number of individuals. These individuals belong to the same context of modern western Christianity as well. As such, this project utilizes the structure of a case study.

Analytical Approach - Thematic Analysis

Thematic analysis is a method used for qualitative analysis. It involves recognizing shared patterns across raw qualitative data by analyzing and interpreting their meaning (Braun & Clarke, 2006). Thematic analysis aims to identify explicit meaning from larger portions of data and infer implicit meaning from them (Guest et al., 2012). It is therefore suitable for examining the in-depth and expansive lived experiences of participants without restricting them to fixed survey questions. By coding with a consistent standard, or labeling data as part of a theme, general trends across multiple sets of data can also more easily be seen(Guest et al., 2012). In the current study, thematic analysis is appropriate for several reasons. First, the widely scattered data from the open-ended survey responses and interviews are difficult to objectively quantify otherwise. Second, new themes can be uncovered along the analysis process, which can produce a wider range of answers to my research question, especially those that were not necessarily expected. Additionally, thematic analysis helps to gain deeper insight into the personal experiences of the interviewees and survey respondents. Lastly, identifying broader themes through thematic analysis can help me formulate more general theories about Christianity. Thus, this project implements thematic analysis from the survey responses and further in the interviews, with the themes generated and refined. Initially, I located open-ended survey responses that are relevant to the core research question, and grouped together responses with similar sentiments, forming an incipient set of themes. Then, relevant responses of greater detail are located in the interviews, which contain in-depth narratives of the participants that help refine

and support the themes and potentially discover new ones. Finally, all responses are color-coded based on their themes, which are further explored, analyzed, and drawn conclusions from.

Research Design & Population

The population of this study are people from an online Christian community of 50000 members, named “r/Christians”, located on the website Reddit. I made a post on the community to gather volunteers to answer my digital survey, and asked the respondents whether they are interested in a follow-up interview. There were no restrictions as to who can answer the survey, but to participate in an interview, the participants must indicate that they are from Europe or North America, for the purpose of my study. Apart from the optional demographic questions, the survey contained 8 multiple choice questions about their Christian faith (with the option to elaborate on their responses), and 3 open ended questions that are more in-depth about their personal experiences with Christianity. The participants completed their survey responses on their own, and their responses are automatically recorded by Google Forms. In the interviews, participants are asked to further elaborate on the responses they provided in the survey, where appropriate. Also, the interview incorporates an extra question about Christianity’s view on death and existentialism, so as to gain understanding on an additional topic that was not covered by the survey. Confidential audios of the interviews are recorded under consent, and their transcripts were generated using phone audio recorder. After gathering all the responses of the participants from both the survey and the interviews, a manual thematic analysis is performed. First, an initial set of themes are generated from open-ended survey responses. Then, these themes are further explored and elaborated by analyzing the transcriptions of the interviews. Thematic analysis is the main method of drawing conclusions to my core research questions.

This study took place from June 21st to June 27th 2022 on “r/Christians.” Data are gathered from the survey and the interviews, on which thematic analysis is performed. In total, the survey received 68 responses, and 3 were ruled out for responding “No” to “Do you believe in Christianity?”, so 65 remain. 6 people, who indicated they are from Europe or North America, participated in an interview, which all lasted between 10 and 30 minutes. The participant pool is moderately diverse with regards to political orientation, branch of faith, and how long they held their faith. Of the 65 participants, 16 are Republican, 10 are Democratic, and the remaining 39 identify as other political orientations, including ones outside of the U.S. political system. 37 are

Protestant, 7 are Catholic, and the remaining 21 belong to one of more than five other branches of belief. The length of time which the participants had had their faith varied from half a year to more than 40 years. However, in terms of race and gender, the participant pool isn't very diverse. 45 participants self-identify as men, and 20 identify as women. 47 are Caucasian, 6 are Asian, 5 are Hispanic, and 4 are African American.

Discussions

In my survey, participants had the option to provide their email addresses if they wished to be contacted for a follow-up interview to elaborate on their survey responses. Out of the survey participants who provided their contact information, six ultimately arranged an interview with me by phone calls, Discord, or Google Meet. One interviewee is Hispanic and five are Caucasian. One identifies as a woman and five identify as men. The interviews lasted between 10 to 30 minutes. I requested the participants' consent to audio recording under the condition that I keep the recordings confidential, by removing all identifying information, including email and phone number, except for their first name. The audio recorder on my phone generated the transcriptions, which I mainly used for analyzing results.

After performing thematic analysis on interview transcriptions, the interviewees' personal experiences related to Christian faith are mainly as follows. First, their meaning of life is directly associated with God and God's teachings about life. Second, participants willingly abide by religious obligations, and though the regulations may not be absolutely followed, compassion and grace are what guide them through conflicts between the obligations and the participants' everyday decision making. Compassion, a core value of Christianity, addresses the fact that humans cannot flawlessly follow obligations and their need for God's forgiveness, mercy, and grace in every moment in life. Third, faith influences participants' daily lives by lifting them up through hardships, helping them appreciate small things in life, and providing peace against anxiety. In terms of my second research question, participants brought up a number of misconceptions they experienced. This incorporates portraying factual details of Christianity inaccurately, believing Christians are hostile toward outsiders, supposing that Christianity conflicts with science, and assuming that Christianity is only a set of rules. The points above are elucidated in the following texts.

The relationship between meaning of life and Christian faith

Several interviewees talked about what life means to them in relation to their Christian faith. Some consider life on Earth as a time to prepare for life after physical death, while others find purpose in interacting with different aspects of Trinity. In any case, God and Christianity is indubitably a part of their greater goals of living.

A few interviewees orient their meaning of life towards living in accordance with God on Earth to prepare for the afterlife. This focus can either possibly bring a greater sense of purpose or a sense of fear. Interviewee Stef, for instance, believes that living by the commandments listed in the Bible and taught to her by her church is the path to leading a successful life. She thinks that living this way will help her become a good human being, which can eventually lead her to heaven after physical death. Interviewee Jacob considers life on earth as an opportunity to respond to the gift of God - Jesus' self-sacrifice that once saved all human beings without anyone paying the cost. He believes that human afterlife depends on how one responds to this gift, and implies that there are terrifying consequences if one rejects it. He further explains his perspective as follows, "If we live in accordance with [the gift], when we die, we have no fear because we'll be standing in front of God, who will say... 'Well done. Good and faithful servant.' The hell is a real place... where those who reject him will go... out of His presence." In fact, to Jacob, the consequences of rejecting the gift of God are so serious that he is willing to go out of his way to share the gospel with others, and welcome new people to his church. Similarly, interviewee Ethan believes in the idea of living life according to God's virtues, but he details what its greater purpose means to him. To him, the fact that there is heaven, an end goal that all humans are constantly working towards, helps him to keep focus in life, knowing that nothing is pointless. For Stef, Jacob, and Ethan, the purpose of life is to live a good life on Earth according to God, which they believe will grant them a happy afterlife. In some instances, like Jacob, there is an element of fear in play; for others, like Ethan, however, this idea gives a sense of purpose that helps to keep focus in life.

Other interviewees do not focus on the afterlife when discussing the meanings of their lives. Instead, they manifested different aspects of Trinity through their perception of living life as a Christian. Trinity is a fundamental belief in Christianity that the single God is of three persons: God the Father, Jesus Christ the Son, and the Holy Spirit. Interviewee Dave, for instance, states

that his fundamental meaning in life is to honor his relationship with God the Father. The nuance here is that Dave primarily emphasizes his relationship with God, rather than living in accordance with God for the sake of achieving a better afterlife. Yet, the two coincide, since the way he honors his relationship with God involves going to church, practicing the teachings of his faith, and honoring his friends and families. Dave also delineates the degree and scope of the meaning of his life. In terms of degree, he used to indulge in the immediate pleasures of hedonism, such as alcohol and sex, but now he found the lasting happiness of close familial relationships more important. In terms of scope, while Dave serves his immediate friends and families, he also tries to contribute to larger causes that extend to his country, humanity as a whole, and even God. Influenced by his faith, Dave seems to have a thorough understanding of his priorities in life, as he honors his relationship with God. On the other hand, interviewee Jason centers the meaning of his life on the allegedly perfect life of Jesus Christ the Son. He considers Jesus' incarnation the example of a perfect human, and strives to live the way he did as documented in the Bible. Specifically, he focuses on serving others proactively, which Jesus emphasized. To Jason, this encompasses doing his best to help others, loving others including strangers, and forgiving others when they wrong him. Sometimes, this even expands to loving his enemies, which certainly requires one's proactiveness that Jesus stressed. While Dave honors his relationship with God the Father to seek guidance for his purpose in life, Jason does so by following the path taken by Jesus Christ the Son, who was incarnated as a full human being with full divinity. They focus on different aspects of Trinity, which further grants them different meanings to their lives.

Ultimately, the interviewees root the meaning of their lives in Christianity, but in their own ways and according to their own interpretations of faith and life. There are no strict, immutable paths set in stone that all Christians must follow. Whether they choose to focus on their relationship with God, or live to have a peaceful afterlife, one thing is certain: faith has shaped their understanding of what it means to lead a successful life, and influenced their actions on a daily basis.

Religious Practices and Obligations in Daily Life

Most Christians practice their beliefs daily, and have religious obligations they commit to. Although these obligations are not bound by absolute rules, they still conflict with what

Christians desire to do. However, Christians continue to follow those rules that non-Christians are not motivated to follow because they find fulfillment in doing so. The participants noted that, although Christians cannot flawlessly abide by rules, Christianity addresses this human imperfection through God's compassion.

Although there are no hard rules in Christianity, obligations can still be challenging to abide to. From Dave's perspective, rules in Christianity act as guidelines down a path for long-term benefit. Yet, Dave acknowledges that, still, many decisions are difficult because they conflict with the moral applications of faith. In Dave's case, an example of this would be choosing whether to indulge in hedonism or invest in long-term goals - the same dilemma of ephemeral pleasure versus long-lasting happiness that was discussed in the previous section. Evidently, although rules in Christianity are not absolute, they may still conflict with one's day to day desires.

Why, then, do Christians follow these rules and obligations? While some participants tie it back to Christianity and the meaning of life, others, like interviewee Sjors, give a more straightforward answer. Sjors used to keep his religious faith to himself, but when he began actively attending church activities, his perspectives shifted. In his own words, "Going to church more and speaking to people, I just realized that love sets you free. I love God. And being a child of God makes you want to abide by those rules." Sjors highlights the social aspect of Christianity as he practices his faith with others, from which he derives a sense of love that liberates him (although he didn't further explain how). He explains that this sense of love towards his people and God encourages him to commit to his religious obligations. He wishes to do so, and it is his own decision; Christianity never forced Sjors to unwillingly follow rules. Love for your neighbors and love for God – a critical part of Christian faith – encourages Christians to abide by their duties.

While Christianity sets moral standards, it also acknowledges humans' sinful nature to not fully live by Christianity's moral principles - there are non-Christians who don't follow the rules of Christianity at all. According to the participants, Christianity addresses this inherent flaw through God's compassion. Coming with respect and good intent, then, Christianity is open to presenting controversial ideas, even to people who may disagree, in order to spread more information and awareness of different opinions to non-Christians. In Ethan's view, Christianity is an all-encompassing religion that touches on an abundance of highly debated topics, which

may upset outsiders. However, Christianity is meant to present its views on these controversial topics in a compassionate manner. For example, according to Ethan, Christians should not condemn homosexuality only for the sake of denouncing or insulting someone; if they do so, its sole purpose should be to raise awareness of the Christian point of view in a loving manner, so that others learn new information. Ethan puts it as, “you tell people their faults, and you love.” That being said, Ethan concedes that when presenting controversial ideas, he has often seen Christians doing so maliciously, insulting others, which defeats the purpose of compassion in spreading Christian beliefs. But compassion isn’t always about spreading Christian teachings to others - it is also about accepting the ideas of the other side. This is captured in what Jason found to be the hardest teaching to follow in Christianity, loving your enemies. He reasons that, given how humans inherently prioritize their own needs, being self-sacrificing is very difficult. But this compassion is critical for upholding the love that Christianity champions.

All things considered, rules in Christianity are not absolute, and serve as guidelines, but they may still conflict with Christians’ desires daily. However, they continue to follow these guidelines, motivated by what Christianity means to them and the social aspect of love in Christianity. Furthermore, understandably, Christian obligations may not be perfectly followed by all humans, especially those who are not Christians to begin with. The compassion aspect of Christianity addresses this by attempting to spread their teachings, with good intent, to outsiders, and also by accepting perspectives that differ from theirs.

Christianity shapes individuals’ mindset towards different aspects of everyday life in multiple ways. First, by God and God’s teachings, it provides mental support for Christians to overcome obstacles in life, and encourages them to move on from such situations as well as past personal mistakes. Second, through God, individuals are able to notice and appreciate subtle details in everyday life, which contributes to cultivating a sense of gratitude and optimism. Third, Christianity brings a sense of peace to its believers via practices such as praying and teachings that help Christians establish their own mindsets for approaching anxiety, such as focusing on the greater purpose. Ultimately, the way faith shapes one’s day to day life depends on one’s own relationship with faith, and may vary drastically, as demonstrated by the different responses provided by the interviewees.

Almost inevitably, everyone struggles at some point in their lives. A few interviewees shared their personal stories of struggle, and discussed how their Christian faith played a

prominent role in helping them to overcome those obstacles. Some put their faith into God's hands to gain motivation for persistence, whereas others prevailed through the repentance of sins. Christianity supports people to grow from their mistakes and face down their struggles.

One interviewee overcame his difficulties mostly through his belief that God is watching over him and paving his way for a flourishing life. For Jacob, there was a period of time when he felt lost, when he was living in Kentucky and there was no progress in life. He couldn't find a job, his relationship ended, his friends were moving away, and he felt isolated. Jacob questioned why this happened to him, and he doubted God. But he held onto his belief that there is no area of life where God's fingerprint doesn't exist, and that God predestined everything - God already determined everything that will happen, all for the greater good. Down this line of reasoning, Jacob knew that his suffering would serve a greater purpose - albeit one that he might not necessarily comprehend at the time - so he persisted. Eventually, Jacob's sufferings paid back, as he encountered good news one after another: being invited to live with his brother, meeting his wife, getting a new job where he was promoted multiple times, and having children. In hindsight, Jacob thinks that God was preparing a way for him to come where he is now. By trusting that God does not waste time, Jacob found support for pushing through a seemingly hopeless time in his life. It also gave him a sense of optimism to help him confront future challenges.

In the same vein, Christianity has supported Dave through some major barriers of his life, but what helped him most was Christianity's view on sins and repentance. During his unhealthy abuse of alcohol, he had a particularly bad argument with his wife, in which he raised his hand to her. Dave explains how his Christian faith set him back onto the right path, "one of the teachings of Christianity is that if you recognize what you've done wrong and you wish to do better, you can be forgiven." This forgiveness, in turn, brought Dave peace, and because of peace, he found gratitude. Dave ended up going to recovery meetings. Christianity recognizes that humans are fallible, and sins can be forgiven. This motivates people to improve and change from the faults of their past. Dave states that Christianity allowed him to move on and become a better person in spite of what he has done. Knowing that there is still hope to lead a better life, despite his previous alcohol abuse and domestic violence, Dave was driven to become better - a dedication he might not have gained without Christianity. With the possibility of change given by Christianity's emphasis on repentance, one is encouraged to set themselves in the right direction, moving on and improving from the wrongs they have done in the past.

Sjors, who is from the Netherlands, relied on similar teachings about repentance, but with more attention towards self-acceptance. He has had his Christian faith since his younger years, but kept it to himself and felt ashamed for it, because, according to him, Christianity wasn't socially welcomed in his country at the time. Sjors claimed that, later, Christianity also became the very guide that helped him to achieve the acceptance of himself, and so he kept his faith, despite being looked down upon by society. Although Sjors did not elaborate on how exactly Christianity helped him arrive at the acceptance of himself, he does take the idea further to his other personal issues. For instance, as a young adult, Sjors drank and consumed drugs with his friends due to peer pressure and excitement. He applied the idea of acceptance to accept his past self and his past mistakes, not for the sake of continuing drinking or doing drugs, but for the sake of moving on and improving. Sjors says that he knows he is a sinner, and everyone is; no one is perfect. He still feels guilt for what he has done, but there is no reason to hold on excessively to it and hinder himself from becoming a better person. Through Christian faith, not only does Sjors accept who he is despite social stigmas about his beliefs, he also, just like Dave, allowed himself to acknowledge his previous mistakes and use them to help himself become a better person.

Through the experiences of Jacob, Dave, and Sjors, one may see how Christian faith influences people's attitude towards dealing with difficulties in their lives. Encouraged by God and God's teachings, Christians can treat difficulties with a sense of greater purpose, as something to face down, move on, and learn from, without being ashamed of having dealt with them.

Living with gratitude towards small things and with a sense of optimism
People may fall into the mindset of constantly wanting to achieve more, and may overlook the accomplishments they already achieved. From the interviews I conducted with the participants, however, I noticed that Christians often displayed a sense of gratefulness, even for tiny components and matters in life. Two interviewees explained to me how this gratitude connects to their faith.

In the survey, Ethan claimed that he has personally known the efforts of the Holy Spirit, which brought up my curiosity to dive deeper into the topic during my interview with him. I asked why he responded that way and if he has specific personal stories behind the statement. Unexpectedly, he admits he never encountered any marvelous miracles; he simply feels blessed

in his life over little things. Simultaneously, Ethan feels that he hasn't done enough to earn those that he considers blessings. Ethan is appreciative of little things that could have been easily overlooked had he not regarded them as efforts of the Holy Spirit. This also implies that Ethan has a higher sense of gratitude for what he possesses and a higher sense of hope for new blessings, however insignificant, to come to him in the future.

While Ethan enjoys small things, so too does Sjors, but Sjors emphasizes more on God's love. As Sjors describes to me why he feels that God's love is omnipresent, he uses his seemingly mundane yet beautiful mornings as an example, "I was just drinking my coffee and looking outside. And there was a huge bee sitting on a flower, and I was looking at it and I was like, 'wow, it's pretty,' you know? It's the small things and the calm of nature [from which I feel God's love]." In fact, to Sjors, the beauty of everything, the beauty of every individual, the love between people, and the way how everything is connected, are impossible to have emerged randomly; Sjors believes God must have created all that exists. He thus sees these details in life as God's kindness towards him, which helps him to notice even more small subtleties in this world which he can appreciate - something Sjors optimistically looks forward to everyday.

Regardless of how they interpret their experiences, both Ethan and Sjors feel grateful and appreciative of subtle details in life, since they are capable of recognizing anything in this world, however mundane, as gifts from God. They celebrate being alive in this world. This mindset could help them to develop and maintain a more positive mindset overall.

Living Peacefully with Less Anxiety

The most common sentiment among the interviewees is that they find peace through their Christian faith, by various means, including praying, giving one's control to God, and focusing on the greater purpose of Christianity. The first involves active practicing, while the latter two are mindsets that the interviewees adopted over time. None of the practices directly resolve the problems in their lives, but they do help with the anxiety by providing comfort and peace of mind.

One of the main practices that help ease away anxieties is through praying, which Jason pointed out is not a perfect solution that immediately takes away pain or suffering. During what he considered difficult times in college, he prayed, despite knowing that his prayers don't eradicate the issues fundamentally. "Praying through all that doesn't necessarily get answered, or

takes away the pain or suffering, or whatever, but that just gives me peace, you know.” he explained. For Jason, prayers do not need to effectively remedy situations by themselves, but rather they are meant to provide mental support to deal with those situations. Sjors gives more insight into why prayers are powerful in this regard - he says that by talking with God about his problems, he feels reassured that everything will turn out alright. Prayers can thus be used as a venue to share one’s feelings and release one’s emotions to someone - in this case, God - who listens, which people may find comfort in. Stef responded to her mental health crisis, in which she almost tried drugs with her friends, using prayers, too. She had a conversation with God as if God was next to her. She spoke informally as if she were sharing her struggles with a friend, to whom she could pour out her negative feelings. Prayers might not be capable of directly solving problems, but they provide mental support to help individuals overcome those issues on their own.

The second approach to dealing with anxiety involves accepting that humans are not omnipotent, and accepting what humans cannot change. Essentially, the idea is to recognize that one is not fully in control over one’s life, but God is. According to Stef, once a person lets go of having control over absolutely everything, it would feel that burden is lifted. By approaching life this way, Stef adopts a new attitude towards whatever occurs in her life, in which she contently accepts everything as God’s will, since God is the one in full control, not her. This helps her to become more accepting of things she cannot avoid but doesn’t desire, especially those that she cannot influence, such as being forced to quarantine due to the COVID-19 pandemic. Stef’s idea is loosely related to Jacob’s previous point that God has predestined all that will happen, since Jacob is also implying that humans do not have full control over their lives. In any case, building upon Stef’s current line of reasoning, Stef continues to conclude that she is not and will never be perfect, since she will never be in charge of her future as much as she wanted to be. When Stef is unable to alter the past, and powerless to be completely in charge of the future, she is stuck with one option: to focus on living in the present. Once Stef began to deliberately focus on the present alone, she stopped worrying about the future and became less bitter at life - a change she claims that even her friends have noticed.

Finally, focusing on the greater purpose of Christian faith can help prevent unnecessary worries. Ethan adopts this approach, as he concentrates on working towards his afterlife, without being bothered by the regular challenges he faces every day. Thus, he knows that his Christian

faith encompasses a bigger picture - heaven. Given that this is Ethan's long-term goal, he does not worry about small, temporary setbacks in his effort, since those inconveniences pale in comparison to the scale of the ultimate goal of his Christian faith. Perhaps as time goes on, this may help Ethan grow to become even more tolerant, to also consider larger issues in his life as simple, temporary obstacles that he will overcome. Ethan's faith may push him to grow even stronger as a person.

Overall, through their personal experiences, the interviewees demonstrated how praying to God and adjusting their mindset in accordance to their faith help them overcome mental health conditions such as stress. The latter approach - adjusting one's mindset - appears to be especially multifaceted, as Stef and Ethan have their own unique adaptations of the method. Ultimately, faith can be up to one's own interpretation, which opens up many more means for it to bring peace.

What Christians Themselves Consider as Misconceptions About their Faith

Throughout the interviews, participants implicated and explicitly shared their experiences of having their Christian faith being misunderstood by other people who are not familiar with Christianity. They highlighted misconceptions ranging from subtle factual mistakes to alarming presumptions. The experienced misunderstandings include inaccurate fact portrayal, belief that Christianity is hostile towards others who have different opinions, assumption of incompatibility between science and Christianity, and representation of Christianity only as a set of rules. Each interviewee, however, had different experiences of being misunderstood.

Ethan provides an example for factual mistakes, and clarifies that hell, the opposite of heaven, is not necessarily a fiery place as some may believe. He said that, although hell is generally shed in a negative light, there are no unequivocal answers to what it is like precisely, because the answer is vague, even in the Bible. A more significant misconception Ethan responds to is the impression that Christianity aggressively imposes its beliefs on others, since Christians criticize practices they do not condone. Ethan, in turn, argues that Christians are critical of other people because they want to help them. It is meant to alert others that they are stepping into what Christianity considers as sins, to remind them to be careful - a motive that is very similar to the concept of compassion discussed in the earlier sections. "If you really think that somebody's gonna go to hell [because of their practices], you try to help them," is how

Ethan summarizes this situation. However, as mentioned in previous sections, Ethan does acknowledge that there are Christians who are malicious and defeat the purpose of being critical.

On the other hand, what Jason considers as the largest misconception of Christianity is the assumption that the Bible is one book written by one author. He noticed that this assumption helped opposers of Christianity to find contradictions in the texts, whereas in reality, discrepancies can be found because the Bible is written by different authors of different theologies to begin with. Jason emphasizes that the Bible was passed down through generations of different authors, as it evolved through time. People who thought the Bible is one book written by one author have, in a way, also underestimated the diversity of Christianity, by not realizing the abundance of different authors and ideologies underlying this one book that evolved through centuries.

Moreover, Stef indicates that the incompatibility between faith and science is also a misconception. She recounts a miracle she has encountered, in which her life-long Scoliosis condition cured by itself, while her doctor was requiring her to undergo surgery. Her husband had a similar experience, in which his chronic sickness cured by itself too. These events that are unexplainable by science are what makes it hard for her to deny God. Yet, she states that she does believe in science, but sometimes science cannot answer every phenomenon, which is when faith can provide answers. Stef argues that faith and science can, in fact, complement each other.

Furthermore, Dave addresses a misconception he faced, in which people misunderstand the purpose of religious faith by boiling it down to rules. Dave believes that if a religious faith is limited to rules, then that religion is missing its purpose. Rules, according to Dave, are meant to guide its believers down a certain path for their greater benefit. They are not absolute, and there is no fixed way to navigate them.

Altogether, the misconceptions about Christian faith experienced by the interviewees varied in significance. Some are insignificant details, while others have more profound presumptions that may lead to certain stereotypes. Regardless, misconceptions are unavoidable, since, as Christianity points out, humans are never flawless.

Conclusion

Based on my case study with Christians from Europe and North America, the personal life experiences of Christians are mainly as follows. First, for Christians, the meaning of life is

directly associated with God and their commitments to God. Second, the religious obligations of Christians can often conflict with the decisions they wish to make, but they willingly abide by those obligations, even when rules are not absolute. There may be other factors involved, but this can be motivated by their love for God. One of Christianity's core values, compassion, also tries to extend these obligations to non-Christians, with the intent to help them live a better life according to Christianity. Third, faith influences Christians' daily lives in several ways. This includes supporting Christians through difficulties, enhancing their ability to notice and appreciate subtle occurrences in life, and helping them live peacefully from stress. Moreover, Christians face a range of misconceptions. According to the experiences of participants in this study, it includes portraying factual details of Christianity wrongly, believing that all Christians who criticize others are intentionally hostile, assuming that Christianity conflicts with science, and presuming that Christianity is only a fixed set of rules.

All the above conclusions are based on the experiences shared with me by a few Christians in my case study, and may not be appropriate to generalize for all Christians today across Europe and North America. The sampling method of this study can also cause bias: the participant pool entirely consists of volunteers, who are generally more eager to share their experiences with faith, therefore they are more likely to have stronger opinions about the topic. In addition, the results of this study are mostly based on interviews that are open to interpretation; the results could be different had another person performed thematic analysis on the transcripts in my place.

Nevertheless, parts of the results of this study are supported by prior works in the field. For example, Koenig (2012) confirmed an association between faith and various positive emotions, including well-being, happiness, hope, optimism, meaning and purpose, compassion, forgiveness, and gratefulness. In the section where I investigated how faith shapes the daily lives of individuals, the participants displayed and explained that they had similar psychological traits in different personal experiences they shared with me. Koenig also reported that there was overwhelming evidence showing that faith helps one to cope with adversity - a trend which this study found through individuals' personal experiences as well. With regards to misconceptions, Barnes et al. (2020) found that professors were biased against Christian students when evaluating applicants for a Ph.D. program. One participant in my case study has also reported experiencing a related misconception, the assumption that faith conflicts with science.

This study thus addresses the existing research gap I found in my previous review of literature by providing concrete evidence discovered in the lived experiences of modern Christians from Europe and North America. It also supports previous quantitative studies with detailed evidence. On a broader level, the current project provides a deeper understanding about Christianity in Europe and North America for the general public by digging into the lives of a few individuals and examining the experiences unique to them. Moreover, by inspecting Christians' experiences of being misunderstood, this study also attempts to mitigate existing stereotypes in society about Christians and the unnecessary controversies they lead to. As such, the study strives to potentially inform about religion as a whole and the people devoted to one.

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