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Ability Uncertainty Among Females in Engineering: Can Wonder Woman Save the Day?

Abstract

Belonging uncertainty is a state occurring in academic settings when members of socially stigmatized groups are more uncertain of the quality of their social bonds and subsequently more sensitive to issues of social belonging (Walton & Cohen, 2007). Individuals experiencing belonging uncertainty may also experience ability uncertainty, or a sense of uncertainty regarding one's ability and competence in a given domain (Lewis & Hodges, 2015). One population that may be particularly discouraged by feelings of belonging uncertainty and ability uncertainty is women in engineering, given their underrepresentation in the field (Kokkelenberg & Sinha, 2010). This study aimed to determine whether undergraduate females in engineering report higher levels of belonging uncertainty and ability uncertainty than undergraduate females in other majors. Results from our pilot study suggest they do. Finally, this study explored the effects of a nonverbal behavioral intervention (high-power versus low-power posing) on sense of belonging uncertainty and ability uncertainty. Our findings demonstrated that high-power posing had no significant effect on levels of belonging uncertainty or ability uncertainty. Limitations and future directions for research are discussed.

Keywords: belonging uncertainty, ability uncertainty, engineering, power posing

Introduction

In turning the pages of America's history books, one might observe that great strides have been made toward achieving gender equality in the past fifty years. For instance, although men long outnumbered

women in terms of advanced degree attainment, as of 1991, the number of women ages 25 to 29 holding a bachelor's degree or higher exceeds that of men (Pollard, 2011). In terms of income, between 1967 and 1994, wives' earnings grew drastically, in some cases tripling, leading wives' contributions to family income to increase as a whole, while husbands' contributions to family income decreased (Cancian & Reed, 1999). Yet gender inequalities continue to exist, particularly in the world of work. In general, women tend to earn less than men (Bryant, Winters, & Matson, 2015), but the gender disparities in STEM occupations are especially prominent. For one, women in STEM occupations earn significantly less than men within their first ten years of employment (Xu, 2015). They also earn a considerably lower amount of degrees in STEM fields, namely in engineering (Beede et al., 2011). Of the women who do earn STEM degrees, few end up working in STEM occupations, especially early in their career (Glass, Sassier, Levitte, & Michelmore, 2013). Research shows that women with STEM degrees are more likely to work in education or healthcare (Beede et al., 2011). Considering our nation's current standing in the STEM fields, we would certainly benefit from a larger STEM workforce that includes women. As of 2012, the United States ranked 29th in science literacy and 36th in mathematics literacy (PISA, 2012). Given these statistics, the lack of women in STEM is a serious issue, not only for women, but for our nation.

When one examines the plight of women in engineering specifically, the picture grows bleak. Among all the STEM fields, women are particularly underrepresented in engineering (Kokkelenberg & Sinha, 2010). According to a report released by the National Science Foundation (2015), women make up a mere thirty percent of scientists and engineers working in

science and engineering occupations (NSF, 2015).

Although women remain underrepresented in the STEM fields, it is not due to lack of ability. Beekman and Ober (2015) found that among college-bound high school seniors, females demonstrated the advanced mathematical skills necessary to pursue a career and succeed in STEM. And yet, females are scarcely pursuing careers in STEM, nor are they succeeding relative to their male counterparts. To reduce gender disparities in STEM fields, it is important to understand the root causes of this state of affair.

Let us begin with the predictors of academic success among STEM undergraduates. A large body of research on STEM at the university level indicates that academic preparation, access to resources, and performance are strong predictors of success among STEM undergraduates (May & Chubin, 2003; Ehrenberg, 2010; Griffith, 2010). Social support and a positive university environment are also strong predictors of success, specifically for female STEM undergraduates. (Rosenthal, London, Levy, & Lobel, 2011; Szelenyi, Denson, & Inkelas, 2013). Other research finds that individual factors, such as level of aspiration, play a significant role in motivating underrepresented students to overcome academic obstacles (Grossman & Porche, 2013). Gender seems to influence all of these factors. For instance, Gayles and Ampaw (2014) found that the effects of a STEM student's experience on degree attainment are conditional on gender. In other words, males and females have different experiences that lead to different levels of degree attainment in STEM, with women being at a disadvantage in regards to the latter. The question now becomes, what mechanism could be responsible for producing such disparate outcomes of degree attainment between males and females in STEM?

One such mechanism that may be responsible for discouraging women in STEM is belonging uncertainty. Walton and Cohen (2007) define belonging uncertainty as a state occurring in academic and professional settings, when members of socially stigmatized groups are more uncertain of the quality of their social bonds and subsequently more sensitive to issues of social belonging. Walton and Cohen found that when minority students were made uncertain of their social bonds in an intellectual domain, they demonstrated a consecutive drop in belonging and potential (Walton & Cohen, 2007). Since women are a socially stigmatized group in the sciences, perhaps uncertainty of their connectedness with peers in STEM serves to lower their sense of belonging and potential, thus explaining the disproportionately small number of women in STEM.

Lewis and Hodges (2015) suggest that social belonging is only half the picture when it comes to belonging uncertainty. The other mechanism that may compromise one's sense of academic belonging is ability uncertainty, or uncertainty about one's status as an able and competent member in a domain (Lewis & Hodges, 2015). Past research suggests that ability-based threats such as ability certainty are perhaps more relevant to women in STEM than socially-based threats such as belonging uncertainty. For instance, Walton and Cohen found that female participants' feelings of belonging were not significantly affected by a manipulation that led participants to believe they had few friends in computer science (2007). However, female participants' feelings of belonging were significantly affected by a manipulation that led them to believe they did not possess the skills required to succeed in computer science (Walton & Cohen, 2007). While it is entirely possible that females in STEM feel

uncertainty regarding both their social fit and abilities, the results of Walton and Cohen's (2007) study suggest that females in STEM are far more susceptible to doubts of ability than social belonging.

Past research demonstrates that general feelings of uncertainty are highly aversive and can cause anxiety (Seyranian, 2012). Feelings of belonging uncertainty, in particular, can compromise minority students' belief in their ability to succeed (Walton & Cohen, 2007). Clearly, belonging uncertainty presents a serious threat to the success of stigmatized groups in academic and professional settings, namely women in STEM. The next question becomes, how can educational and professional institutions work to mitigate the effects of such threats? Walton and Cohen's research found that normalizing hardship and belonging doubt, or presenting these states of belonging uncertainty as common occurrences across all groups, significantly increased Black students' sense of belonging and achievement behavior (Walton & Cohen, 2007). Black students in Walton and Cohen's study were presented with a survey intended to teach them that all ethnic groups had belonging concerns during their first year of college, and that these worries lessened with time (Walton & Cohen, 2007). Although this intervention may prove successful in reducing belonging uncertainty amongst women in STEM, one limitation of such an intervention is that it requires the student to passively rely on the environment for support, rather than actively serve as their own source of support. In applied settings such as classrooms and the world of work, females may not be exposed to reassuring environments. Therefore, the current study tests an alternative intervention that individuals can freely implement: high-power posing.

Before one understands the high-power posing intervention, one must first understand the body-

mind connection. It is well-established that one's bodily state can affect one's state of mind. For instance, when facial muscles associated with smiling are facilitated, individuals find cartoons more humorous (Strack, Martin, & Stepper, 1988). Similarly, when males are asked to form a fist, they feel more assertive and powerful (Schubert & Koole, 2009). Bodily states can also affect changes in behavior. For example, individuals who are asked to stand in expansive postures are more likely to steal money, cheat on a test, and commit traffic violations, when given the opportunity to do so (Yap, Wazlawek, Lucas, Cuddy, & Carney, 2013). Finally, bodily states have been shown to affect cognitive biases, with slumped postures leading to biased recall of negative words among depressed patients, and upright postures leading to no word recall bias amongst the same population (Michalak, Mischnat, & Teismann, 2014). Power posing operates by similarly utilizing one's bodily state to affect their state of mind.

Past research has also demonstrated a link between posture and power as it relates to gender. In the results of one study, when gender was made salient to female participants by a male instructor issuing a sexist remark, females adopted submissive postures (de Lemus, Spears, & Moya, 2012). The same study found that females who interacted with a male instructor who stood in a dominant pose exhibited increased smiling (de Lemus, Spears, & Moya, 2012), which Hall and Laffrance cite as a sign of subordination (as cited in de Lemus, Spears & Moya, 2012). Smiling is often demonstrated by females in low-power positions (Hall, Coats, & Smith LeBeau, 2005). Given that females in low-power roles tend to adopt low-power poses, combined with ample research supporting that bodily states have a great effect on the mind, perhaps prompting females to adopt high-power poses will

encourage females to subsequently adopt high-power roles.

Posing in expansive postures (high-power poses), as opposed to contractive postures (low-power poses), held for only five to six minutes can have enormous benefits (Cuddy, Wilmuth, Yap, & Carney, 2015; Carney, Cuddy, & Yap, 2010). For instance, high-power posing has been shown to improve performance during a job interview (Cuddy, Wilmuth, Yap, & Carney, 2015), increase self-reported feelings of power (Carney, Cuddy, & Yap, 2010), increase levels of testosterone, a hormone associated with power (Carney, Cuddy, & Yap, 2010; Minvaleev, Nozdrachev, Kir'yanova, & Ivanov, 2004), and decrease levels of cortisol, a hormone associated with stress (Carney, Cuddy, & Yap, 2010; Minvaleev, Nozdrachev, Kir'yanova, & Ivanov, 2004). In accordance with decreased levels of cortisol, past literature has revealed that powerful individuals demonstrate lower levels of stress and anxiety than individuals with less power (Sherman et al., 2012). Therefore, it is especially warranted to expect that high-power posing leads to feelings of increased power.

The literature shows that the link between high-power posing and feelings of power is mostly universal, with the effects of high-power posing being confirmed across cultures, and also across sighted versus blind individuals (Tracy & Matsumoto, 2008). However, past research has simultaneously revealed cross-cultural discrepancies in feelings of power when type of posture was manipulated (Park, Streamer, Huang, & Galinsky, 2013). Furthermore, past research has exhibited differential effects of posture on feelings of power across gender (Schubert & Koole, 2009). Therefore, it is best to assume that, for the most part, power posing is universal, yet one must remain aware of subtle cultural and gender-based differences when

reviewing the literature on power posing.

The first goal of this study was to examine whether undergraduate females in engineering experience significantly lower levels of social belonging and significantly higher levels of ability uncertainty than undergraduate females in other majors. The second goal of this study was to introduce a high-power posing intervention among females in engineering after ability uncertainty had been made salient, and to examine whether high-power posing would mitigate the effects of ability uncertainty by increasing sense of power and decreasing levels of ability uncertainty.

Pilot Study

Method

Participants. 135 female undergraduate students from California State Polytechnic University, Pomona were recruited for the pilot study. 35 students were from the College of Agriculture, 67 students were from the College of Letters, Arts, & Social Sciences, and 33 students were from the College of Engineering. Participants were recruited through SONA Systems, on-campus organizations for female engineering students (e.g., Society of Women Engineers), and flyers posted in participants' respective departments.

Materials

Belonging. To measure belonging, the item, "To what degree do you experience a sense of belonging or exclusion [at your institution]?" (Sidanius, Van Laar, Levin & Sinclair, 2004) was adapted to present a 4-item measure that will assess degree of institutional belonging, degree of institutional exclusion, degree of

major-based belonging, and degree of major-based exclusion. Participants were also administered a 10-item measure intended to measure sense of social and academic fit in STEM (Walton, Logel, Peach, Spencer, & Zanna, n.d.). Finally, participants were asked to complete a 3-item belonging uncertainty scale and a 4-item prospective belonging uncertainty scale (Walton & Cohen, 2007).

Ability uncertainty. To measure ability uncertainty, participants completed a 12-item Ability Uncertainty Scale (Lewis & Hodges, 2014).

Procedure. To ensure that undergraduate female engineering majors at California State Polytechnic University, California experience belonging uncertainty and ability uncertainty, we examined 135 participants' sense of belonging uncertainty and ability uncertainty (among other measures). Thirty-three participants were undergraduate females from the College of Engineering (smallest female-to-male ratio; Institutional Research and Academic Resources, 2015), 67 participants were undergraduate females from the College of Letters, Arts, & Social Sciences (average female-to-male ratio, Institutional Research and Academic Resources, 2015), and 35 participants were undergraduate females from the College of Agriculture (largest female-to-male ratio, Institutional Research and Academic Resources, 2015). Participants were required to report levels of belonging uncertainty and ability uncertainty through an online survey consisting of 38 items total, including demographics questions. The survey was administered through Qualtrics, an online survey software. We anticipated that female undergraduates from the College of Engineering would, on average, demonstrate significantly higher levels of belonging uncertainty and ability uncertainty compared with female undergraduates from the Colleges of Letters, Arts, and Social Sciences

and Agriculture.

Results and Discussion

Pairwise comparisons conducted with independent sample t-tests showed that females from the College of Engineering ($M > 4.75$, $SD > 1.26$) reported significantly lower levels of social belonging than females from the College of Letters, Arts, & Social Sciences ($M > 5.32$, $SD > 0.99$), $t(98) > 2.49$, $p > .015$ (see Figure 2). Furthermore, pairwise comparisons conducted with independent sample t-tests showed that females from the College of Engineering ($M > 3.91$, $SD > 1.33$) reported significantly higher levels of ability uncertainty than females from the College of Letters, Arts, & Social Sciences ($M > 3.32$, $SD > 1.25$), $t(98) > -2.173$, $p > .032$ (see Figure 3). Refer to Table 1 for descriptive statistics pertaining to social belonging and ability uncertainty across all three colleges.

Although female undergraduates from the College of Engineering did not report significantly lower levels of social belonging and significantly higher levels of ability uncertainty than female undergraduates from the College of Agriculture, as we expected, the general trend was consistent with our prediction. Furthermore, the results of the pilot study directly support our hypothesis that female undergraduates from the College of Engineering would report significantly lower levels of social belonging and significantly higher levels of ability uncertainty than females from the College of Letters, Arts, & Social Sciences.

Study 1

Method

Participants. 601 female undergraduate students from the Colleges of Engineering and Science were recruited for Study 1. Participants were recruited through SONA Systems, on-campus organizations for female engineering students (e.g., Society of Women Engineers), and flyers posted in participants' respective departments.

Materials

Belonging. To measure belonging, the item, "To what degree do you experience a sense of belonging or exclusion [at your institution]?" (Sidanius, Van Laar, Levin & Sinclair, 2004) was adapted to present a 4-item measure that will assess degree of institutional belonging, degree of institutional exclusion, degree of major-based belonging, and degree of major-based exclusion. Participants were also administered a 10-item measure intended to measure sense of social and academic fit in STEM (Walton, Logel, Peach, Spencer, & Zanna, n.d.). Finally, participants were asked to complete a 3-item belonging uncertainty scale and a 4-item prospective belonging uncertainty scale (Walton & Cohen, 2007).

Ability uncertainty. To measure ability uncertainty, participants completed a 12-item Ability Uncertainty Scale (Lewis & Hodges, 2014).

Power. To measure participants' feelings of power, two self-report items were used. The first item read, "How powerful do you feel, on a scale of 1 to 7?" (Carney, Cuddy, & Yap, 2010). The second item read, "How in charge do you feel on a scale of 1 to 7?"

(Carney, Cuddy, & Yap, 2010).

Neutral word filler task. The neutral word filler task consisted of 104 neutral words gathered from Affective Norms for English Words (ANEW): Instruction Manual and Affective Ratings (Bradley & Lang, 1999). ANEW items with an arousal mean of equal to or less than 4.43 were included in the task. This threshold was determined using Kousta, Vinson, and Vigliocco's (2009) lexical and sublexical characteristics of stimuli. Participants were presented with the task in the form of notecards. The 104 notecards displayed the selected 104 neutral words using black text against a tan background. Order in which the words were initially presented was determined using a random sequence generator. Subsequent presentation of the notecards was random, as the cards were randomly shuffled after each trial.

Procedure. 60 undergraduate females from the Colleges of Science and Engineering were administered an ability uncertainty manipulation consisting of one free-response item prompting them to recall a time when they felt they did not possess the skills necessary to succeed in science or engineering at Cal Poly Pomona. A second item asked participants to indicate how often they encounter such situations. A manipulation check consisting of the 12-item ability uncertainty scale ensured the validity of the ability uncertainty manipulation. Following the ability uncertainty manipulation, participants in condition 1 were asked to assume a high-power pose, and participants in condition 2 were asked to assume a low-power pose (see Figure 1) for six minutes. Participants were randomly assigned to either condition 1 (high-power pose) or condition 2 (low-power pose). While assuming their respective poses, participants were asked to rate the pleasantness of 104 neutral words, or as many words as they were

able to complete in six minutes. The experimenter provided brief instructions to participants (“Please rate the pleasantness of the following words on a scale from 1 to 10”) prior to the word rating task. Participants were asked to provide their answers verbally. The experimenter recorded participant responses in order to avoid distracting participants from maintaining their pose. Finally, participants in both conditions were administered a post assessment, in which they indicated their sense of belonging uncertainty, ability uncertainty, and feelings of power.

Results and Discussion

Results of the one-way ANOVA analyses demonstrated that high-power posing did not significantly decrease participants’ levels of ability uncertainty, nor did it significantly increase levels of social belonging. Therefore, our second hypothesis was not supported.

General Discussion

The results of the pilot study directly support the hypothesized significant difference in levels of belonging uncertainty and ability uncertainty between females in engineering and other undergraduate females at California State Polytechnic University, Pomona. Therefore, our first hypothesis was supported. However, the results of Study 1 did not support our second hypothesis. There was no significant difference in levels of social belonging or ability uncertainty between those in the high-power condition and those in the low-power condition.

Future Directions

Future studies would be well-served to replicate Study 1 among a larger sample, specifically, a sample that is restricted to include women in engineering. As previously that the inclusion of female undergraduates from the College of Science threatened the internal validity of Study 1. By restricting the experiment to women in engineering, a population that is known to experience significantly higher levels of ability uncertainty and significantly lower levels of social belonging (as indicated by the results of our pilot study), the experiment may yield different results.

Furthermore, in future studies utilizing an ability uncertainty manipulation similar to that of Study 1, the manipulation might be strengthened to more powerfully activate an association between ability and group status. For instance, our original ability uncertainty manipulation read, “Tell us about a time when you felt you did not have the skills necessary to succeed in science.” The manipulation could have been strengthened by instead reading, “Tell us about a time when you felt you did not have the skills necessary to succeed in science because you are a woman” (italics added for emphasis). By doing so, participants would be more powerfully inclined to activate their self-concept of “woman in science,” which may elicit higher feelings of ability uncertainty.

Finally, the study of ability uncertainty must be extended to other underrepresented populations in STEM, such as ethnic and racial minorities. Since ethnic and racial minorities are similarly underrepresented in STEM fields (NSF, 2015), they would certainly benefit from such research and intervention strategies.

Limitations

Regarding impediments to our project's progress, one major obstacle was recruiting women in engineering. Since we could not offer these participants course credit (as we are able to do with psychology majors), it was extremely difficult to encourage females in engineering to participate in our study. Fortunately, we were able to work with Society of Women Engineers to recruit females for our pilot study and experiment. Hallmark™ also kindly donated a gift basket (valued at \$50.00) to our study, thereby allowing us to incentivize participants. We automatically entered all participants' names into a raffle, by which they had an opportunity to win the basket. We also put our study up on SONA Systems, California State Polytechnic University's online subject pool. We hoped that this would increase the visibility of our study, and encourage more subjects to participate. Finally, we opened the experiment to include all women in science (specifically, women from the College of Science and the College of Engineering). This change allowed us to recruit on a larger scale, therefore increasing our sample size in Study 1.

Although extending the opportunity for participation in Study 1 to women from the College of Science yielded a larger sample size, we suspect that this change posed a threat to the internal validity of Study 1. Specifically, it is possible that female undergraduates in the College of Science experience levels of social belonging and ability uncertainty different from those of female undergraduates in the College of Engineering. Since we did not include female undergraduates in the College of Science in our pilot study, we are unable to conclusively assume equivalence between the two populations.

Another limitation of our study that is worth

considering is the nature of the ability uncertainty manipulation. Results of the manipulation check indicated that the ability uncertainty manipulation did not yield extreme levels of ability uncertainty among participants, as we expected. Perhaps with a stronger manipulation, participants may have experienced higher levels of ability uncertainty, therefore strengthening the mitigating effect of the high-power posing intervention.

Finally, our study utilized one-on-one sessions with participants. Although we cannot definitively state that such individual sessions accounted for our insignificant results, it is worth considering that perhaps the effect of power posing would have differed in a group setting. Future research should explore the differential effects of power posing as implemented in an individual versus group environment.

Implications

Although the results of Study 1 proved inconclusive, the results of the pilot study have many possible applications. First and foremost, these results extend the current literature on ability uncertainty and belonging uncertainty to include women in engineering. Currently, no such literature exists. Furthermore, these results allow us to better understand the unique obstacles that women in engineering face, so that we may work toward mitigating these challenges and increasing the representation of women in STEM. Finally, these results underline a potential avenue for psychological factors to target when developing interventions intended to increase women's numbers in STEM. By developing more effective interventions for women in STEM, we may work toward closing the long-standing gender gap and attaining a more equal society.

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Table 1
Mean Levels of Social Belonging and Ability Uncertainty

	Social Belonging		Ability Uncertainty	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
College of Engineering	4.75	1.26	3.91	1.33
College of Letters, Arts, & Social Sciences	5.32	0.99	3.32	1.25
College of Agriculture	5.02	1.41	3.39	1.21

Note. *M* = mean.

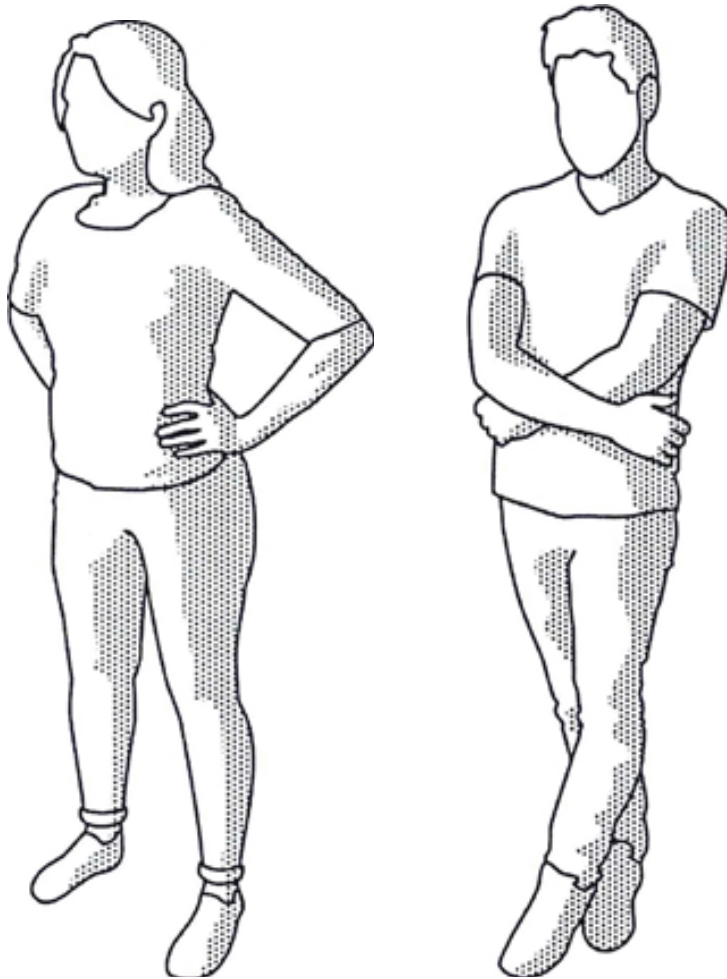


Figure 1. High-power and low-power pose (Cuddy, Wilmoth, Yap, & Comey, 2015).

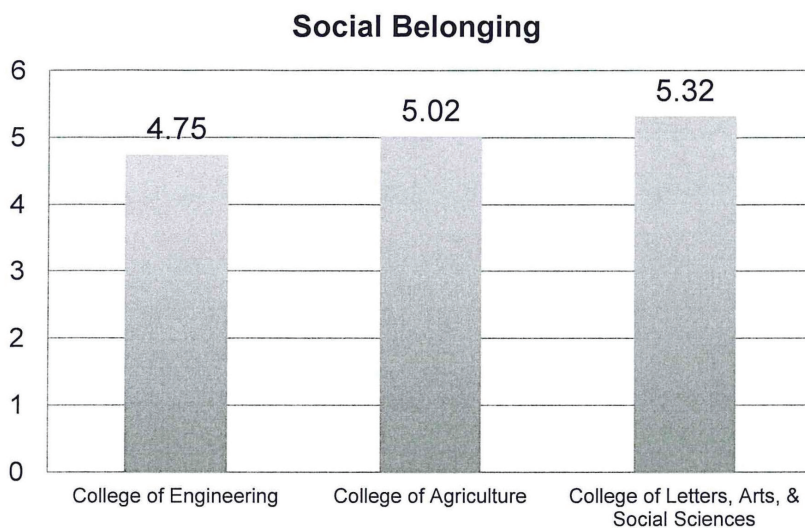


Figure 2. Mean levels of social belonging across female undergraduates from the College of Engineering; Agriculture; and Letters, Arts, & Social Sciences.

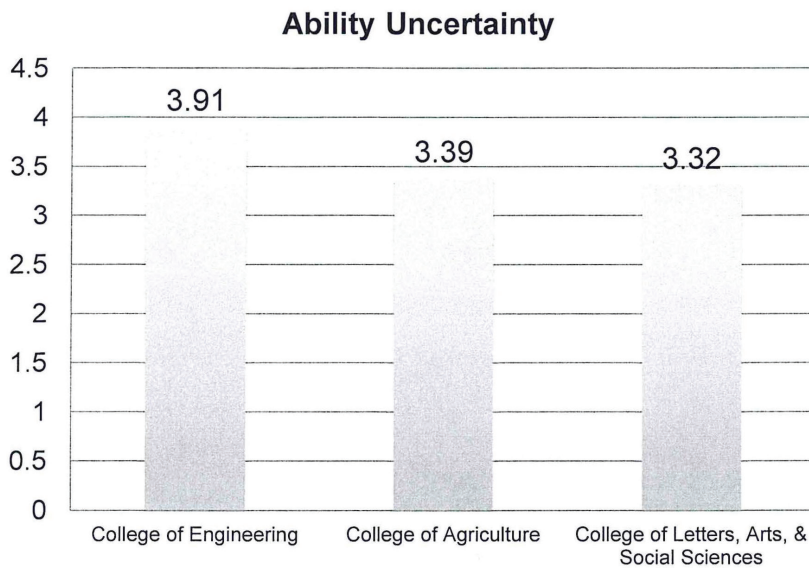
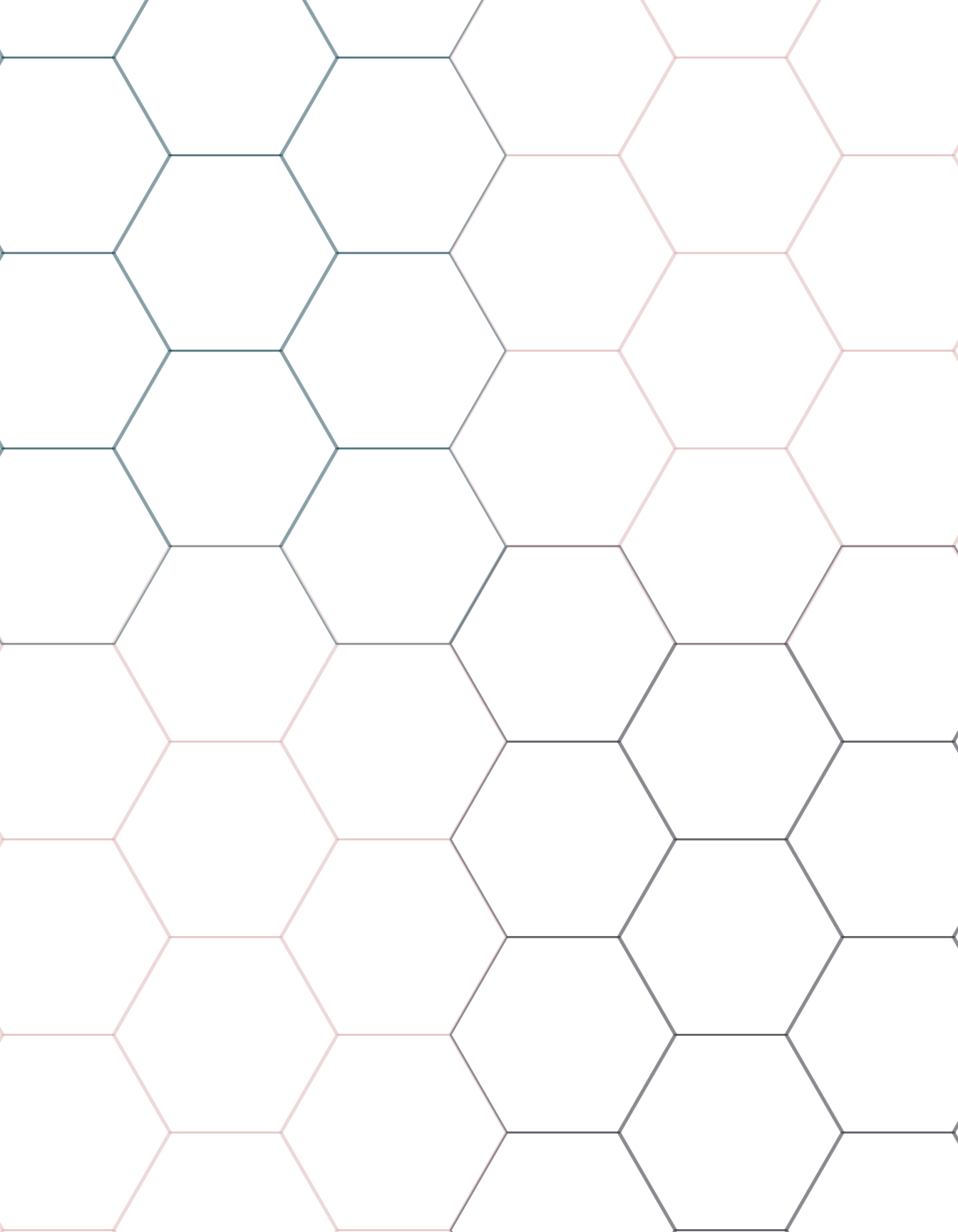


Figure 3. Mean levels of ability uncertainty across female undergraduates from the College of Engineering; Agriculture; and Letters, Arts, & Social Sciences.



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Identification of the Genes that Regulate Silk Production in Spiders: A Computational Biology Approach

Abstract

The molecular basis of spider silk production is of broad interest because of its possible mechanical applications. For instance, dragline silk, which is produced in the major ampullate gland of certain spiders, has been found to be tougher than nylon and Kevlar®. However, even though there is research on the mechanical and structural properties of spider silk, the gene expression and regulation responsible for spider silk production remains largely unexplored. In this project, we tried to identify the genes that regulate spider silk production by analyzing 8 RNAseq libraries from silk glands of male and female *Dysdera* spiders. Using a reference transcriptome, a differential expression analysis is done to identify statistically relevant expressed genes. The programs BowTie2 and TopHat were used to perform alignment to the reference transcriptome. To perform differential expression analysis, tuxedo tool suite of programs (CuffLinks, CuffMerge, CuffCompare), HTSeq, and DESeq, were used to determine statistically significant differentially expressed genes. This analysis will provide insights regarding the genes that are either upregulated or downregulated during silk production in *Dysdera* spiders.

Introduction

Spider silk has become an important topic in numerous fields due to the potential applications that can be derived from its mechanical properties (reviewed in Ayoub et al. 2007). However, spiders possess more than one type of silk producing glands. It has been shown that Spiders can produce up to six to seven different types of silk from different types of glands, which can vary in tensile strength and elasticity (Lewis,

2006; Fu et al., 2009). One of the spider silk producing glands, the major ampullate gland, has been the focus of spider silk research due to its abundance and ease of access (Xu & Lewis, 1990).

Dragline silk, which is produced from the major ampullate gland, is known for its extremely high tensile strength and toughness (Ayoub et al., 2007). Its mechanical properties are of ten compared to synthetic fibers, which are known to have high modulus and strength. On the other hand, dragline silk, which possesses average strength, are significantly tougher than both nylon and Kevlar (Fu et al., 2009; Xu & Lewis, 1990). These properties are of ten associated with the proteins structures that constitutes spider silk.

The majority of research regarding spider silk proteins revolve around major ampullate spidroins 1 and 2 (MaSp1 and MaSp2, respectively) and these proteins are mostly found in silks produced in major ampullate glands (Xu and Lewis, 1990; Hinman and Lewis, 1992). Research has shown that proteins like MaSp2 and MaSp1 have high molecular weight. MaSp1 and MaSp2 is also shown to contain repetitive domains that is glycine-rich and poly-alanine at its end (Gatesy et al., 2001). These proteins contain different amino acid sequence variation in different spidroins are involved on the different strength and toughness of the fibers (Hayashi & Lewis, 1998; Hayashi et al., 1999; Rising et al., 2005; Gaines & Marcotte, 2008).

Although its mechanical and structural properties are extensively being studied, we have yet to discover the complete list of genes that are involved in spider silk gland development and its possible and crucial involvement in spider silk production. Studying the genes that are may be responsible for attaining the uniqueness of the gland may provide insight on how spider silk production is regulated. These genes may be

involved in the intricate detailing of how spider silk are manufacture within the gland such as the details of the formation of the silk protein's secondary structure, and folding and assembly of these silk proteins (Fu et al., 2009).

In this research, transcript activity from various silk glands of male and female *Dysdera* spiders will be analyzed in silico. These collections of transcript activities were sequenced using a next-generation sequencing technique called RNAseq. Differential expression analysis will be done using the pipeline for the tuxedo tools and R programming's Bioconductor packages. The RNAseq libraries from male and female *Dysdera* spiders are first subjected to whole genome alignment using the programs BowTie2 and TopHat. The resulting data from TopHat was then subjected to the tuxedo pipeline for differential expression analysis: CuffLinks, CuffMerge, and CuffCompare. The results are then counted and visualized through the programs HTSeq and DESeq (Anders, Pyl and Huber, 2014; Anders and Huber, 2010).

Differential expression analysis will be done using the pipeline for tuxedo tools by first performing whole genome alignment using the programs BowTie2 and TopHat, and finally performing differential expression analysis using CuffLinks, CuffMerge, CuffDiff, and CummeRbund. A separate program, an R Bioconductor package named DESeq, will also be used for differential expression analysis. These methodologies will help visualize which genes are utilized during spider silk formation.

Methods

RNAseq libraries are formed from the obtained mRNA transcript activities of total glands of male and female *Dysdera* spiders. Due to the limitations of our current technology, sequencing full-length mRNA sequence have yet to be achieved and therefore transcripts are fragmented first before running through RNAseq (Fig 1). RNAseq then generates a library of these fragmented mRNA sequences (via their comple-

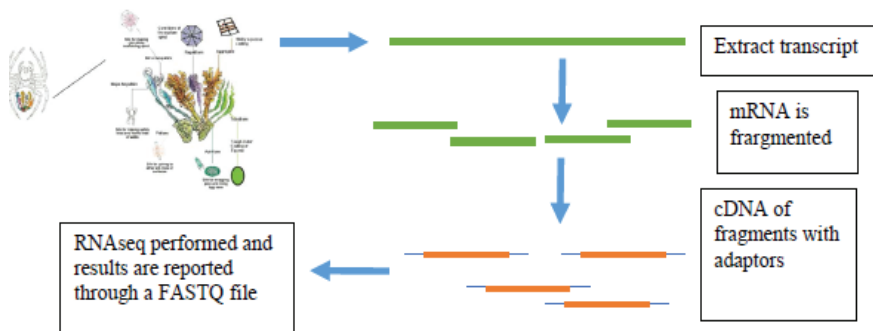


Figure 1. Sequencing of RNA transcript via RNAseq

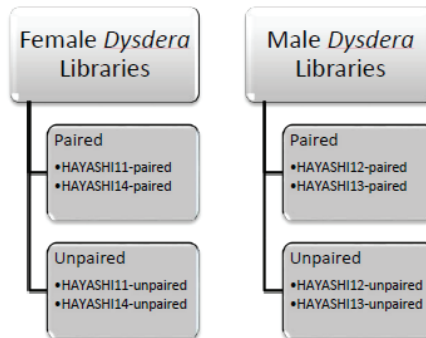


Figure 2. Male and Female *Dysdera* libraries and their distinct library names

mentary DNA). Male and female *Dysdera* spiders were separated into different libraries (Fig 2).

I. Quality assessment analysis of the FastQ libraries using ShortRead

The extracted mRNA sequences are then subjected to quality assessment analysis in order to determine if the FastQ libraries have a good quality before running them through the RNAseq analysis pipeline. The QA is performed using a package from R Bioconductor called ShortRead (Morgan et al., 2009).

II. Analysis of gene expression via the Tuxedo Tools

After the determination of the sequence quality using the QA analysis of ShortRead, the fragments contained inside the FastQ libraries are then subjected through the RNAseq analysis pipeline for differential gene expression analysis. First, in order to analyze gene expression, these fragments are then aligned with a reference transcriptome. The rationale is that, the more expressed a gene is, the more mRNA

it produces, and therefore, the more fragments it will have prior to sequencing via RNAseq. However, since there are no currently existing good quality, fully sequenced genome for spiders, a reference transcriptome was constructed by PI Dr. Arensburger using the data from the RNAseq libraries and *de novo* constructing a reference transcriptome through a program called Trinity (Grabherr et al., 2011).

After the *de novo* construction of a reference transcriptome, the libraries are first subjected to one of the first line of the tuxedo tools. By first using the alignment tool BowTie2 (Langmead et al., 2012), allows the confirmation of the following: the fragments contained in the FastQ libraries are able to align and the reference transcriptome can be used for the rest of the RNAseq analysis.

After subjecting them into the first alignment tool and confirming the following conditions stated above, the FastQ libraries are then subjected to a more sophisticated alignment tool of the tuxedo tools, TopHat (Trapnell et al., 2012). Using TopHat, the pro-

gram considers possible exon-exon splicing junctions (Trapnell et al., 2012).

The TopHat results are then used for the following remaining tuxedo tools: CuffLinks, CuffMerge, and CuffCompare (Trapnell et al., 2012), to generate and identify sections of the transcriptome assembly that may be expressed. CuffLinks will use the TopHat aligned matches to quantify expression as well as make a transcript assembly for each library. CuffMerge will merge all these transcript assembly from the eight libraries to construct a master transcriptome. CuffCompare provides additionally comparison of the generated transcriptome to the alignment. After the utilization of the tuxedo tools, differential analysis is conducted.

III. Differential expression analysis using DESeq

After running the RNAseq data through the tuxedo pipeline, it is subjected to differential expression analysis using HTSeq and DESeq (Anders, Pyl and Huber, 2014; Anders and Huber, 2010). DESeq is an R Bioconductor package that is a visualization tool that

allows biologists to see differential expression from obtained samples (Anders and Huber, 2010). However, a third-party program is required to count the frequency of the alignment from the alignment program used to the generated transcriptome assembly as DESeq does not possess such program capabilities. One of the most commonly used program in conjunction with DESeq is HTSeq. HTSeq quantifies the alignment of of the result from an alignment program (such as those of TopHat) to a transcriptome or generated transcriptome (which can be done through the Tuxedo Pipeline) (Anders, Pyl and Huber, 2014).

Results

The following libraries were the extracted mRNA sequences from the spiders that were analyzed using RNAseq (Figure 1). Using RNAseq, both single end and paired end were used for RNAseq: single end means the fragment DNA was only read in one direc-

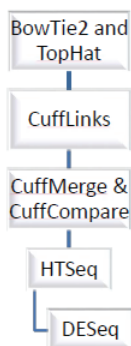


Figure 3. RNAseq Analysis Pipeline Used.

Unpaired Library	# of Reads	Paired Library	# of Reads
HAYASHI11-unpaired.fa	1,775,663	HAYASHI11-paired.fq	585,728
HAYASHI12-unpaired.fa	152,101	HAYASHI12-paired.fq	91,156
HAYASHI13-unpaired.fa	640,198	HAYASHI13-paired.fq	197,324
HAYASHI14-unpaired.fa	519,784	HAYASHI14-paired.fq	214,672

Table 1. Table of the RNAseq libraries totaling 8. Four libraries were sequenced single-end and the other four were sequenced paired-end. Number of reads are the amount of sequenced fragmented DNA in that designated library

tion while paired end sequencing means the fragment DNA was read in both directions. The libraries were

first subjected for quality assessment and ran through the first few steps of the tuxedo tools.

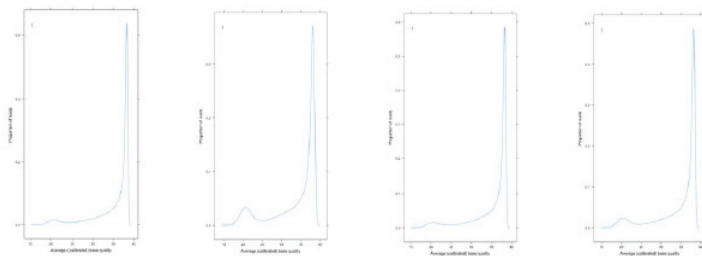


Figure 4. Quality assessment of the paired libraries using Bioconductor package ShortRead. Peaks that leans toward the right indicates good quality library.

I. Quality assessment of RNAseq libraries using ShortRead

Note that the libraries HAYASHI11-unpaired.fa, HAYASHI12—unpaired.fa, HAYASHI13-unpaired.fa, and HAYASHI14-unpaired.fa, were not included on the QA report generated by ShortRead because ShortRead can only recognize FastQ files and not FASTA files (extensions of .fq and .fa respectively). According to ShortRead, Overall Read Quality graphs with peaks at the right panel are good quality reads. The RNAseq libraries show overall good quality reads. Next, these li-

braries were aligned to a reference genome (via Trinity) using the BowTie2.

II. TopHat Alignment Results

TopHat alignment program is then used to align the unpaired and paired libraries to the reference transcriptome. This is done because TopHat offers a more sophisticated, yet more memory intensive calculations, alignment since it considers possible splicing junctions (Trapnell et al., 2012). Below are the results of the unpaired libraries. Besides the alignment summary results, TopHat also reports accepted hits

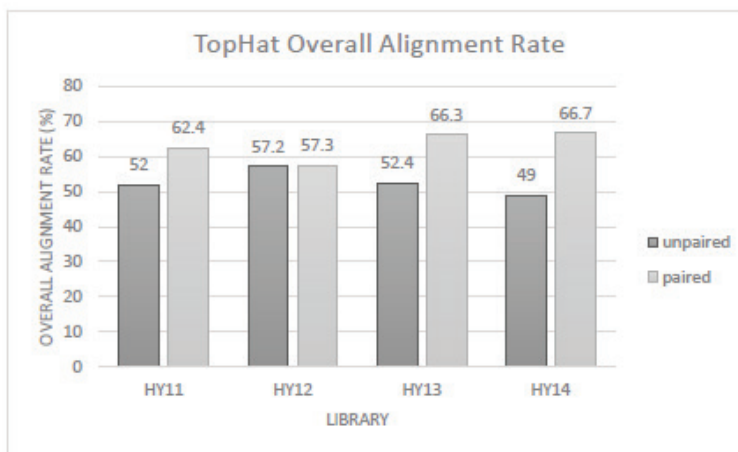


Figure 5. Overall alignment rate of paired and unpaired libraries using TopHat. Overall alignment rate was reported in percentages.

Unpaired Library	# of Loci	Paired-End Library	# of Loci
HAYASHI11-unpaired.fa	65, 804	HAYASHI11-paired.fq	42, 377
HAYASHI12-unpaired.fa	20, 306	HAYASHI12-paired.fq	8, 236
HAYASHI13-unpaired.fa	43, 661	HAYASHI13-paired.fq	22, 605
HAYASHI14-unpaired.fa	49, 8649	HAYASHI14-paired.fq	22, 047

Table 2. Table of the number of loci after running the TopHat alignment results into CuffLinks.

(mapped reads) and unmapped reads in a .BAM file.

III. DEseq and HTSeq results

After aligning the RNAseq libraries to TopHat and running the results of TopHat to the tuxedo pipeline, both HTSeq and DESeq were performed – HTSeq was used for the counting while DESeq was used for visualization. First, DESeq was used to obtain a dispersion curve for all the libraries to determine the amount

of variation within the libraries (Figure 5). A heatmap was conducted to see the top 30 most commonly expressed genes for all the eight libraries (Figure 6). Another heatmap was generated to see the relation and graphically represent the variation between the eight libraries (Figure 7). Additionally, a PCA plot was generated in order to see the relationship between males and females (for both paired and unpaired) *Dysdera* libraries (Figure 8).

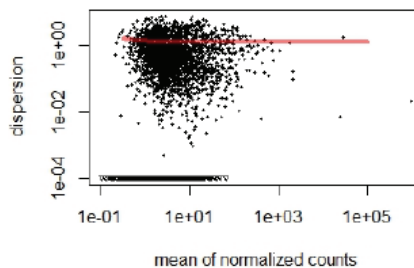


Figure 6. Estimated pool dispersion for all 8 samples with a regression curve.

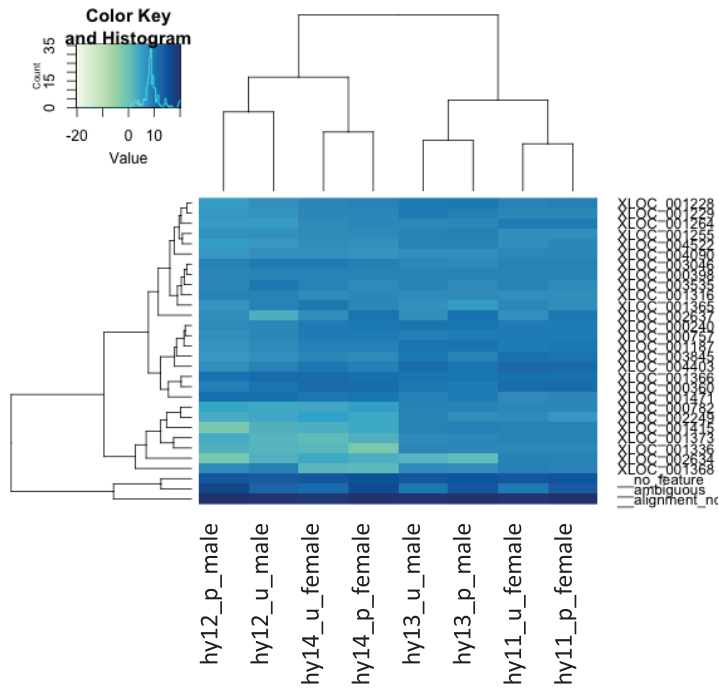


Figure 7. Heatmaps showing the expression data of the 30 most highly expressed genes (transformed data). Clustering of samples does not align with the experimental factor (male vs. female).

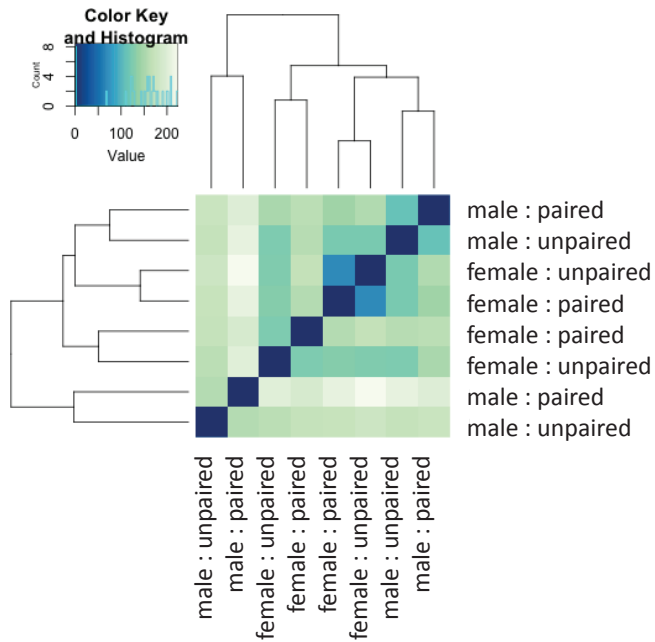


Figure 8. Heatmap showing the Euclidean distances between the samples as calculated from the variance stabilizing transformation of the count data.

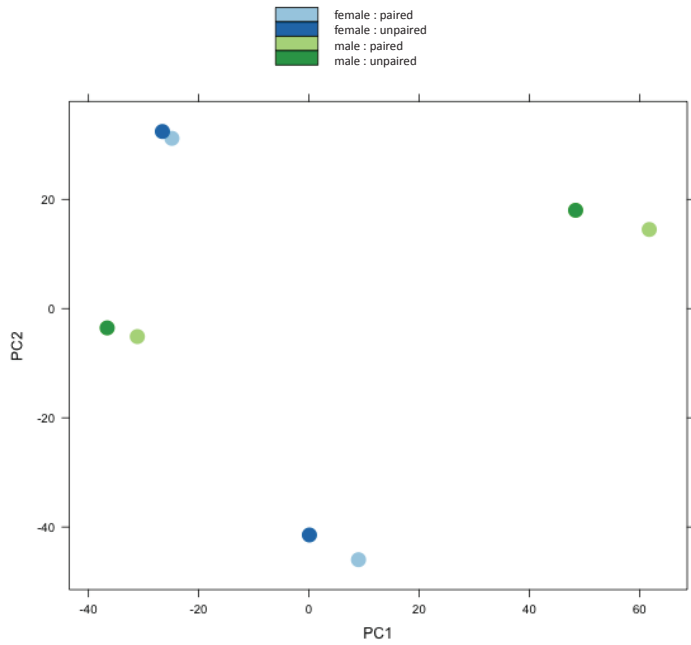


Figure 9. PCA plot. The 8 samples shown in the 2D plane spanned by their first two principal components.

Discussions

Using RNAseq, the extracted mRNA sequences of male and female sequences of male and female *Dysdera* spiders were sequenced using both single-end and paired-end sequencing. Single-end or unpaired sequencing is when the fragmented DNA is only read one way while paired-end sequencing is when the fragmented DNA is read both ways. The advantage of using paired-end DNA sequencing is that it gives more coverage and a more sensitive sequencing since it detects repetitive sequences, gives an idea of how long the sequence is, and it detects insertions and deletions within the DNA. Also, the difference between single-end and paired-end sequencing is the resulting final FastQ file: single-end has one file while paired-end has two accompanying files for one read, which is both read left and right ways. This mate files, two separate files containing both left and right reads, are DNA sequences of the same fragmented DNA but from sequenced from different directions.

The libraries were then subjected to quality assessment analysis using Bioconductor package ShortRead (Morgan et al., 2009). ShortRead produces a graph as seen in Figure 4., which shows the quality of the paired libraries. The x-axis is the average (calibrated) base quality and the y-axis is the proportion of the reads. The peaks of the graphs leaned towards the right side of the graph, therefore, the peaks were heavily concentrated on a higher base quality (x-axis). This indicates that the libraries possess good quality and therefore can be used for the differential expression analysis.

After determining the quality of the reads, it is first subjected to the alignment program BowTie2 and using a reference transcriptome, which was

constructed *de novo* by PI Dr. Arensburger using the program Trinity. BowTie2 was used in order to check if both paired and unpaired libraries are able to align to the reference transcriptome (results not shown). After determining that the libraries are indeed able to align, TopHat was primarily used to perform the alignment.

TopHat offers a more sophisticated and sensitive alignment than BowTie2 – it considers splicing junctions. The resulting overall alignment was indicated in Figure 5. Note that there was a drop in the overall alignment rate compared to BowTie2. This is expected since TopHat considers sections of the reads that might belong to exon-exon splicing junctions as well as introns. TopHat also reports both mapped and unmapped reads in a .bam file (a file that contains sequence alignment data). These files are subjected to differential expression analysis.

Using CuffLinks, the results from TopHat were quantified and used for another transcript assembly. CuffLinks found gene loci from the TopHat alignment results as seen in Table 2. Each library has different number of loci, primarily due to the differences on the size of the libraries which were affected due to other factors such as performing RNAseq and the actual extraction of RNA from the sample spiders. However, to determine if there are overlapping loci between each library, CuffMerge was utilized. CuffMerge merges all the transcript assembly into one master assembly. After the assembly of one whole master transcript, the results from TopHat (the fragments and where they are located), had to be aligned back to determine if they are a part of a gene.

This counting was done through HTSeq and the results from HTSeq were visualized through a R-bioconductor package, DESeq. First DESeq tests the dispersion of the results from HTSeq through a double

log graph (Figure 6). In Fig. 6, as mean read count increases, the dispersion decreases. This is important in analyzing the data as more biological variation that the data has, the differences between the data points become significant. However, DESeq tends to underestimate the dispersion of the data and does this based on sample size. Since there's only 8 libraries for male and female spiders (4 libraries for each sex of *Dysdera*), it underestimates some of the data points and moves them below the red fitted line as seen in Figure 5.

After the analysis of the dispersion of the data, two heatmaps were produced: one heatmap was for the top 30 genes that were commonly expressed among the 8 libraries of *Dysdera* (Figure 7) while the second heatmap was for determining the relationship between the different sexes of *Dysdera* (Figure 8). In Figure 7, most the genes listed were almost as equally expressed in all the libraries of *Dysdera* regardless of sex. However, there were transcripts to this exception: XLOC_000782, XLOC_002249, XLOC_001415, XLOC_001373, XLOC_1336, XLOC_001368, which were expressed less in HAYASHI12 paired and unpaired libraries (male *Dysdera*), and HAYASHI14 paired and unpaired libraries (female *Dysdera*) compared to HAYASHI13 (male) and HAYASHI11 (female) paired and unpaired libraries. XLOC_002634, in addition to having less expression with HAYASHI12 and HAYASHI14 libraries, also has less expression in HAYASHI13 libraries. The cause of this difference between the expression, also taking note that it is not a difference in sex, may have been due to the biological sample. Additional data analysis, such as aligning this set of genes to a non-random database, can be done to determine the nature of the genes that were differentially expressed.

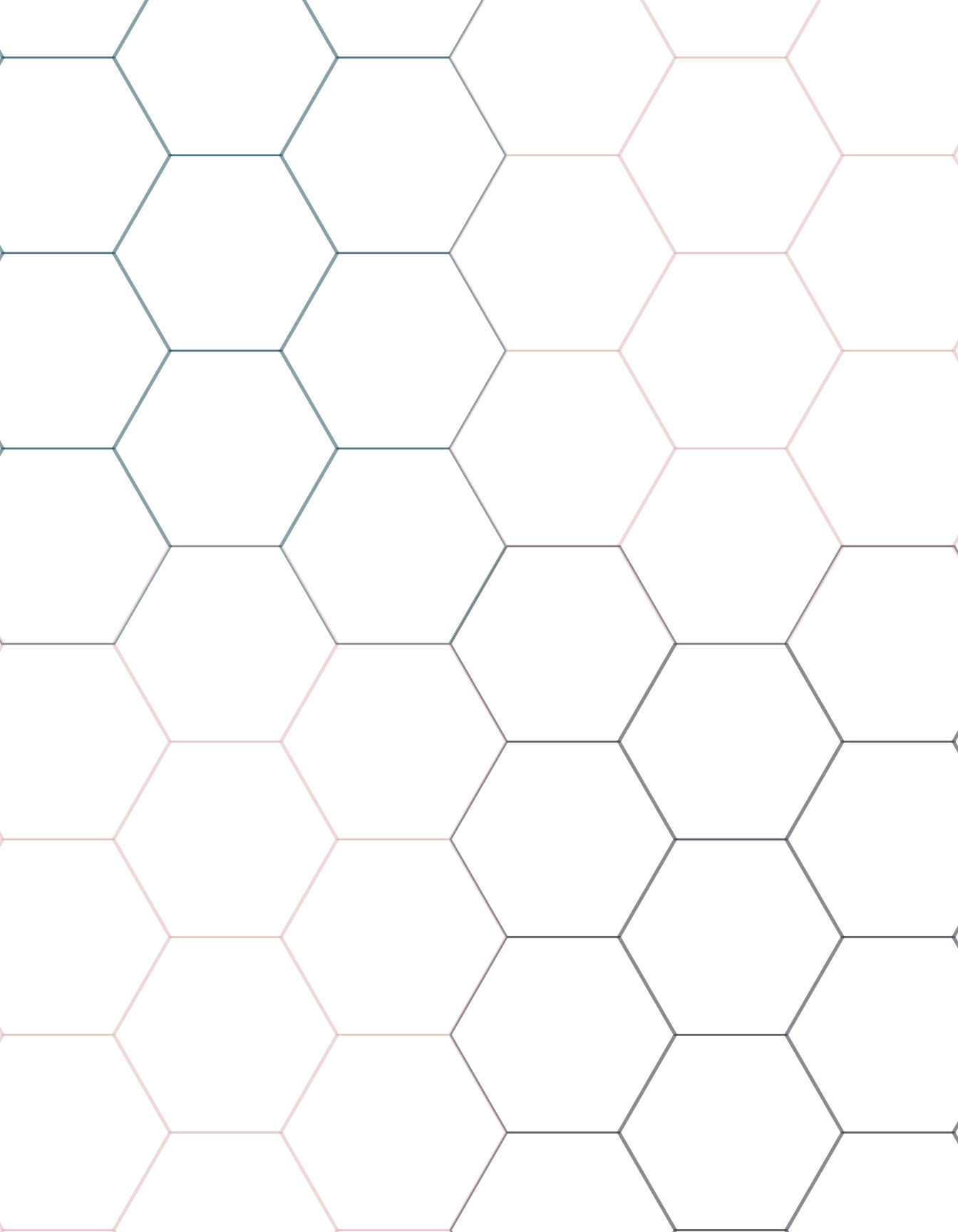
The second heatmap (Fig 8), which pertains

to the sexes of the *Dysdera* spiders, illustrates that there are no differences between the expression of genes in the sample. This is because of the Euclidian distances between the samples – four of the male and female libraries are more related to one another than the other four male and female libraries. This was further confirmed from a PCA graph that was generated (Fig 9). As expected, paired and unpaired libraries of each male and female libraries are related to one another. However, both the PCA plot and the Fig 8 heatmap supports that there's no difference between the genetic expression of both male and female *Dysdera* spiders. This suggests that the silk production between male and female *Dysdera* spiders may use the same gene expression.

Though this study demonstrates the list of genes that are expressed in *Dysdera* spiders, regardless of sex, further research is required in order to evaluate the nature of the genes. This means that these individual genes have to be run through a database using local alignment tools to find any gene similarity to existing genes present in other species. Additionally, the list of the genes may contain novel genes that have yet to be discovered. Further annotation, such as determination of conserved domains (or conserved sequences) from the resulting proteins of these genes in order to give light of their function should be performed.

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Exploring the Interrelationships Between School-Work-Life Balance Among College Students

Literature Review

In 2011 the US census reported that 72% of undergraduate students work. Not only are students working, about one million students are completing internships, conducting research, and participating in school activities to become a competing candidate for graduate school and employment (Carnevale, Smith, Melton, & Price, p. 15). Attending school full time, participating in research, and maintaining a job may negatively impact a student's grades. In turn affecting the chances of being admitted into a graduate program or obtaining a high paying job. Similarly, as time has moved forward, the cost of an education has exponentially grown. Since 1995 private colleges have raised their tuition by 179 percent, while public universities have raised their out-of state tuition 226 percent, and the in-state-tuition by 296 percent (Mitchell, 2015).

Johnson, Rochkind, Ott and DuPont (2009)

found that: The number one reason students give for leaving school is the fact that they had to work and go to school at the same time and, despite their best efforts, the stress if trying to do both eventually took it's toll. (p. 16)

These students are of ten forced into a circular situation where they need to work more hours to pay for their education, causing the need for more time to study to graduate on time. According to a New York Times article, only one in five students who enroll in a two-year institution will earn an associates degree in three years, and two of five students who enroll in a four-year institution will graduate in six years (Lewin, 2009). These results are alarming given the cost of tuition and how long it may take students to graduate.

Students are also including extra curricular activities. These activities are now 'strongly suggested'

to students to increase their chances of obtaining a job after graduation or acceptance into graduate school. Some of these extracurricular activities include unpaid internships.

According to Carnevale, Smith, Melton, and Price (2015), approximately one million, half of all college seniors, have participated in an internship and they stated that, The starting annual salary for college graduates who completed a paid internship was \$52,000, compared to \$36,000 for those who completed an unpaid internship and \$37,000 for those who did not complete an internship. (Carnevale, Smith, Melton, & Price, 2015, p. 15).

However, disadvantaged students who cannot afford to work an unpaid internship may need to work, attend class, study and complete an internship. This leaves little to no time for self care, or family time. Self care is defined as,

what people do for themselves to establish and maintain health, and to prevent and deal with illness. It is a broad concept encompassing hygiene (general and personal), nutrition (type and quality of food eaten), lifestyle (sporting activities, leisure etc), environmental factors (living conditions, social habits, etc.) socio-economic factors (income level, cultural beliefs, etc.) and self-medication (World Health Organization, 2015, p. #).

This situation may leave many feeling overwhelmed and possibly burned out. Students who do not participate in self-care have a higher burnout rate (Miner, 2010, p. 34). Work-life balance has been studied extensively among college students in the literature. However, school-life balance has only been studied recently; yet both essentially stem from the same problems and principles.

Those who have better balance in their lives will have more positive overall work-life balance, subjective wellbeing, and work/ non-work life satisfaction (Grawitch, Maloney, Barber, and Mooshegian, 2013, p. 281; Gropel, Kuhl, 2009, p. 369). Achieving one's life balance can come from their own techniques, or programs offered by their employers. Studies have shown that even when employees do not use the work-life balance services, simply being offered to them and knowing they are available helps to increase one's work-life balance (e.g., Zheng et al. 2015, p. 369, 372).

College students who experienced high levels of stress often say they wish they had more time; but maybe time is not the answer. Perhaps, what students in college need is to learn to balance their multiple demands. Those who feel they have enough time to adequately complete their work, goals and self care are often the happiest people. Boundaries and self control are two ways to implement time management. Duckworth and Seligman (2006) define self control as 'the ability to suppress prepotent responses in the service of a higher goal' (p. 199; as cited in Kuhnle, Hof er, & Kilian, 2010, p. 252). Self control is needed to uphold and maintain boundaries. Conversely, Bulger, Matthews and Hoffman (2007) found that although boundaries need to be made and implemented for a well rounded life style, they also need to be flexible (p. 365).

These two ideas coincide because old values, of school and work, are not diminishing. Though emotional and physical health care are two values that are beginning to become just as important as school and work, leaving less time and resources to be focused on any one value (Kuhnle, Hof er, & Kilian, 2010). Meaning that those who are happier or wish to be happier with their lives should develop enough self control to uphold the boundaries they make, yet be flexible enough

to make the appropriate changes to their schedule or lifestyle when needed.

College students were found to focus and work around the most important goal or value at the present time. Meaning that the students would have to have the self control to prioritize according to the most demanding goal or value at the time and focus on it until they could move on to the next one (Kuhnle, Hof er, & Kilian, 2010, p. 254). Similarly it was found in a study that those who had higher work enhancement were those who had flexible work and personal schedules (Bulger, Matthews, & Hoffman, 2007, p. 371). Work enhancement is defined as when one's job improves their mood in their personal life (Bulger, Matthews, & Hoffman, 2007, p. 369).

Although previous studies have looked into values, boundaries, goals, and flexibility, to our knowledge no published study has explored the school work life balance of college students. The following hypothesis are proposed:

H1: Students who practice school-family balance will have greater life satisfaction.

H2: Students who practice work-family balance will have greater life satisfaction.

Method

Participants

A diverse sample of 265 participants were college students recruited from a large university in Southern California. The participants were 18 years old and older. One goal of this study was to include participants from various majors, ethnic backgrounds, social class, and different employment histories. Participants were recruited using SONA, an online website used by the joint department of Psychology and Sociology at

a large commuter school located in Southern California. SONA is used to recruit participants for class studies, and senior projects. Students who decide to participate will be compensated by being given 0.5 point of class credit or extra credit for any class, that allows them to receive this credit.

Instruments

The general life satisfaction of the participants is determined with a five item, 7-point likert scale developed by Diener (1985). The scale ranged from 1: strongly disagree-7: strongly agree. It has a 61 % and above accuracy rating when compared to other life satisfaction scales (Diener, Emmons, Larsen, & Griffen, 1985, p. 4). Similarly a 7-point liker scale, from 1: strongly disagree -7: strongly agree, will be used to find one's satisfaction with their work. It is a five item scale initiated by Vrklevski, and Franklin (2008). The validity was established while determining the satisfaction with work for criminal and noncriminal legal professionals (Vrklevski, Franklin, 2008). Satisfaction with Work-Family Balance is determined by a 5-point likert scale with questions like how satisfied are you with the way you

divide your time between work and personal or family life. This scale was also modified to measure the participants satisfaction with school-family balance.

Procedures

Once a student has chosen to participate they were given a link to the online survey. The survey was posted on Qualtrics. Qualtrics is a website that will not only host the survey, and allow the participants to answer the questions, it will also gather the data. The data was then entered into SPSS, a software program utilized by California State Polytechnic University, Pomona to run statistical analysis on study the researcher wishes to enter. A regression analysis was ran on the data determining the strength of the variables in relation to their overall well being; which was overall life satisfaction.

Results

A series of correlations between the variables of interest were conducted. All the variables were significantly correlated at $p < .01$ (see Table 1).

Table I. Correlations, Means, and Standard Deviations (N > 265)

	1	2	3	<i>M</i>	<i>SD</i>
1. School- Family Balance	---	.69**	.63**	3.25	.93
2. Work-Family Balance		---	.48**	3.22	.84
3. Satisfaction with Life			---	4.22	1.32

Note. * $p < .05$ ** $p < .01$

Table 2 presents the regression analysis, demonstrating that all variables are significant in predicting satisfaction with life. School-family balance being the strongest predictor, followed by academic satisfaction and work-family balance. The positive correlation found between school-life balance, satisfaction with life were found to be significant, $F(3, 262) > 89.46, p < .001$. The samples multiple correlation coefficient was .69, with school-life balance being the strongest predictor of satisfaction with life.

Discussion

This study was completed in hopes of making undergraduate college students, administrators and professors aware of the various roles students play today. It was completed with the desire to promote balance in students lives, in turn helping them earn better grades while maintaining an adequate level of overall well-being.

Both hypothesis one and two were found to

be supported. Although, hypothesis one was found to be more significant than hypothesis two. It is possible school-family balance has the most profound impact on students life satisfaction because their main concern at this stage in their life is to complete their education. Their current focus is to create the basis for their career.

Work-family balance is significant due to this being the sample pools income; how they pay for tuition, and basic necessities. As previously stated students are now expected to maintain a high GPA, work while attending college and participating in extracurricular activities. Despite this, work-family balance is not as significant in predicting the participants satisfaction with life, possibly because their employment at the time is of ten not their career choice.

Previous research has found that the number one reason students are not completing higher education due to the lack of financial support, not because they are incapable (Johnson, Rochkind, Ott and DuPont 2009, p. 16). The average cost of higher education has

Table 2. Results of Regression Subjective Well-Being on Predictor Variable

Predictor Variables	<i>B</i>	β	<i>t</i>
School- Family Balance	.65	.46	7.78*
Work-Family Balance	.18	.11	1.93***

Note. $R^2 = .48, p < .001$.

* $p < .05$ ** $p < .01$ *** $p < .001$

risen over 200 percent since 1995, according to Mitchell (2015). Students who are unable to balance their school life with their work life, while not practicing any self care are dropping out of college.

Those who maintain a balanced work and family life are healthier and more productive than their counterparts. Studies have also found that each person has their own meaning to what a balanced life style is. However, most of them have a few similar techniques used to help them achieve their balanced lifestyle. Prior research has found that those who maintain their boundaries, have proficient self-control, and maintain a flexible schedule.

Future studies should take a more in depth look at why undergraduate students view school-family balance as a more significant predictor of their life satisfaction. The next stage would be to run this study at various campuses. Socioeconomic background, should also be taken into account. This will help determine the students financial need, and stress of paying for tuition and basic necessities. Relationship status should also be taken into account. It is possible those who are currently in a relationship are better at balancing their time between school-work and their personal life. Gender differences should also be a variable in future studies. This study should be replicated to support the findings, in hopes that administrators at universities will work to improve the undergraduate setting. In turn allowing students to achieve greater school-family balance, improving their overall life satisfaction.

Conclusion

The cost of higher education in the United States has risen on average over 200 percent since 1995. Rising tuition and increased rigorous require-

ments to obtain admittance into graduate school and receive an increased salary after being awarded a bachelors degree have caused students to work, complete internships, and various extracurricular activities while attending classes. Presenting the need for students to adequately balance their lives while completing their undergraduate career.

This study supports previous research stating that those who practice a balanced lifestyle have grater overall life satisfaction. Undergraduate students who have developed a balanced lifestyle between school and their family have greater life satisfaction. Similarly, the same is true for work and family balance. Despite having significance and being a predictor of life satisfaction, work-family balance was not as strong as school-family balance in relation to life satisfaction. It is suspected this is due to school being students main priority at this time. However, further studies should replicate this study and be qualitative in order to understand why the results are so.

Should these studies findings be implemented, students would be able to maintain better overall health. They may also earn better grades, in turn giving them better chances of being admitted into a graduate program or receiving a higher starting salary.

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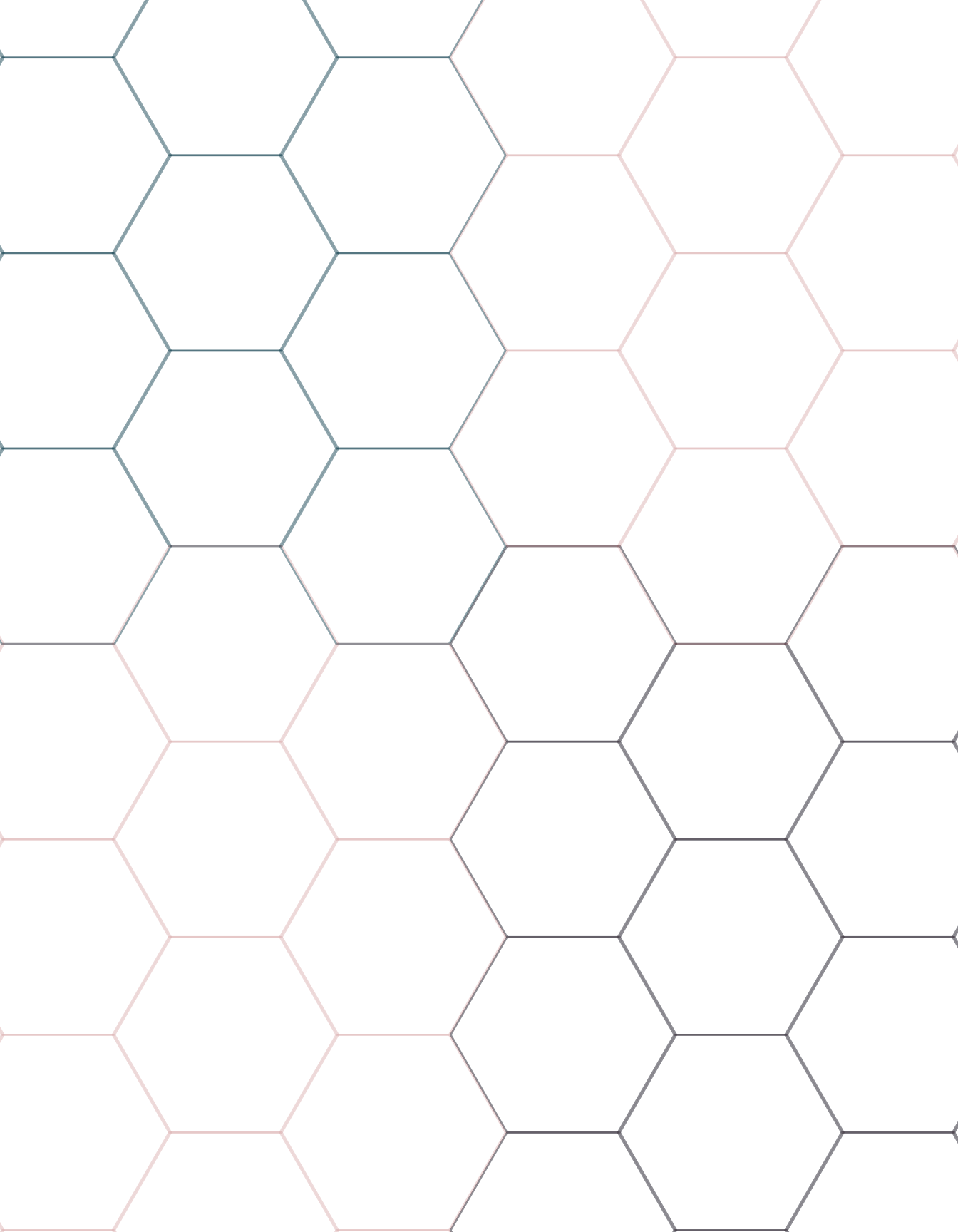
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Dean Coco Computer Vision for Real-Time Hazard Detection in
Dr. Z. Aliyazicioglu High-Power Rockets
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Abstract

This project application designs a computer vision system to detect hazards during the descent of a high-power rocket and live stream the video with outlined hazards to a ground station. In the field of high-power rocketry there are few applications involving computer vision and hazard detection. Computer vision has been adopted by many applications in recent years with image recognition techniques being applied to license plate recognition in traffic cameras [4] and facial recognition in social media applications [5]. However, a common issue to arise in the application of computer vision is the high cost of host computers, image processing software, and the system's portability capabilities. This project addresses these matters by taking advantage of the Raspberry Pi 2 as the processing computer for its compact size, 900 MHz processor and dedicated GPU. Also, utilizing the open source Open CV library for its image processing algorithms. The key functions of the proposed system are: 1) image acquisition, 2) image analysis by means of contours, contour properties and other processing techniques, and 3) transmitting a live stream video to the ground station with detected hazards outlined. Through the success of the project, related applications can incorporate and further the application by utilizing the system to accomplish the task of altering the flight path of the high-power rocket away from the detected hazards.

Major Objective(s)

The major objective of the research project is to design and implement a computer vision system to detect hazards for the descent of high-power rockets. The proposed system will accomplish the following subtasks:

1. Begin recording video during the descent of the rocket.
2. Continuously acquire and process each frame of the video for object recognition.
3. Decide whether any found object(s) is/are a predetermined hazard.
4. Send the ground station a live stream of the video with any detected hazards outlined.
5. End the recording process once the rocket has touched down

Background Research

High-power rocketry is a trending field of interest amongst engineers, scientists and aeronautic enthusiast. This field allows research experiments and testing to be done on a small scale, and in conditions that cannot regularly be attained, that can later have large implications. Hazard detection adds an aspect to rocketry that allows the user to get real-time information. Hazard detection can also play a larger role such as the protection of the structure of the rocket, its electrical components, and/or record experimental data. To date there have been few applications involving computer vision and hazard detection.

Computer vision has become increasingly popular in recent years with image recognition techniques being applied in everyday life. These range from license plate recognition in traffic cameras [4] to facial recognition in the social media application Snap Chat [5]. From these examples, it can be noted that image processing is computer dependent.

Although computer vision has become

popular, it is still computationally expensive. The real-time component of computer vision demands a fast processor and calls for each frame to be processed at 30-40 milliseconds [3], amounting to approximately 25-33 frames per second. Moreover, image processing software is commonly expensive due to its high level language. A third point in question to arise in computer vision is the issue of portability. Because of the requirement for large processing speeds traditional computer that accomplish this task are stationary at some discrete locations.

This project focuses on these topics by exploiting the Raspberry Pi 2 minicomputer and open source OpenCV library. The compact nature of the Raspberry Pi allows for easy portability while still providing sufficient processing power with a CPU speed of 900 MHz and a dedicated GPU. Additionally, the open source computer vision library, OpenCV, and its image recognition algorithms will eliminate the need to purchase expensive software. The proposed algorithms for object recognition will make use of the contour

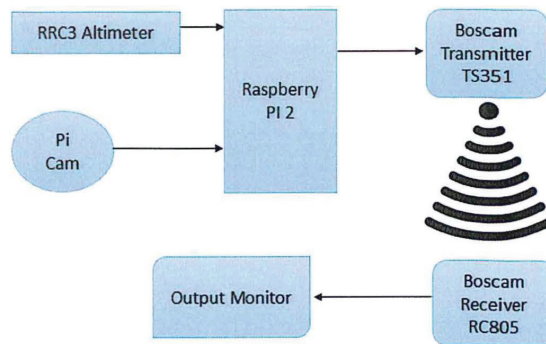
finding method and contour properties, among other processing techniques.

Design/ Methods/Experimental Procedure

I. System Design

The system's block representation is shown in Figure 1.1. To begin, the Open CV library and Python environment were downloaded onto the Raspberry Pi. In the figure the Raspberry Pi has three sets of wired connections: a picamera connected to the camera port, an RRC3 altimeter connected to the GPIO ports, and a Boscam 32 channel 5.8 GHz wireless AV video transmitter connected to the HDMI output. At the ground station a Boscam 5.8 GHz receiver is connected to a display screen and output the corresponding video transmission. Briefly explained, the RRC3 altimeter will begin the recording process once it has sensed the rocket has undergone its descent. At this point the picamera will continuously send a frames to the rasp-

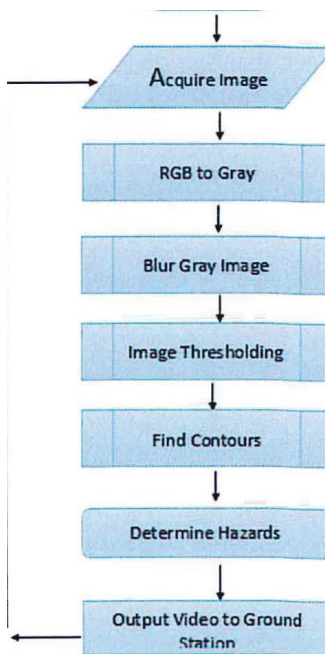
Figure 1.1. System Overview



berry pi to be processes. These processed frames will show any detected hazards and be sent to the ground station via the transmitter and receiver.

II. Object Recognition Algorithm Design Figure

Figure 1.2 Algorithm Flowchart



The image flow *of the* proposed hazard detection algorithm is shown in Figure 1.2. The processing of the algorithm is explained as follows:

1. The image will be acquired and converted from a BGR image to a gray scale image. This is done to support the following processing techniques and assist in detecting the edges of an image by removing the color, since it is not of importance for the application.
2. Using low-pass filter on the gray scale image to make it blurry. The purpose is to remove fine or sharp features 1.2 Algorithm Flowchart 5 from the image and focus solely on the outline of an object.
3. The blurred image is converted to a binary image by applying a thresholding technique. The Gaussian thresholding technique makes the gray image black and white, while also taking into account variable lighting.
4. With this new binary image, the contour finding function is applied and returns an unordered list of found contours.
5. Using this list of contours, the area for each *of the* contours is calculated and stored in a parallel list of areas. In addition, a dictionary is made that stores the index of the contour that is accessed by the area of the respective contour. The area list is then sorted from smallest to largest.
6. Finally, the original image outlines the five largest contours from the list sorted list of areas by accessing their index form the dictionary created,

and send this back to the ground station.

III. Experimental Procedure

In order to realize the success of the stated system, the experimental procedure is broken down into the following sub-tasks:

1. Write a script to continuously acquire an image and save in a video file format.
2. Build off of previous script and convert images from BGR-7 Grayscale-7 Blur image-7 Thresholding-7 find the contours *of the* image and output result to a local screen to be analyzed.
3. Test for different objects to be detected in a single frame. Output results to a local screen and analyze the accuracy of detection.
4. Test different conversion techniques to increase object detection and explore different properties of

contours to organize objects.

5. Test object detection in a video and output the video with outlined hazards to a local screen. Analyze the object recognition accuracy.
6. Test wireless video transmission.
7. Test system accuracy with a simulated scenario.
8. Test during flight of a high-power rocket.

Results

Subtasks one through five have successfully been completed. Subtask two has its representative images shown in Figure 1.3 through Figure 1.5. Figure 1.3 shows an image converted from rgb values to gray scale. Next, the image in Figure 1.4 represents the blurred gray scale image. From this image in Figure 1.4, it can be seen that the sharp edges are gone in comparison to Figure 1.3. Next step, the image is converted

Figure 1.3



Figure 1.4



Figure 1.5



Figure 1.6



to binary, as is shown in Figure 1.5. It is shown that the objects that are detected are any enclosing black lines. And finally, the contours of the image are found and output to the screen in Figure 1.6. In Figure 1.6, it is shown that due to the lighting of the room, many bright or intense spots in the image are considered objects. This may also be the cause of not choosing the proper filter for the input image of the contour finding function. These methods will be altered to improve the image recognition of the algorithm.

With the completion of the majority of ground testing, the testing of the wireless video transmission for the system can be continued. Unfortunately, the transmission of the signal has not been successful the last couple of attempts. Although the wiring and connections appear fine there is no output at the receiver end. Trouble shooting for this part of the system has been under work. Initial thoughts presume there to be a problem with the soldering of the rca cable. If the problem still occurs, I will try a different attachment for the rca cable.

Future Work

Once the issue *of the* wireless transmission is resolved, then the design for an encasing of the system can be done. This includes all *of the* components *of the* system that will be in the rocket during flight. This casing will be used for the in flight testing *of the* high-power rocket. Once the in-flight testing has begun, the accuracy *of the* hazard detection, as well as the processing time, can be properly assessed.

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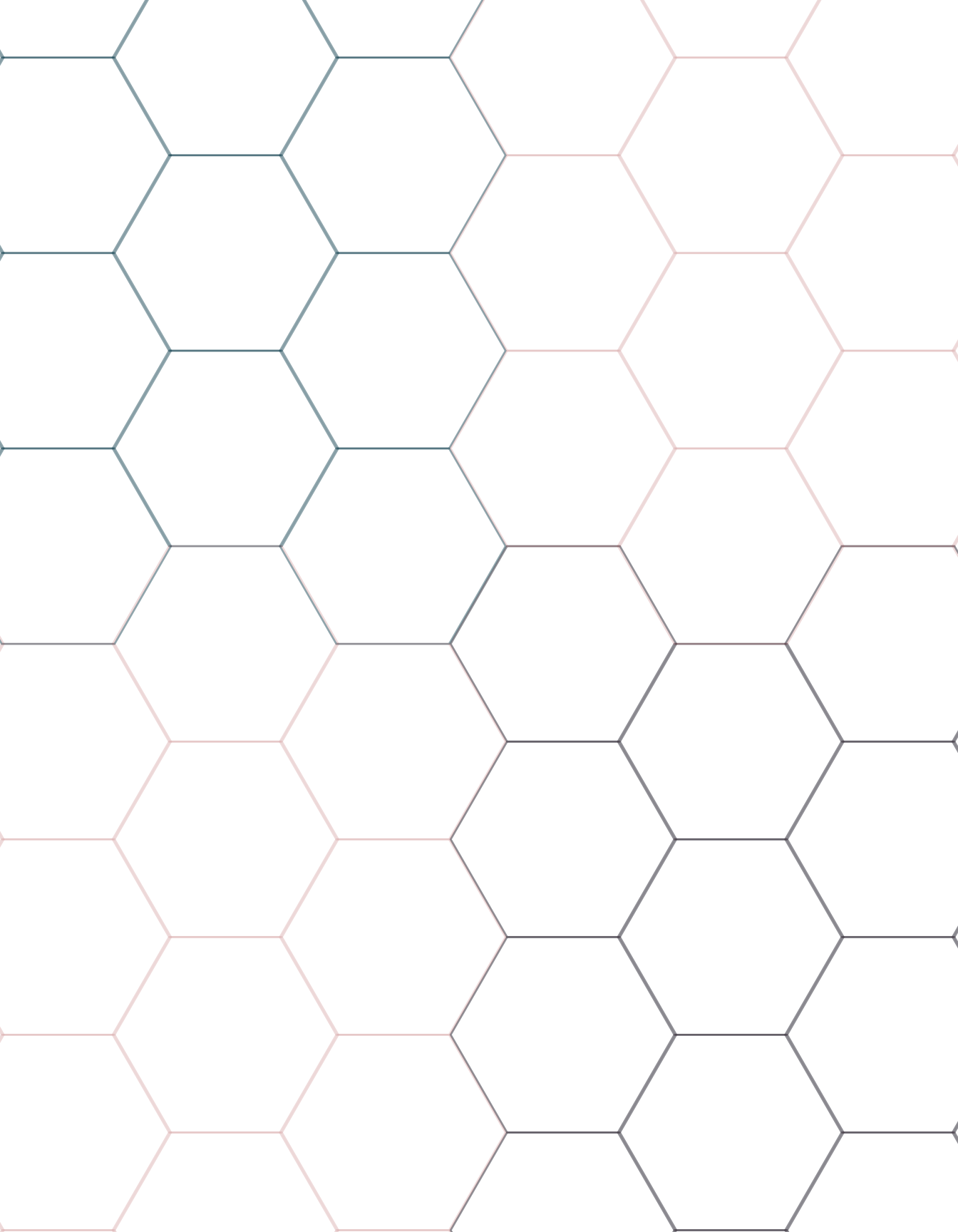
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The Generation of 1959: Competing Visions of the Cuban Revolution

Abstract

Much of the scholarship on the development of the Cuban Revolution has focused on its relationship to Cold War tensions or the two most prominent figures of the revolution, Fidel Castro and Che Guevara. These two figures did indeed have the most power and influence over the course of the revolution, but the Cuban Revolution was not solely influenced and shaped by these two influential figures. Both during and after Castro's take over, there were prominent and influential secondary figures that played a significant role in the guerrilla campaign waged by the 26th of July Movement, the subsequent takeover of the government, and the policies of the revolutionary regime in Cuba. Figures such as Carlos Franqui, Haydee Santamaria, Camilo Cienfuegos, and Celia Sanchez among others held significant influence at different stages of the revolution. These secondary figures came from a wide range of socioeconomic backgrounds and had diverse influences and ideologies, yet were brought together for a common struggle. These secondary figures each had a different outcome as a result of their involvement in the revolution; some stayed close to the regime until death, others went into exile. This research looks to shed light on the similarities and differences of the Cuban revolutionaries and how that impacted them and the outcomes and trajectory of the Cuban Revolution itself. Although these secondary figures came together for a common cause, it was their differences that influenced their relationship to the Castro regime and their experience in revolutionary Cuba.

Introduction

Much of the scholarship on the development of the Cuban Revolution has focused on its relationship to Cold War tensions between the United States or the two most prominent figures of the revolution, Fidel Castro and Che Guevara. These two figures did indeed have the most power and influence over the course of the revolution, but the Cuban Revolution was not solely influenced and shaped by these two influential figures. Both during and after Castro's take over, there were prominent and influential secondary figures that played a significant role in the guerrilla campaign waged by the 26th of July Movement, the subsequent takeover of the government, and the policies of the revolutionary regime in Cuba. Figures such as Carlos Franqui, Haydee Santamaria, Camilo Cienfuegos, and Celia Sanchez among others held significant influence at different stages of the revolution. These secondary figures came from a wide range of socioeconomic backgrounds and had diverse influences and ideologies, yet were brought together for a common struggle. These secondary figures each had a different outcome as a result of their involvement in the revolution; some stayed close to the regime until death, others went into exile. This research looks to shed light on the similarities and differences of the Cuban revolutionaries and how that impacted them and the outcomes and trajectory of the Cuban Revolution itself. Although these secondary figures came together for a common cause, it was their differences that influenced their relationship to the Castro regime and their experience in revolutionary Cuba.

These secondary figures came from varied backgrounds, challenging the long-held belief among historians that revolutionaries largely come from the

middling classes. Crane Brinton argued in his seminal work that revolutionaries do not come from the dregs of society, instead claiming that revolutionaries come from the upper classes of society. This long-held belief is directly challenged by the makeup of the secondary figures of the Cuban revolution. These figures varied in social standing, education attainment levels, and upbringing. Furthermore, the revolutionaries studied in this paper are not mere "rank and file" soldiers. Although they fought alongside the Castro brothers and Che Guevara during the guerrilla campaign, these figures had a tremendous influence on the course the revolution would take. This influence manifested itself in ways that, while not at the highest levels of Cuban decision making, played an important role in the way the revolution was implemented on ground level. All of these figures, especially at the outset of the guerrilla campaign, held tremendous influence. They had Fidel and Che's ear during decision-making time. Once the revolution took hold of Cuban government, the secondary figures (with the exception of Camilo Cienfuegos) were took positions in different official capacities. Their official role was to push forward the agenda of the Cuban revolution, but, through these official capacities, these revolutionaries were able to carve out their unique visions for the revolution and put it into practice in subtle ways. These revolutionary figures all came together in a common cause against the Bautista regime, but they arrived at this point after varied experiences that cultivated in each of them unique perspectives on what the Cuban Revolution could, and should, be.

Haydee Santamaria

Born in a provincial town in rural Cuba,

Haydee Santamaria became a heroine of the Cuban Revolution. She was one of only two women-the other being Celia Sanchez-that were involved in the revolution in each of its phases. She fought on the front lines of the failed 1953 attack on the Moncada military barracks and showed great resilience when she was captured and interrogated by Cuban forces. Later, during the guerrilla campaign she was a military and intellectual leader. Although she had never left the country, she mustered up the courage to travel to the United States to secure financing and weapons from mafia thugs.² After the 26th of July Movement won the revolutionary war, Haydee founded the Casa de las Americas, a publishing house that would be an intellectual, cultural, and literary hot spot for Cuba and Latin America. Despite only achieving a sixth grade education, she was pivotal in developing this cultural space for the people of Latin America. It was through this publishing house that Haydee was able to achieve her vision of the revolution. She believed, as many other revolutionaries in Cuba did, that the Cuban Revolution was a beacon for the rest of the third world. As such she used this publishing house to spread this message throughout the third world. Most importantly she allowed writers and artists who held slightly dissenting opinions to publish works and make their voice known. Through this cause she was able to make sure that the dominant voice of the revolution-the official narrative-was not the only voice that was heard.

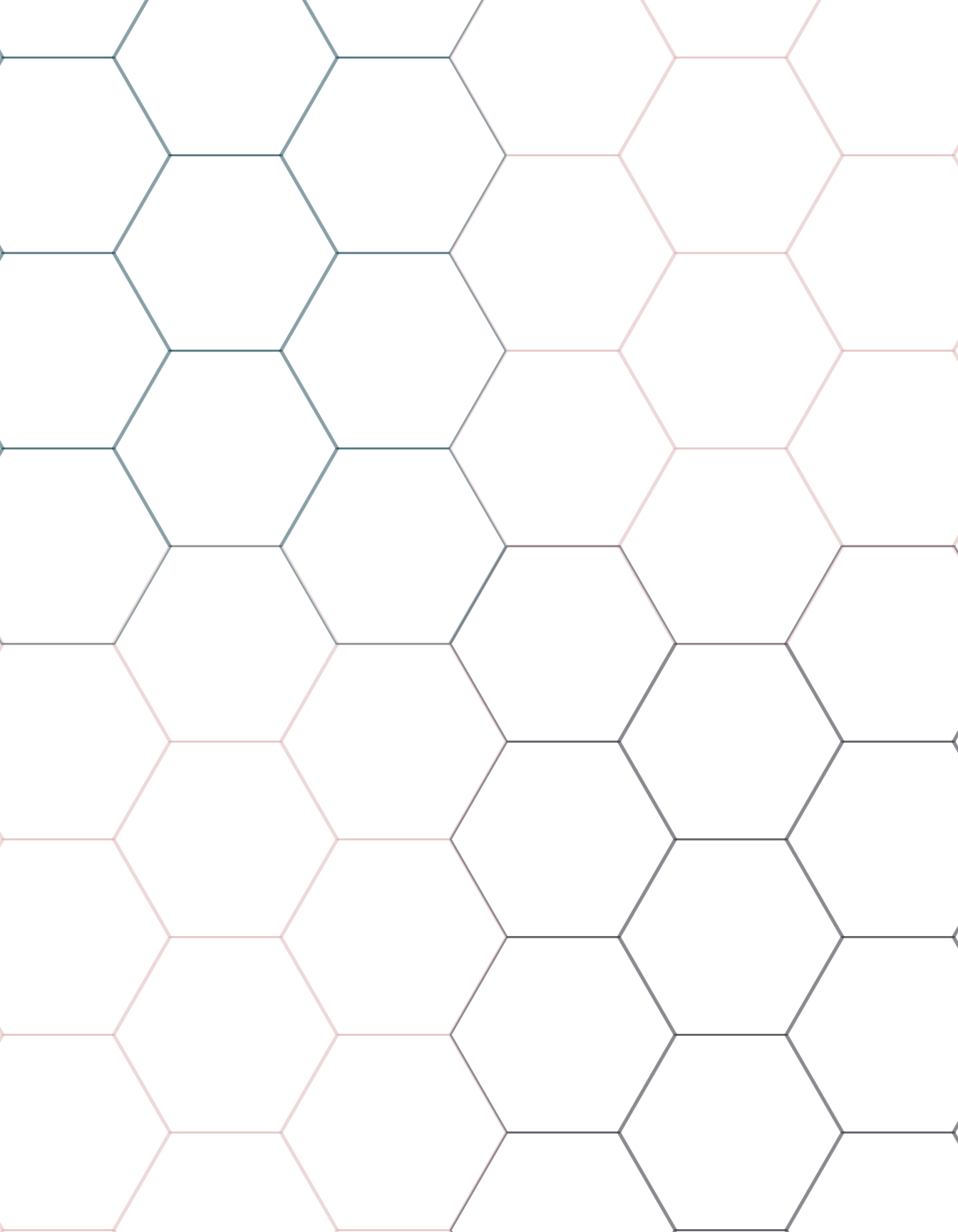
Carlos Franqui

Perhaps the most fascinating secondary figure of the Cuban Revolution was Carlos Franqui. Another figure who came from rural Cuba, Franqui grew to become a compassionate person. He credits this to

his early education by a black school teacher he had. Once he came of age, Franqui joined the communist party. He soon found, however, that his views did not align with the communists as much as he thought they would. He described himself as a democratic socialist. As such he left the communist party. Soon, he found himself joining the guerrilla campaign in the Sierra Maestra as the head of the revolutionary newspaper, *Revolucion*. He was also the head of propaganda, a role through which he would influence key speeches and press releases for the regime up until his self imposed exile in 1967. He fled the country in 1967. Historians still debate what the biggest reason for his departure from Cuba was. Franqui himself cited Fidel's support for the Soviet Union's invasion of Czechoslovakia in 1967, but other sources suggest that it was because of his fear that Fidel was slowly acting towards his assassination. In exile, Franqui became a vocal critic of the revolution, arguing that the revolution is lost.

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Developing Bi-directional Charging Functions for Electric Vehicles

Abstract

Electric Vehicles (EV) are increasingly adopted by consumers in the U.S. and around the world. However, the EV draw lots of power from supply feeders for charging, leading to increased power losses in the power lines and depressed feeder voltages. The EV charging also interferes with normal operation of other motor-based equipment such as residential appliances. This study seeks a solution to mitigate the EV adverse impacts while improving its value for the owners. Specifically, the study investigates a technique to enable bi-directional charging (i.e. both charge and discharge) functions for the vehicles using ACDC-AC converters. These functions can create additional benefits for the EV owners. They can make use of the EV battery power for running other appliances when desired, such as for camping trips. The bi-directional functions are also useful for the grid as the EV can inject their battery power to support the grid under emergency conditions.

I. Introduction

The growing number of electric vehicles (EV) in production directly correlates to an increase in applications utilizing its capabilities. According to vehicle travel trend, the average personal electric vehicle travels on the road is less than 10 percent of the day. EVs can bring benefits to home energy management, especially to feed priority loads during power outages and other emergencies. From the point of view of the power grid, EVs can bring benefits to ancillary services and compensation for the renewable energy sources intermittency. Energy is stored in electric vehicles during the night-when the price is low, and is withdrawn during peak-time, when the price is high. Elec-

tric vehicles act like pumped-storage units and allow vehicle owners to gain revenue from the difference of prices and compensate part of the initial investment.

The growth in electric vehicles is mirrored in the amount of research that this growth is generating. In the article Bidirectional battery charger for electric vehicle, Kang Miao[1] begin by describing four ancillary functions electric vehicles can provide to the grid. Peak power is hard for an electric vehicle to discharge due to storage limitations, however this obstacle can be overcome if the vehicles aggregated or if there were refueling. Electric vehicles can have the option of providing these ancillary services during peak periods while consuming power during off-peak periods. Since spinning reserves are paid by the time they are available the arrangements can be favorable for electric vehicles. While connected to the grid there are considered spinning, yet incur short periods of generating power. Electric vehicles can be great for renewable energy storage and backup. Since a fair amount of renewable energy is generated during the daytime and remains unused, electric vehicles have the ability to act as capacitors and store it, which can be later used during off-peak hours.

Similarly, the article Accurate electrical battery model capable of predicting run-time and 1-V performance Min and Rincon-Mora[2], propose and implement an accurate, intuitive, and comprehensive electrical battery model. The authors discuss the complexity of electric batteries and design a model that can be utilized in calculations and designs involving batteries. This model accounts for all dynamic characteristics of the battery, from nonlinear open-circuit voltage, current, temperature, cycle number, and storage time-dependent capacity to transient response.

A more developed example of this type of

work can be seen in Bidirectional battery charger with Grid-to-Vehicle, Vehicle-to-Grid and Vehicle-to-Home technologies. In this publication Pinto[3] discusses a design, control algorithms, and hardware topology for a portable bidirectional battery charger, to be implemented in Grid-to-Vehicle (G2V), Vehicle-to-Grid (V2G), and Vehicle-to-Home (V2H) situations. IGBT transistors are used to implement a full bridge rectifier. The rectifier circuit is connected to a reversible DC-DC converter circuit that utilizes two additional IGBTs in conjunction with an inductor and capacitor, to create a buck or boost effect for charging and discharging respectively.

In order to accomplish maximum amplitude of the individual current harmonics a single-phase Phase-Jocked Loop (PLL) is first implemented. Two sine waves with unitary amplitudes, shifted by 90 degrees are used to synchronize with the power grid. During the G2V operation mode, the full-bridge ACDC bidirectional converter operates as active rectifier with sinusoidal current and unitary power factor. The buck portion of the DC-DC link is also active in order to supply the battery with the lower needed voltage.

During V2H and V2G operation modes the rectifier circuit is inactive and the boost circuit becomes active in order to get the DC link voltage to the rated amount. Voltage levels decrease during discharge mode, in order to keep the active power constant, current is proportionately increased. This is done by a PI controller that self-adjust its duty cycle for a PWM modulator. After design was completed the authors ran simulation test to calibrate the circuit using various values of passive components. The results validated the hardware topology and controls algorithms. Once calibrated a , scale proto-type was created and tested.

In the case of V2G specifically, Gallardo-Lozano[4] shows that for the V2G operation to work

properly, a Balanced Sinusoidal Source Current control strategy is proposed so that the charger demands or injects into the grid a perfect sinusoidal and balanced source current in phase with the positive sequence fundamental component of the phase-toneutral grid voltage.

Regarding V2H, Tuttle[5] shows how Vehicle-to-Home capabilities can provide ancillary services in times of blackouts and grid distribution faults. Roof top photovoltaic generation is required to shut down if the grids power is lost, to ensure the system does not back feed to the grid creating safety problems. However, a V2H system is able to maintain functionality to a islanded load. Data was taken from an ongoing smart grid demonstration study (Pecan Street Inc.) to estimate the instantaneous load that can be put on a PEV system. The overall Pecan Street study utilizes a test bed of 250 modern, greenbuilt homes constructed after 2007, and 160 homes ranging from 10-92 years in age. The homes are instrumented with various forms of energy metering equipment, which tracks electricity, natural gas, and water use. Of the homes in the study, 185 have roof top PV panels. The power production from roof top PV is metered separately from electric demand. The study then utilized the PV production and electric demands from data collected over a year as inputs for the system and vehicle model testing.

The system consisted of a PV-PEV-PHEV combo system. The BEVs tested were 19.2 kWh and 32kWh. These values were taken from the rated values of the Nissan leaf and entrylevel Tesla respectfully. First energy was consumed from the PV portion, and if load demands we less than the output of the PVs the BEV was charged to its maximum capacity. Once the PV exhausted its reserves the PEV was utilized, until finally the PHEV reserves were tapped. While the PHEV was

in use the excess energy was used to charge the BEV which allowed the authors to calculate and map the state of charge vs. gasoline relationship.

During of f-peak months, the PV output compliments the PHEV generator to substantially extend backup durations from a few days to nearly 25 days.

II . Methodology

Since the most widely used batteries for electric vehicles are lithium-ion (Li-Ion) and nickel-metal hydride (Ni-MH), I will begin by researching the recharge specifications and limitations for the two batteries. This will allow me to obtain rated performance and load drawing specifications, to optimize a design for both. With the necessary data, I will design electronic replica of circuit using circuit design software such as MultiSim. This allows me to get a global perspective of the design so that I may improve data flow paths and create a more compact design. After the electronic design is completed I will begin running test with software. To check that my control system is running efficiently, I will use toolboxes in Matlab (Stateflow and Control System) to run simulations. Once the design is proficient, I will Integrate the car battery chargedischarge and control system with power loads and perform simulation and analysis of the integrated system. The analysis aims to evaluate the effectiveness of the system in managing the interaction of the EV with the household appliances and the power grid. This will allow me to visually see how the components are working within the design and monitor both input and output current and voltages. With this data I am able to see phase differences between the voltage and current, and have the ability to correct it to reduce reactive power, maximizing power transmission.

III. Development Of Bi-Directional Charging Function: Modeling And Function Specifications

A. Battery Modeling

From the perspective of power grid, an EV is viewed as a load during charging and as a source during discharging. An appropriate battery model is necessary to accurately represent the characteristics of an EV battery. Likewise, a state of charge (SOC) must be implemented in the controls to select between the two scenarios. The electric circuit-based model is best due to its capability to represent the electric characteristics of a battery. The controlled voltage source is described by an equation developed by Shepherd[1]. This equation describes the electrochemical behavior of a battery in terms of SOC, terminal voltage, open circuit voltage, internal resistance and discharge current.

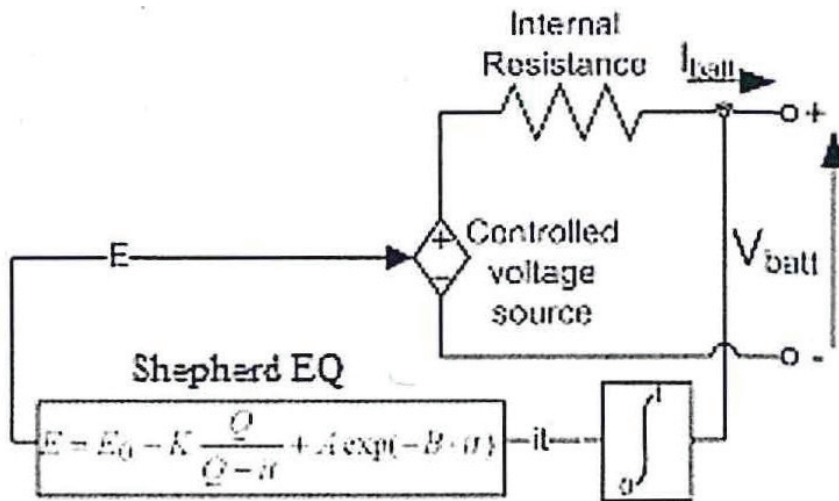


Fig. 1. Electric circuit battery model

The electrical battery model is able to calculate the SOC[2] of a lithium ion battery by:

$$SOC = 100 \left(1 - \frac{it}{Q} \right)$$

Fig. 2. State of charge equation

B. Bidirectional Battery Charger

The key components for an EV bidirectional battery charger are AC/DC converter and DC/DC converter. During EV charging mode, an AC/DC bidirectional converter rectifies the AC power to DC power.

Meanwhile, the AC/DC bidirectional converter inverts the DC power of the EV battery to AC power and injects it to power grid during EV discharging mode. On the other hand, the DC/DC converter is responsible for controlling the bidirectional power flow by using direct current control technique. It acts as a buck or boost converter during charging or discharging mode, respectively[3].

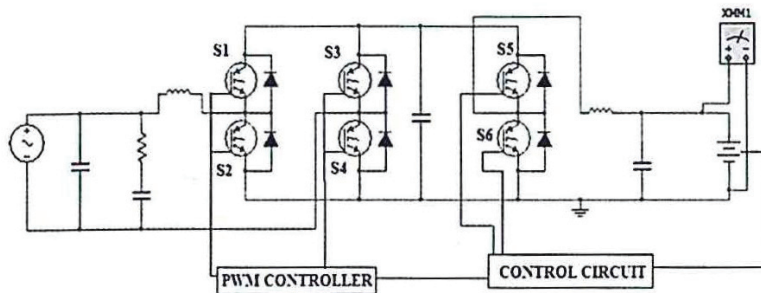


Fig. 3. Circuit design

C. Controls

The direction of power flow can be represented by the direction of the current. In this paper, the direct current control technique is used to control the bidirectional power flow for V2G implementation. This control strategy is applied to the DC/DC converter where it acts as a buck converter when IGBT1 is triggered and as a boost converter when IGBT2 is triggered. DC/DC converters controller can be categorized into two control parts, which are the charging control and discharging control. Initially, this controller compares the reference battery current with the measured battery current to decide between the charging and discharging mode. This is an important procedure to decide the next step of the controller. For charging mode, the error between the measured battery current and reference battery current is computed. This error passes through the PI controller for tuning. The output of the PI controller will be used to generate pulses by using sinusoidal pulse width modulation (SPWM) technique. The pulses generated in this stage are used to trigger IGBT1. Throughout the charging process, IGBT2

is turned Off. For discharging mode, the controller computes the error between the reference battery current and measured battery current. Then, the PI controller will perform the tuning of the calculated error. The output is sent to SPWM to generate the necessary pulses for IGBT2. During the discharging mode, IGBT2 is turned On.

D. Vehicle-to-Home (V2H)

Vehicle to home technology is a system that allows owners to utilize EVs as power source for home utilities. It requires the aforementioned bidirectional AC-DC circuit to be implemented. During the V2H operation mode the full-bridge ACDC bidirectional converter synthesizes a sine-wave voltage with the desired amplitude and frequency to feed the home loads. In order to the full-bridge AC-DC bidirectional converter deliver back to the power grid the energy stored in the traction batteries, the DC link voltage must be slightly greater than the peak value of the power grid voltage. Therefore, the reversible DC-DC converter has to operate as a boost converter, once the traction batteries

voltage is smaller than the required to the DC link voltage. The circuit is composed of two power converters that share a DC link. One is to interface the power grid and other is to interface the traction batteries.

1) Vehicle-to-Grid (V2G): Vehicle-to-grid (V2G) technology allows users to plug EV s directly into the grid and act as a power source to stabilize grid operations. The framework of V2G concept involves several important elements, such as energy resources,

power utility, system operator, aggregator, bidirectional battery charging facilities, communication facilities, intelligent metering and battery management[4]. A bidirectional V2G charger has the similar benefits as unidirectional V2G charger, as well as can achieve load leveling, peak load shaving, reactive power support, active power regulation and harmonic filtering[2][5]. Furthermore, a bidirectional V2G concept can provide more system flexibility to power utility and of fer significant financial benefit's to EV owner.

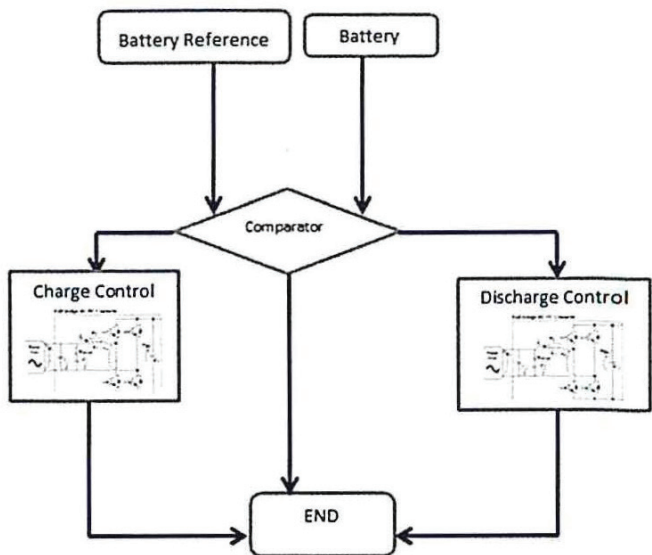


Fig. 4. State diagram

IV. Simulation And Results

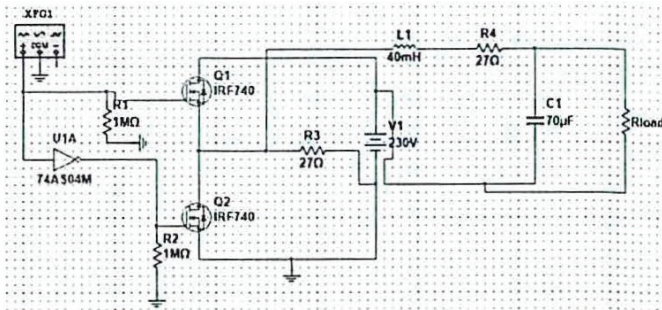


Fig. 5. Inverter

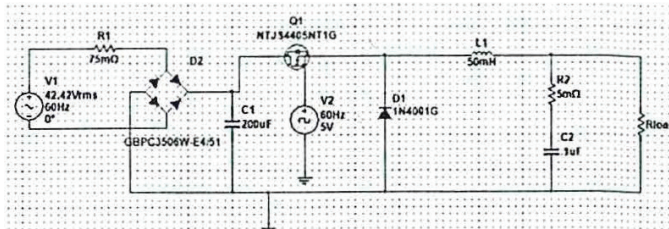


Fig. 6. Converter (Charger)

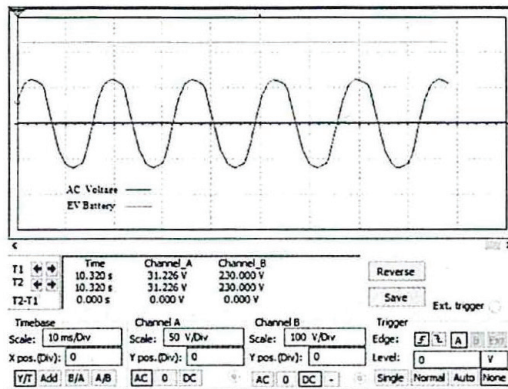


Fig. 7. AC output vs. DC input (Discharge)

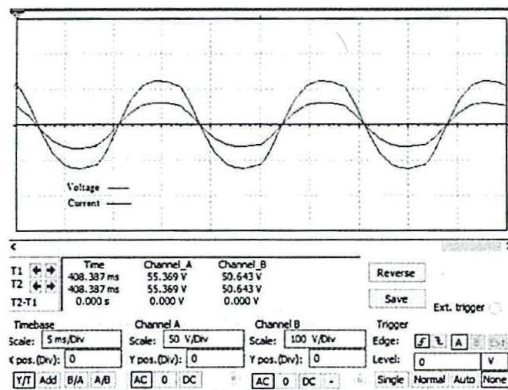


Fig. 8. Voltage vs. Current output (Discharge)

A. Charge/Discharge

The following figures (Fig. 5 -Fig. 9) represent a simplified replica of the circuit, and various forms of analysis and efficiency examinations. Fig. 5 shows a simplified circuit of all components which will be on during discharge (inverter). Fig. 6 depicts the the working inverter, with a 230V DC input, and 120V AC out at 60Hz. Fig. 7 depicts the voltage along with current AC sine waves in phase with one another with roughly the same amplitude (Note: a 1 kilo ohm resistor is used as load resistance). Fig. 8 shows a simplified circuit of all components which will be on during charging (converter). Fig. 7 depicts DC voltage and currents with one each roughly the same amplitude (Note: a 1 kilo ohm resistor is used as load resistance).

V. Conclusion

As of now I have completed the design for the bidirectional circuit. With a relative low load resistance and ideal passive components, currents and voltages, during both discharge and charge, has seen a relatively high efficiency rating. Currently working on methods to improve efficiency with a varying load resistance, while maintaining high power flow efficiency.

1) *Future Work:* After high efficiency is maintained, I plan to introduce varying passive components for a wide range of EV battery voltages before beginning the physical design. At which point I plan to create a program with a user interface which will monitor, initiate, and cease power transmission.

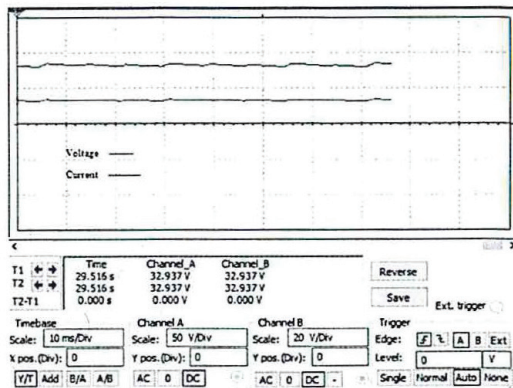


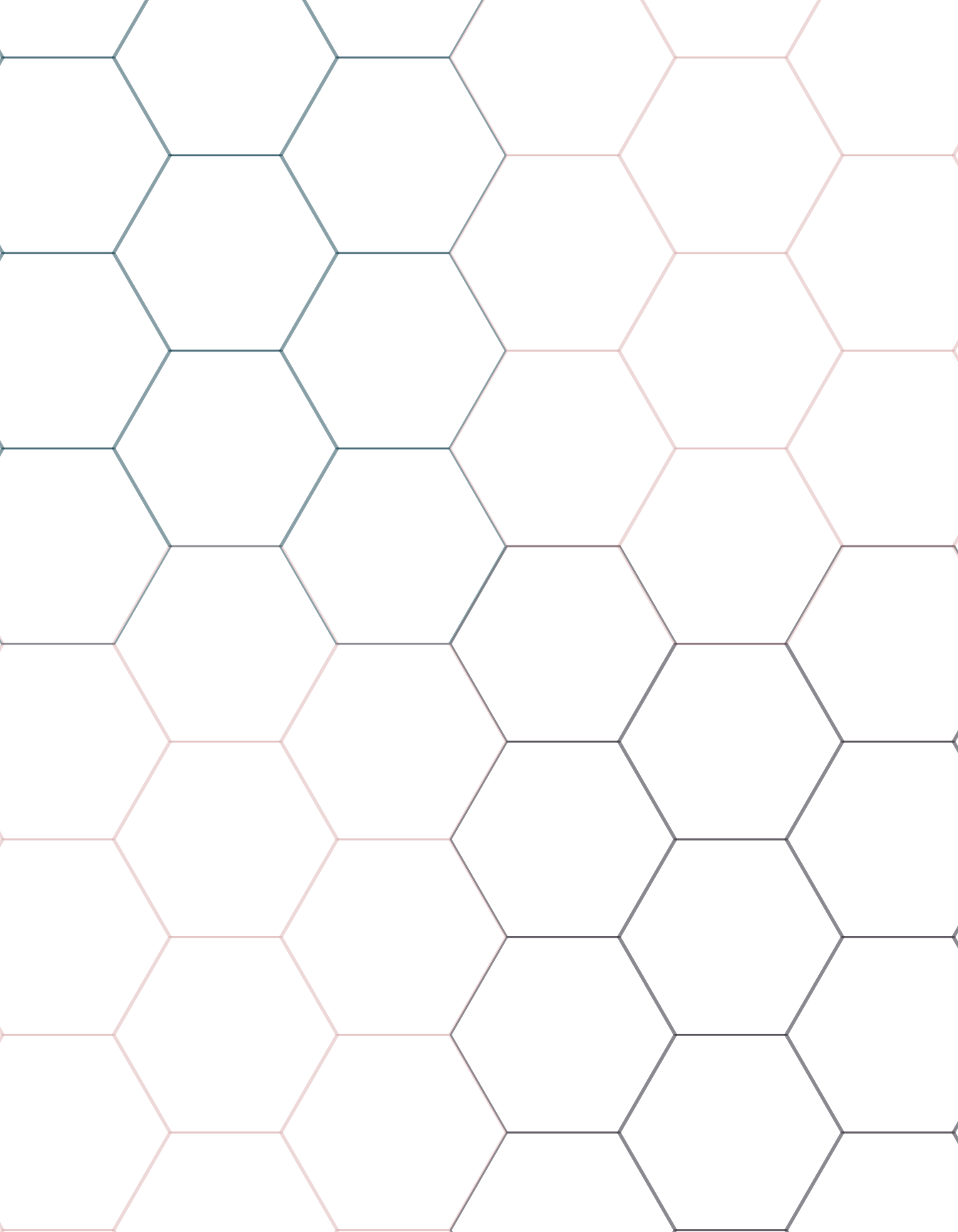
Fig. 9. Voltage vs. Current output (Charger)

Acknowledgment

I would like to thank my research mentor Dr. Ha Le for her guidance, patience, and knowledge in the field of power and renewable energy. The McNair Scholars program, and many program advisers, for their support and opportunity to conduct undergraduate research. California State Polytechnic University, Pomona for allowing me to utilize their facilities to conduct my research.

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Development of Fiber Optic Biosensors for the Rapid Detection of Methicillin-Resistant *Staphylococcus aureus*

Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) is known for skin infections and is potentially life threatening if not treated immediately. Its presence in livestock and farm workers suggest agriculture industries may have an impact in spreading the infection. Its methicillin-resistance, encoded by *mecA*, protects it from beta-lactam antibiotics. Current diagnostic techniques are very slow (48-72 hours) and performed only by trained personnel. We are developing a rapid detection method for MRSA based on tapered fiber optic biosensors, which we have recently demonstrated for detection of binding between immunoglobulin-G (IgG) and anti-IgG. This method does not require any fluorescent labels and data acquired in real time allows rapid detection in less than 3 hours. MRSA is detected by a hybridization reaction between immobilized *mecA* probes (oligonucleotides) on the tapered fiber sensor surface and target complimentary *mecA* (prepared by heat-treatment and lysostaphin cell lysis of *S. aureus*). The protocol and the reagents used to bind *mecA* probes to the sensor surface were the same as the one used in our previous IgG-anti-IgG binding studies. Typical buffers used in hybridization reactions include sodium dodecyl sulfate (SDS) and standard saline citrate (SSC). In our preliminary experiments, we found that both *mecA*⁺ and *mecA*⁻ generated large sensor signals. We hypothesized these signals were contributed by the reagents of the buffer and not the hybridization reaction. Through multiple control experiments, we discovered by removing the SDS from the buffer we were able to show difference in the sensor response to *mecA*⁺ and *mecA*⁻.

Introduction

With the past success of functionality of our biosensors immobilized with IgG in rapidly detecting anti-IgG, we have modeled the biosensor functionalization protocol to detect the *mecA* gene in MRSA extracted DNA samples (Miller et al., 2014). The DNA samples were prepared referencing functional DNA extraction parameters. Immobilization of the *mecA* oligonucleotide probe was also referenced from the same experiment. Our IgG biosensor functionalization protocol adapted to the new *mecA* oligonucleotide-biosensor functionalization protocol with ease due to identical bio-chemicals used with the exception of the reagent probe (IgG to *mecA* oligonucleotide) in immobilization. Testing parameters were recreated to suit the conditions required for *mecA* hybridization between the biosensor and DNA samples (Jenison et al., 2000). *mecA* oligonucleotide probes were referenced from an updated recent study of the same team (Jenison et al., 2014).

However, due to inconsistent data when testing against extracted *mecA*⁺-samples, we devised several troubleshooting experiments. Through various trials using unfunctionalized biosensors, we discovered that the sodium dodecyl sulfate (SDS) in the hybridization buffer was causing the inconsistent shifting.

To validate that the detected shifting was due to DNA hybridization between the *mecA* probe and target DNA, a series of additional experiments using *mecA* complementary DNA (cDNA) as a sample instead of extracted DNA samples. Even with removal of SDS from hybridization buffer, irregular shifting still occurred. We suspect that the shifting is being caused by "microbubbles" forming on the sensor's surface. To confirm this,

we have implemented a sonication step prior to data collection to remove these bubbles. Further experiments still need to be performed for confirmation.

Materials and Methods

Silica fiber optical sensor fabrication and Refractive Index

The optical silica fiber was tapered by using a butane torch (Fig. 1-1A, 1-1B). The final product was then fabricated onto a glass slide in a U-shape using tape. As the refractive index around the sensor is changed, the transmission spectrum will undergo a phase shift (Fig. 1-1C). This phase shift can be quantified by tracking the location of peaks in the spectra (Miller et al., 2014).

mecA oligonucleotide probes

The *mecA* oligonucleotide probes were ordered from Integrated DNA Technologies (IDT) with modified 5' and 3' amino ends:

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mecA1:
/5AmMC12/GTCATTCTACTTCACCATT
ACCAAC
mecA2:
/5AmMC6/GTCATTCTACTTCACCATTA
CCAAC
mecA3:
GTCATTCTACTTCACCATTACCAAC/3A
mMO/
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The optical silica fibers were functionalized using the *mecA1* oligonucleotide probes (Jenison et al., 2000).

Biosensor functionalization

The fused silica fiber surface was treated with plasma produced by a high-frequency generator for 2 minutes

to deposit hydroxyl groups on the glass surface. The surface was then coated using a silane reagent with an amine functional group (APTES > 3Aminopropyltrimethoxysilane). We used BS3 (Bis[sulfosuccinimidyl] suberate) as our amineamine crosslinker. Finally, the *mecA* oligonucleotide is immobilized via its amino groups forming an amide bond with the free end of the crosslinker. We used bovine serum albumin (BSA) protein for blocking to prevent non-specific binding.

MRSA DNA sample preparation

MRSA samples were prepared through standard cell culture inoculation. Grown samples underwent DNA extraction by first inoculating a single colony in reaction buffer (75 mmol/L NaCl, 25 mmol/L EDTA, 20 mmol/L Tris, pH 7.5) followed by vortex mixing. The solution was then treated with 2μl of lysostaphin (10 mg/L) solution for cell lysis, incubated at room temperature for 20 min, 95° for 10 min, and mixed via vortex. Lysostaphin treated samples were inoculated onto agar plates and incubated to test for cell death. The sample solution was then centrifuged for 20 min at 13,000 rpm (Jenison et al., 2000). The supernatant of the samples were tested for purity using a NanoDrop1000 spectrophotometer.

Experimental setup (Fig. 1D)

Amplified spontaneous emission from a semiconductor optical amplifier (SOA) was used as a broadband light source (1450-1600 nm). A 1x5 optical switch allowed us to measure the source and the sensor response -5 seconds apart and up to 4 different sensors can be automatically interrogated with one channel reserved for reference measurement to account for any fluctuations in the source power. An optical spectrum analyzer (OSA) was used to determine the optical power of the

SOA as a function of wavelength (Miller et al., 2014).

DNA Hybridization

The DNA sample was diluted (50:50) in hybridization buffer [10X Standard Saline Citrate (SSC)] and heated to 95°C for 10 min. The biosensor was then introduced to the solution and incubated at 57°C for 2 hours. The biosensor and solution were then incubated at 23°C for 10 min, followed by washes with 0.1X SSC, 1 g/L SDS and 0.1X SSC solutions (Jenison et al., 2000).

Troubleshooting with un-functionalized and plasma treated sensors

To determine why the data produced by the hybridiza-

tion experiments behaved unpredictably, troubleshooting tests were devised to break down testing parameters. This allowed isolation of specific areas in each test and control which element in the testing procedure likely caused this unpredictable factor. Un-functionalized sensors were tested against diH₂O and hybridization buffer (no DNA) to observe potential shifting in the refractive index. Identical parameters to the hybridization experiments without functionalized biosensors or the presence of DNA in hybridization buffer.

Hybridization with single-stranded complementary DNA (cDNA) Single stranded cDNA (5' GTTGGTAATGGT-GAAGTAGAAATGAC-3') was purchased from IDT. 1 μ M cDNA sample was prepared by diluting in 6X SSC. Sam-

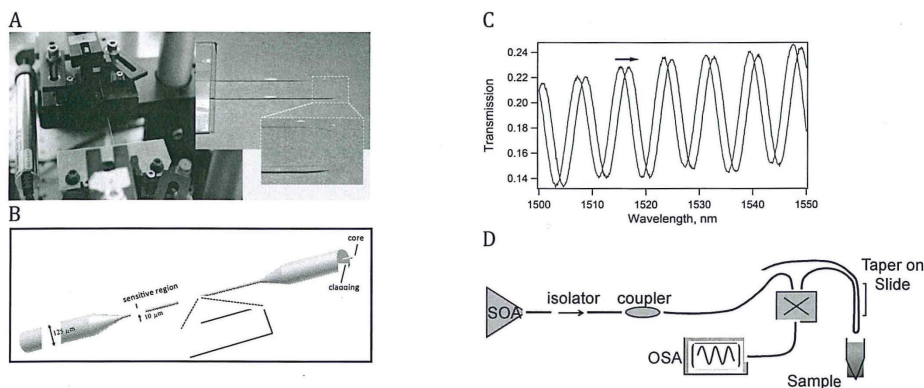


Fig. 1-1. Silica fiber optical sensor fabrication and Refractive Index. (A) Tapering with a butane torch. (B) Diagram depicting immobilization of IgG antibodies on sensitive region of silica fiber surface following tapering. (C) Transmission spectrum undergoing a phase shift, indicating changes in the optical properties of the experimental sample. (D) Experimental set up of fabricated biosensor attached to semiconductor optical amplifier (SOA) and optical spectrum analyzer (OSA) for testing in sample.

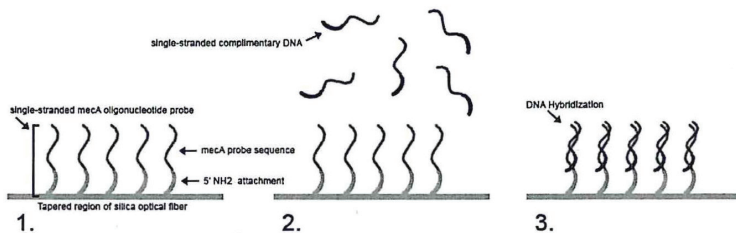


Fig. 1-2. DNA hybridization diagram. *mecA* oligonucleotide probes are functionalized by the 5' NH₂ end onto the surface of the tapered region of the silica optical fiber (1). The fiber optic biosensor is introduced to solution containing single-stranded complementary DNA (2). DNA Hybridization has occurred (3).

ple solution was tested in room temperature (23°C) conditions for hybridization. *mecA* probe functionalization remained the same. (Fig. 18)

Results

IgG/Anti-IgG detection

Three different concentrations of anti-IgG were tested with the results shown in Fig. 2A. Fig. 2A.1-A.3 show the peak shift vs time for different concentrations. Typical diameter of the tapered region is about 8-10 mm. However, in a recent experiment, we made the taper even thinner leading to enhanced sensitivity, and the average shift at 50 ng/mL was as high as that at 500 ng/mL. As shown in Fig. 2A.4, we get measurable difference even in the first few minutes, which suggests that we might use the rate of shift with time to determine concentration.

mecA hybridization with functionalized and unfunctionalized sensors

Two strains of MRSA DNA samples and two strains of non-MRSA DNA samples were tested. Preliminary

results are shown in Fig. 2B.

Both functionalized (Fig. 2B.1, B.2) and unfunctionalized (Fig. 2B.3, B.4) biosensors were tested with positive and negative strains. The functionalized biosensors observed shifting to the right similar to the IgG/anti-IgG binding experiments, indicating potential DNA hybridization between the *mecA* oligonucleotide probe immobilized to the biosensor surface and *mecA* gene contained in the MRSA DNA sample. The negative control test showed no shifting, indicating no interaction between the biosensor and sample. The unfunctionalized biosensors observed no shifting when tested with the *mecA* gene containing MRSA DNA sample. However, the negative control test showed shifting similar to the functionalized biosensor positive control test. This implies that the unfunctionalized biosensor's refractive index was not affected by DNA hybridization.

Troubleshooting with unfunctionalized and plasma treated sensors against varying solutions

The unfunctionalized sensor trials tested against the

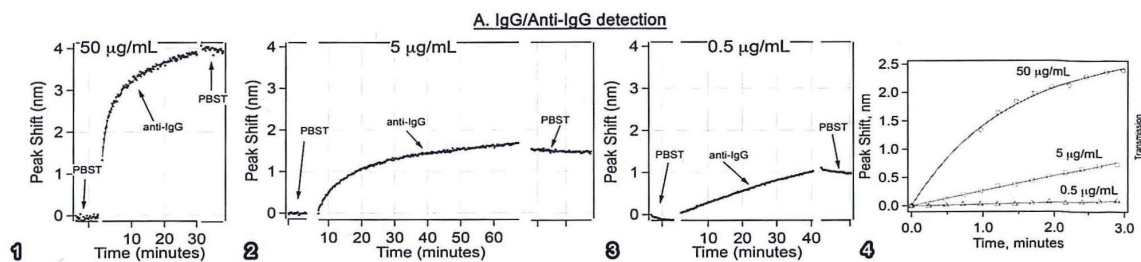


Fig. 2A. IgG/anti-IgG (peak shift vs. time) in different concentrations. (1) 50 $\mu\text{g/mL}$ (2) 5 $\mu\text{g/mL}$ (3) 0.5 $\mu\text{g/mL}$ (4) Comparison of 50 $\mu\text{g/mL}$, 5 $\mu\text{g/mL}$, and 0.5 $\mu\text{g/mL}$.

B. *mecA* gene detection

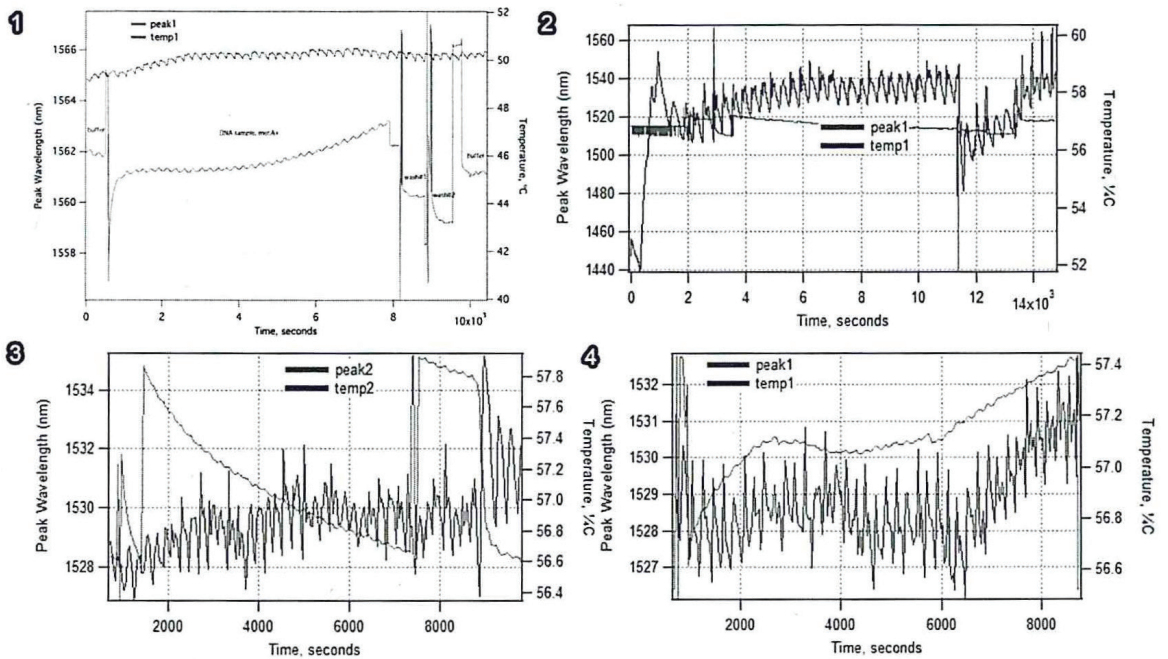


Fig. 2B. *mecA* detection using functionalized vs. un-functionalized sensors (peak wavelength vs. time). (1, 2) Functionalized biosensors testing against *mecA* positive (1) and *mecA* negative samples. (3, 4) Un-functionalized biosensors testing against *mecA* positive (3) and *mecA* negative (4) samples.

A. Test against diH₂O

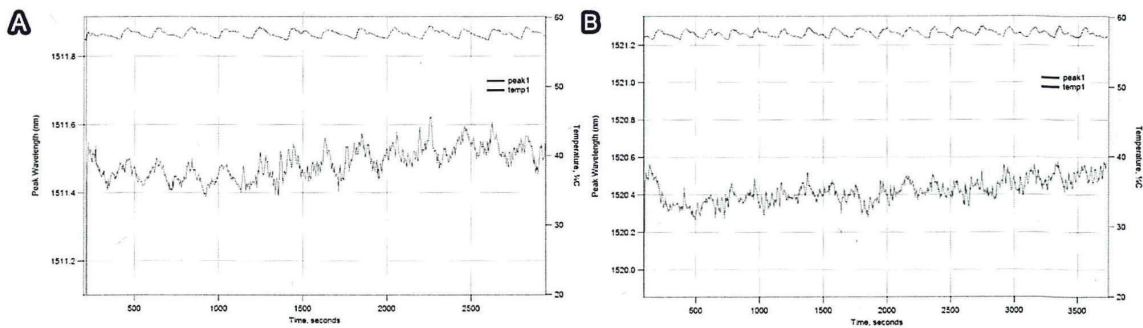
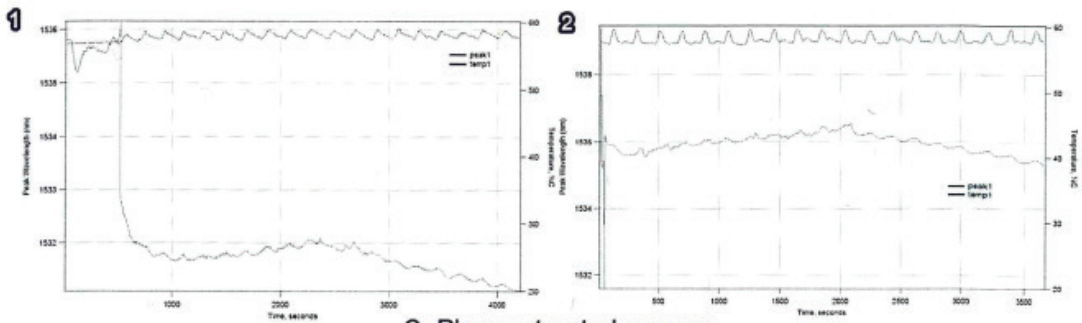


Fig. 3A. Troubleshooting using un-functionalized sensors against diH₂O (peak wavelength vs. time). (1, 2) Trials show no shifting.

B. Unfunctionalized sensors



C. Plasma-treated sensors

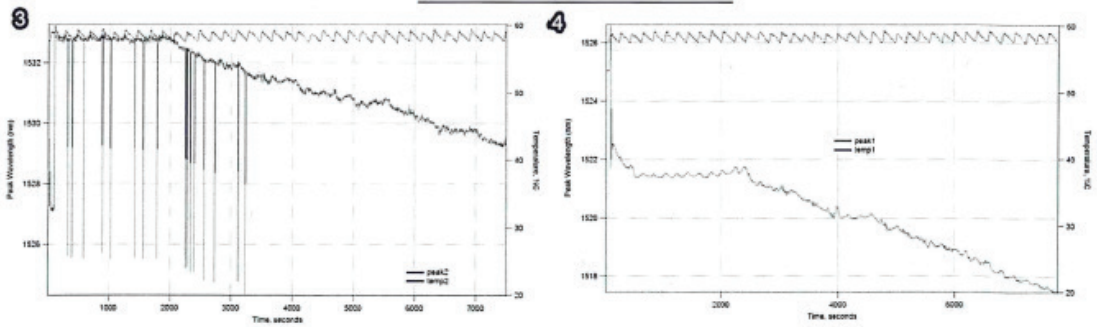


Fig. 3B. Troubleshooting using un-functionalized sensors against hybridization buffer (peak wavelength vs. time). (1, 2) Trials show minor shifting. Fig. 3C. Troubleshooting using plasma treated sensors against hybridization buffer (peak wavelength vs. time). (3, 4) Trials show more apparent shifting.

diHzO (Fig. 3A) behaved similar with no shifting. The tests using hybridization buffer (Fig. 3B, 3C) on the other hand behaved differently between trials and when compared to the tests against the diHzO. Removal of SDS in the hybridization buffer demonstrated more consistent results compared to hybridization buffer containing SDS.

Hybridization with single-stranded complementary DNA (cDNA)

Initial tests when testing functionalized sensors against cDNA did not demonstrate large variation of shifting amongst tests, but still showed inconsistencies. As a result, Unfunctionalized sensors were tested in varying solutions (cDNA, 6X SSC, diHzO). Tests in 6X SSC and diHzO brought to the attention of upward shifting when transferring the sensor between two different mediums.

Discussion

Through binding of IgG and anti-IgG, we have demonstrated the ability for real-time biosensing of proteins with tapered optical fibers. The sensor limit of detection is estimated to be less than 50 ng/mL. We anticipated successful nucleic acid immobilization to the sensor silica fiber surface due to the identical reagents used in functionalization. We were able to modify the functionalization procedure using *mecA* oligonucleotide probes in place of IgG reagent for rapid detection of extracted MRSA DNA samples. The *mecA* oligonucleotide probes were expected to hybridize with complimentary *mecA* gene sequences and display peak shifts in the refractive index. Through our preliminary experiments using nucleic acid based detection, we have found inconclusive results. While significant

shifting was found in *mecA* gene containing MRSA DNA samples in functionalized biosensors, failure to pass negative control tests for unfunctionalized biosensors implies the need to troubleshoot.

With the results obtained from the troubleshooting experiments, we can look further into the effects that the Hybridization Buffer might be having on the tapers. In the plasma treated sensors, we observed an odd occurrence of shifting happening after the 30 min mark. The spectrum drops and continues in a down ward progression for the full two hours. It can be noted that in the unfunctionalized sensor test, we can still see this effect happening only that it is less obvious.

We determined that the 1 g/L SDS in the hybridization buffer affected the refractive index by producing bubbles in solution which we infer to be micelles. After removing 1 g/L SDS from the hybridization buffer, which only consisted of 0.1X SSC, we found a significant difference between *mecA* + and *mecA* detection.

However, our results still remained inconclusive with inconsistent results following the *mecA* detection experiments. We developed a validation experiment to detect singlestranded complementary DNA by adjusting the concentrations to 1 μ M, increasing the 0.1X SSC to 6X SSC and testing in room temperature. When testing un-functionalized sensors in hybridization buffer only contained 6X SSC and diHzO, we noticed a trend when transferring the sensor between the two mediums. There is an apparent upward shifting progression which we suspected to be caused by the need for the sensor to acclimate between each medium. By using a sonication device prior to testing, we are in the preliminary stages of investigating whether micelles

are the culprit to the inconsistent data. It appears that conditioning the environment for hybridization is the difficult issue.

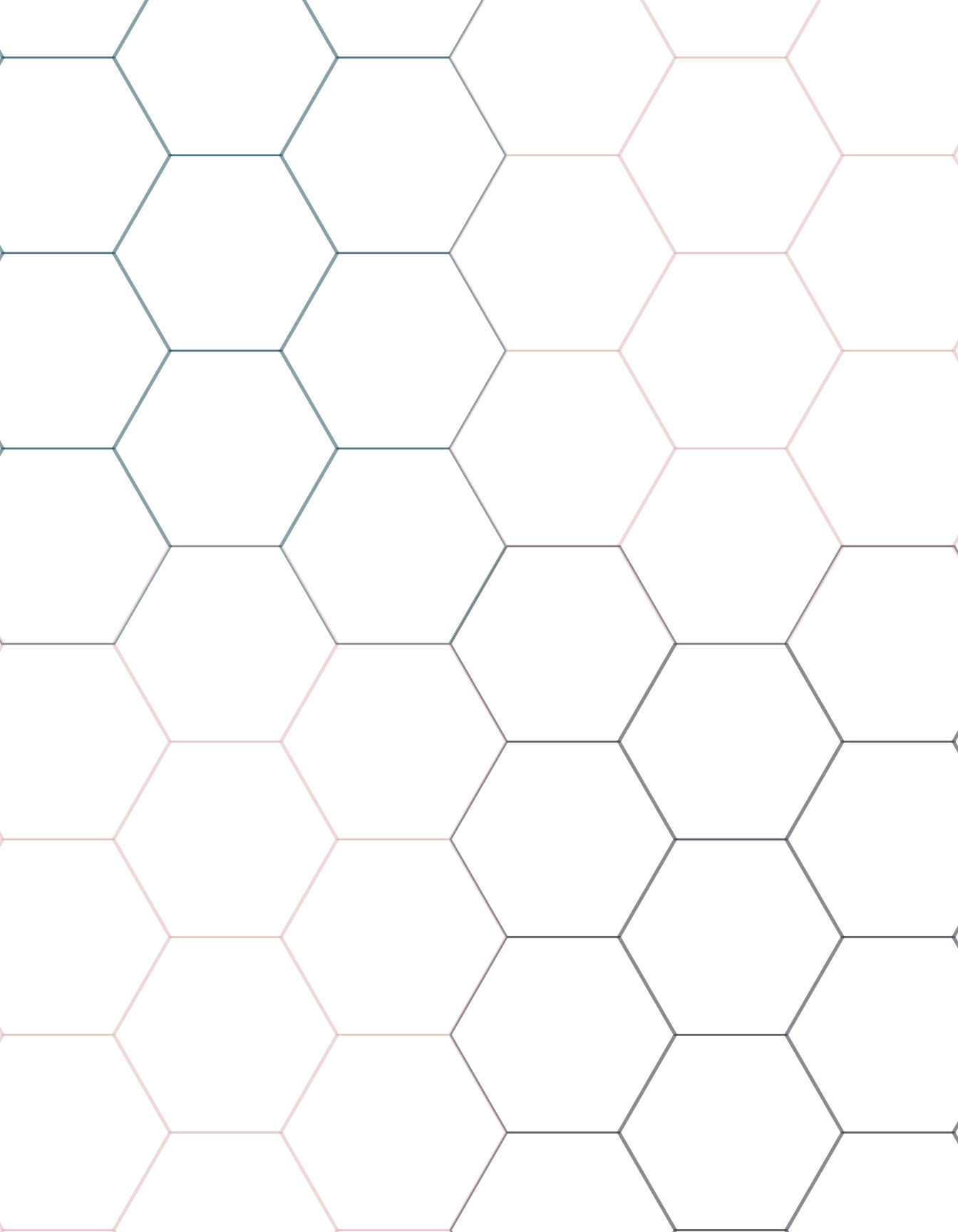
Considering we have been exclusively working with un-functionalized sensors, the *mecA* probe could not cause the irregular shifting. By removing 1 g/L SDS from the hybridization buffer, the results began to show consistencies. Nevertheless, the ongoing occurrence of upward shifting when transferring the sensor between diH₂O and 6X SSC hints at the idea that something besides the functionalization protocol, sensor itself, and hybridization buffer are not likely to cause the irregular shifting. We suspect the cause for this is a physical factor on the surface of the sensor.

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Hsien-Te Kao Epidemiological Human Mind

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Abstract

The advancement of social media has significantly increased the spread and impact of an identity or identified idea in the population. The affected population, of ten unconsciously, experiences physiological and psychological behavior changes. Our mind generates and processes uncountably many identities daily, and each identity is communicated distinctly based on personality, experience, relationship, and much more. An identity is developed from an individual and transfers onto another person resulting in the spread of an identity in the population. Interactions, including social, human, and nonhuman, allow an exchange of an identity associated with an expression that can be positive, negative, or a mixture. The process of an identity in the human mind and the impact of an identity from an individual on the population remain ambiguous. In this research, we have broken down a continuous process of an identity in the human mind into three major processes: development, maintenance, and progression. Each stage of an identity exhibits different impacts on the human mind and is associated with unique human behaviors. Since there is a direct relationship between the human mind and behavior, we can predict overall changes to an identity in a person's mind in respect to their behaviors. We apply epidemiological concepts to study the spread of an identity in a population and predict the changes to an identity within a person. The Susceptible and Infectious (*S/I*) epidemic model is modified to capture the characteristics of each stage of an identity in the human mind. The relationship between an identity and the human mind can be modeled using mathematical modeling and epidemiological concepts on the spread of an identity in terms of development, maintenance,

and progression.

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Preamble

The development of epidemiology is founded on the need to understand behaviors, causes, and effects of biological diseases in specific populations. Epidemiology has supported the study of public health

and shaped health related policies through identifying the risk factors in target diseases. Since epidemiology and biological science share many similar goals and concepts, epidemiology is deeply associated with biological science, and this associativity sometimes restricts the expansion of epidemiology into other areas of study like social studies, political science, etc. In social science, we study the relationships among individuals within a society, and these relationships are as complex and unstable as diseases, but the interaction between these relationships and humans shares similarities with the interaction between disease and humans. By integrating epidemiological concepts into the social sciences, we are able to treat these relationships among individuals as diseases, and we can study etiology, transmission, outbreak, and other epidemiological studies of human relationships. We need to study specific areas within divisions of social sciences like elections in political science and human decisions in social studies in order to modify the epidemiological concepts and models to capture the nature of the relationships between humans in that area. In this research, we explore the relationship between epidemiology and the human mind and behavior by addressing three major processes of an identity in the human mind: development, maintenance, and progression. From observations, we establish mathematical models that capture the different characteristics of the human mind and behavior at each stage of an identity and create parameter conditions to predict the possible outcomes. In Chapter 1, we develop the Existence Model to describe the relationship between human identity and recognitions and the formation of a dominating identity. In Chapter 2, we develop the Perspective Model to describe the relationship between human perspective and responses and the formation

of a persistent response. In Chapter 3, we develop the Radicalization Model to capture the progression of radicalization from human affection and its behaviors. By reading this research, we hope the readers will have a new understanding of epidemiology in terms of social science, and other researchers will continue the expansion of epidemiology into other areas of study in addition to biological science.

Chapter 1 Existence Model

1.1 Introduction

On February 2, 2009, RuPaul Andre Charles, also known as RuPaul, shocked the American entertainment industry with his new reality television show, RuPaul's Drag Race, that focuses on drag queen and drag racing [8]. With high supports around the globe, the show became the highest rated television programme on LGBT network Logo TV and aired internationally in countries like Latin America, Germany, and United Kingdom. His show continues to challenge the stereotypes toward gender, sexuality, and drag queen in the society through showcasing the natural beauty of each drag queen. RuPaul's Drag Race is known for its humor, fashion, and drag queen among their audiences. Breaking free from the restriction of gender, RuPaul expresses his uniqueness by interchangeable gender and roles as drag queen, model, singer, and actor in the show and public [2]. RuPaul has become the inspiration and mentor for the contestants in the show and the LGBTQ+ community. RuPaul is one of many LGBTQ+ members that advocates for the equalized acceptance of LGBTQ+ people in society. Continuously, they challenge the binary system in the structure of society regarding sex, gender, race and much more to remove

the social normativity on all people.

In society, the binary system has always been problematic when it generated numerous discriminations based on a person's gender, sexuality, class, and other characteristics. In addition, the binary system established a limitation on our understanding toward an identity when we restrict our mind to only two possible concepts or choices [9]. The binary system is studied heavily to understand the structure of society and social normativity in ethnic studies. The binary system has originated from the binary opposition that is defined as a pair of related terms or concepts that are opposite in meaning. Binary opposition is integrated deeply in human culture and can be found in many areas like philosophy, social interaction, and language. The binary opposition is expressed as the presence-absence dichotomy where presence occupies a position of dominance over absence because absence is defined in terms of presence when absence means not presence. Presence and absence is viewed as a fundamental element of human thought. The binary opposition is constructed into the human mind where we are constantly using binary opposition in the formation of our understanding of an identity and expression of our response toward an identity.

Under the influences of binary opposition, many situations in our life require the usage of binary system. Regardless of whether it is conscious or subconscious action, dichotomy has become the fundamental formation of human ideology where we are constantly using it every single day [3]. We have learned to view the world in terms of binary system through the systemic construction from multiple institutions. We establish the identification of an idea through the internalized classification of concepts. An identity or identified idea is affected by the classi-

fication of a concept, presence and absence, so we can describe an identity as a product of a collective classified concepts. As time progresses, an identity will change accordingly to the changes within the classified concepts. Of ten, we limit our understanding of classification into two categories, it is "X" or it is not "X", through defining the classification into one concept and forming the other concept from the opposition. By fixing the classified concepts of an identity, we short the identification process and create a check list for each identity. Our classification is also affected by others' classification through recognitions. It is common that others give their recognitions or we ask other people for their recognitions on an identity.

When the identification is solely based on our own classification with no external recognitions, the identity, it is or it is not, is associated with the strength of presence and absence that person has on the concepts. When the identification has recognitions from others, the strength of your presence and absence can increase or decrease by others' recognitions created by their classification, so your classification will be affected by their dominating classification. A dominating classification exists when presence and absence are unbalanced, and either presence or absence with stronger strength will generate a dominating classification. The creation of an identity can be viewed as infectious disease where people are affected by both presence and absence recognitions toward classifying concepts. As a result, we can predict a person's dominating classification in respect to their belief toward an identity. In a setting, a strong identity occurs when majority population believe its existence based on the similar dominating classification caused by different recognitions. In this chapter, the formation of a strong identity will be modeled using epidemiological con-

cepts on the spread of classification through recognition and the transition of an individual's classification.

1.2 Formulation of the I² Model

The *SIS* Model is one of the compartmental models in epidemiology that captures infection characteristics of no immunity upon neutralization, high contagiousness, and appearance in a short duration of time. The *SIS* Model has two classes, susceptible and infected, with contact rate β and removal rate γ . The susceptible *S* class contains individuals that are vulnerable to the infection, and the infected *I* class contains infected individuals that are infectious to the susceptible [5]. The following is the differential equations for the *SIS* Model:

$$\begin{aligned}\frac{dS}{dt} &= -\frac{\beta SI}{N} + \gamma I \\ \frac{dI}{dt} &= \frac{\beta SI}{N} - \gamma I\end{aligned}$$

The behaviors of human classification share many similarities with the *SIS* Model when humans cannot be completely immune to another recognition given to them, and the influences of a recognition take action immediately regardless of their current identification. The influences of a recognition may be significantly large or unnoticeably small, but it does affect the strength of presence and absence toward an identity. Human classification can spread from both active and passive behaviors of a person. Active behavior is defined when there exist both receiving and giving between two or more people like social interaction. Passive behavior is defined when there exists only receiving in a person with no interaction like reading the

comments of a video. From the similarities between the *SIS* Model and human classification, we will modify the *SIS* Model based on the characteristics of human classification.

Since human classification has two distinct elements, presence and absence, we will introduce a second infected class into the *SIS* Model and remove the susceptible class to create I² Model. Since humans will subconsciously form classification toward an identity, it is not possible for a person to not have a classification, and hence the infected class inherits the susceptible class. We will also refer to the I² Model as the Existence Model. The Existence Model will focus on the dynamics between recognitions of presence and absence toward a person's classification and recognition. In the real world, there are births and deaths in the population, and the birth and death counts will affect the spread of recognition and the development of a strong identity. It is essential to include this factor in the I² Model, so we will include average birth rate η and average death rate μ in the model. Since human classification appears in a short duration of time, we will assume there are no significant changes to the total population size due to birth and death in a small time interval, $\eta > \mu$. The number of individuals in each class is denoted by I⁺(t) and I⁻(t), where

- I⁺(t) represents the number of presence recognizers who are infectious and able to spread presence recognition to an absence recognizer.
- I⁻(t) represents the number of absence recognizers who are infectious and able to spread absence recognition to a presence recognizer.

The I² Model is formulated under the following premises:

- Premise 1: Since there are no significant changes to the total population size due to average birth and death rates in a small time interval, the total population size remains constant over the duration of time t . The total population size is denoted as N , where

$$I^+(t) + I^-(t) > N$$

- Premise 2: We will assume there is no false classification, and all recognitions have equal amount of influence throughout the duration of the time t , so the parameters remain constant. The recognizer class converts into another recognizer class at a rate proportional to the number of recognizers from the other recognizer class.
- Premise 3: We will ignore any internal and external factors like age, race, environment, and sex that can affect the outcome significantly. New recognizers are uniformly distributed among the recognizer class.

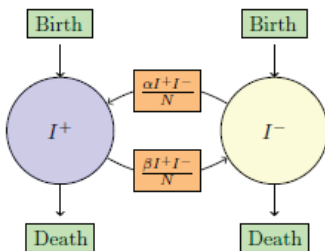


Figure 1.1: I^2 Model Structure

We establish the differential equations form of the I^2 Model from the premises, the standard SIS Model, and the visual representation of I^2 Model. Parameters α and

β are the presence and absence recognition influential rates. We will build the differential equations based on the behaviors of individuals entering and exiting in each class.

- The presence class receives the new presence recognizers from the absence class and birth and loses the presence recognizers to the absence class and from death.

$$\text{Thus, } \frac{dI^+}{dt} = \frac{\alpha I^+ I^-}{N} - \frac{\beta I^+ I^-}{N} + \mu I^+ - \eta I^+$$

- The absence class receives the new absence recognizers from the presence class and birth and loses the absence recognizers to the presence class and from death.

$$\text{Thus, } \frac{dI^-}{dt} = \frac{\beta I^+ I^-}{N} - \frac{\alpha I^+ I^-}{N} + \mu I^- - \eta I^-$$

From the assumptions above we have

$$\frac{dI^+}{dt} + \frac{dI^-}{dt} = 0$$

Since the sum of the rates of change from all two classes is equal to 0, the population in the system remains as a constant. This confirms our premise 1 that $I^+(t) + I^-(t) > N$. We can summarize the differential equations form of the I^2 Model as:

$$\begin{aligned} \frac{dI^+}{dt} &= \frac{\alpha I^+ I^-}{N} - \frac{\beta I^+ I^-}{N} \\ \frac{dI^-}{dt} &= \frac{\beta I^+ I^-}{N} - \frac{\alpha I^+ I^-}{N} \end{aligned}$$

1.2.1 Rescale to Proportional System I^+I^-

Define $i^+ = \frac{I^+}{N}, i^- = \frac{I^-}{N}, i^- = 1 - i^+$. After rescaling the system, we summarize the differential equations of the I² Model as follows:

$$\begin{aligned} \frac{di^+}{dt} &= \alpha i^+(1 - i^+) - \beta i^+(1 - i^+) \\ \frac{di^-}{dt} &= \beta i^+(1 - i^+) - \alpha i^+(1 - i^+) \end{aligned}$$

1.2.2 Reduce 2 x 2 System to 1 x 1 System

Since $i^- = 1 - i^+$, the system (1.2) becomes

$$\frac{di^+}{dt} = (\alpha - \beta)i^+(1 - i^+)$$

1.2.3 Function i*

Solving the equation (1.3),

$$\begin{aligned} \frac{di^+}{dt} &= (\alpha - \beta)i^+(1 - i^+) \\ \int \frac{di^+}{i^+(1 - i^+)} &= \int (\alpha - \beta)dt \\ \ln(i^+) - \ln(1 - i^+) &= (\alpha - \beta)t + C \end{aligned}$$

Let $i^*(0) > L$ where $0 < L < 1$.

$$\begin{aligned} L &= \frac{e^C}{1 + e^C} \\ L + Le^C &= e^C \\ L &= (1 - L)e^C \\ C &= \ln\left(\frac{L}{1 - L}\right) \\ i^+ &= \frac{\frac{e^{(\alpha - \beta)t(L)}}{1 - L}}{1 + \frac{e^{(\alpha - \beta)t(L)}}{1 - L}} \\ i^+ &= \frac{Le^{(\alpha - \beta)t}}{1 - L + Le^{(\alpha - \beta)t}} \end{aligned}$$

For $\alpha > \beta, \lim_{t \rightarrow \infty} i^+ = 1$.

For $\alpha = \beta, \lim_{t \rightarrow \infty} i^+ = L$.

For $\alpha < \beta, \lim_{t \rightarrow \infty} i^+ = 0$.

1.3 Model Analysis

1.3.1 Equilibrium Analysis

Setting $\frac{di^+}{dt}$ equal to 0, we find all the possible equilibria. We classify the behavior around the equilibria. In addition, we observe how the initial presence recognizers i^* will be affected by the equilibria.

Let $\frac{di^+}{dt} = 0$. Then

$$\begin{aligned} \frac{di^+}{dt} &= (\alpha - \beta)i^+(1 - i^+) \\ 0 &= (\alpha - \beta)i^+(1 - i^+) \end{aligned}$$

By solving $di^+ > 0$, we obtain three possible i^* values for the equilibria.

$$\begin{aligned} i^+ &> 0 \\ i^+ &> 1 \\ i^+ &> i_0^+, \text{ if } \alpha = \beta \end{aligned}$$

Equilibria

- ① $i^+ > 0$
- ② $i^+ > 1$
- ③ $i^+ > i_0^+$

We will use i_0^+ as an arbitrary variable.

Note: Equilibrium 3 exists only when $\alpha = \beta$.

1.3.2 Stability Analysis

From the equilibrium analysis, we obtain two critical points $i^+ = 0$ or 1 and a special condition, $\alpha = \beta$. We will perform stability analysis using the two critical points + and focus on three time intervals $(-\infty, 0]$, $[0, 1]$, and $[1, \infty)$. For $\alpha = \beta$, $\frac{di^+}{dt} > 0$ in $[0, 1]$ and $\frac{di^+}{dt} < 0$ in $(-\infty, 0]$ and $[1, \infty)$. Thus, Equilibrium 1 ($i^+ = 0$) is unstable and Equilibrium 2 ($i^+ = 1$) is stable. For $\alpha < \beta$, $\frac{di^+}{dt} > 0$ in $(-\infty, 0]$ and $[1, \infty)$ and $\frac{di^+}{dt} < 0$ in $[0, 1]$. Thus, Equilibrium ($i^+ > 0$) is stable and Equilibrium 2 ($i^+ = 1$) is unstable. For $\alpha = \beta$, $\frac{di^+}{dt} > 0$ in $(-\infty, \infty)$ and hence Equilibria 1, 2, and 3 are stable. If $\alpha = \beta$, then every point is an Equilibrium 3. The stability analysis results validate the result from i^+ function under the same parameter conditions.

1.4 Case Study

Scenario: There is a city located in New York with 10,000 people. An American internet media com-

pany, BuzzFeed, wants to forecast the change of the outcome for their survey question "Is the color of the sky blue?". From the initial survey result, they discover 70% of the population said the color of the sky is blue (i^+) and 30% of the population said the color of the sky is not blue (i^-). There will be another survey on the 180th day after the initial survey, and they will use the change of the outcome to write an article about social interaction. The people that said the color of the sky is blue have influential rate α , and the people that said the color of the sky is not blue have influential rate β . The units for the influential rate is (days)⁻¹.

1.4.1 Case 1

$$\alpha = 0.09, \beta = 0.06$$

Equilibrium 1 (0) Unstable Node

Equilibrium 2 (1) Stable Node

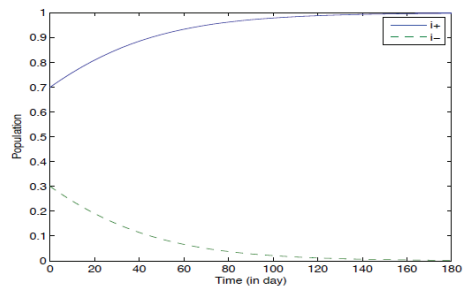


Figure 1.2: Population Chart: Case 1

After 180 days, the number of presence recognizers increases to 1, and the number of absence recognizers decreases to 0. Thus, "the color of the sky is blue" is a popular notion in the town at the 180th day.

1.4.2 Case 2

$$\alpha = 0.06, \beta = 0.1$$

Equilibrium 1 (0) Stable Node

Equilibrium 2 (1) Unstable Node

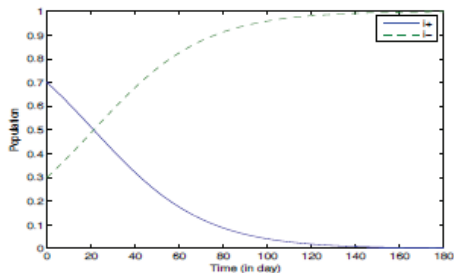


Figure 1.3: Population Chart: Case 2

After 180 days, the number of presence recognizers decreases to 0, and the number of absence recognizers increases to 1. Thus, “the color of the sky is not blue” is a popular notion in the town at the 180th day.

1.4.3 Case 3

$$\alpha = 0.06, \beta = 0.06$$

Equilibrium 1 (0) Neutrally Stable

Equilibrium 2 (1) Neutrally Stable

Equilibrium 3 (0.7) Neutrally Stable

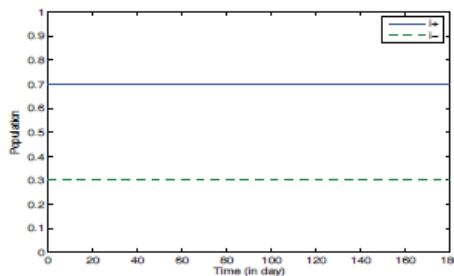


Figure 1.4: Population Chart: Case 3

After 180 days, the number of presence recognizers remains at 0.7, and the number of absence recognizers remains at 0.3. Thus, there is no popular notion in the town at the 180th day.

1.5 Discussion

From the I^2 Model, we can conclude that if two classifications exist in a fixed population, then the contagiousness of one classification will be affected by another classification. This means we can reduce the spread of one classification with another classification in the same population. Introducing more opposite recognizers in the population may not be an effective way to remove the other recognizers. It is important that we focus on the influential rate instead of the number of recognizers because the comparison of the

influential rate between two identifications, presence or absence, has direct relationship with the formation of strong identity. If we are able to reduce the influential rate from one classification, we can slow down the growth of the recognizers in the population. A dominating classification can be created through increasing the influential rate from one classification or decreasing the influential rate from one classification to form an unbalanced relationship between two classifications. Using similar reasoning, a dominating classification can be eliminated in the population if the influential rates are equal between two classifications. We can also change the current dominating classification to the opposition by decreasing its influential rates or increasing the opposition influential rates.

1.5.1 Result

The final supporters for Case 1, 2, and 3 are found using equilibrium analysis.

Case Study Result			
Case	Conditions	Dominating Identity	Final Recognizers i_F^+
1 (1.4.1)	$\alpha > \beta$	Presence	1
2 (1.4.2)	$\alpha < \beta$	Absence	0
3 (1.4.3)	$\alpha = \beta$	Presence ($i_T^+ > i_T^-$)	i_T^+
		Absence ($i_T^+ < i_T^-$)	i_T^-

Table 1.1: Case Study Result

1.6 Conclusion

This chapter investigates the development of a strong identity based on two distinct classifications, presence or absence, in a fixed population. A dominating classification occurs when a type, either presence or absence, of recognizers occupies the majority population, and the presence or absence of a classification is

in reference to the concepts of an identity or identified idea. The formation of a strong identity is modeled by assuming relationship between the spread of human classification and recognition. By using an epidemiological model, I^2 model, created from the classical SIS Model, we are able to establish different conditions that produce a dominating classification in a fixed population. We summarize the conditions as follows:

- Between two classifications, one classification will become dominating if it has higher rate of change for recognizers
- Between two classifications, no classification will become dominating if both have relatively close rate of change for recognizers
- An identity is strong as long as its associated classification is dominated

Our results offer insights on how two classifications interact in a fixed population and the creation of a dominating classification from this interaction. In this chapter, we drew the connection between strong identity, classification, and recognition. In addition, we can predict the formation of a strong identity based on the initial recognizers and the chance of people making the similar classification. We understand that the complexity in human classification and formation of a strong identity cannot be modeled accurately, but our model offers a simple logical reasoning for the phenomenon happening in the development of human identity.

Chapter 2 Perspective Model

2.1 Introduction

On October 22, 2015, an English singer Adele

Laurie Blue Adkins, also known as Adele, posted her song "Hello" from the new album, 25, on YouTube. In less than a month, the video views had grown to over 400 million views with more than four million likes [1]. The positive progression of her video views was caused by a large number of people supporting the song through watching the video, sharing the video through social media, and talking to their friends about the song. The song instantly became viral over the Internet, radio, and in daily life. We can conclude there exists a persistent response of favoring the song when a large number of people are supporting the song in different means. Since Adele is remembered by the audiences for her vocal skills, emotional connections, and deep voice, her songs mostly have high positive influential and retention rate. Therefore, there was a larger group of supporters than haters for this song, and hence people had a higher chance to be exposed to multiple positive influences. There was no surprise that this song became popular, since most people loved the song after listening to it for the first time and were repeatedly affected by the large amount of positive influences around them.

When the people watched the video for the first time, they formed opinions toward the song, and they established their initial strength of likes and dislikes. Based on the strength of likes and dislikes, they could have positive or negative preference toward the song where they became either a supporter or hater from their dominating preference. The strength of likes and dislikes could increase or decrease depending on the influences. For example, a person who rewatched the video could experience a positive influence from the emotional connections that increased the strength of likes and decreased the strength of dislikes. Then, this would either reassure their status as a supporter

or change their status from a hater to supporter. The effects of an influence vary by person, so two people could perceive a different effect, positive or negative, from the same influence and two people could experience significant change or unnoticeable change due to the strength of likes and dislikes. Using the previous example, if the same person rewatched the video ten times it could cause a negative influence from boredom that decreases the strength of likes and increases the strength of dislikes. From their preference, they developed their perspective toward the song and acted accordingly to the perspective.

Many questions we encounter in our life require an answer of yes or no. We are constantly making hundreds of decisions every single day, and the majority of our decisions are affected by our preferences, likes or dislikes. A decision is the internal process of determining our perspective toward an identity or identified idea, and a response is the external behaviors associated with the decision. Human preference is the process that analyzes the strength between likes and dislikes and concludes a dominating preference, and human perspective is the reflection of the dominating preference where human perspective is the result of human preference. When likes and dislikes are unbalanced, either likes or dislikes with stronger strength will generate a dominating preference. Not only developing from our experiences, our preferences are also affected by others' preferences when it is common that others give their opinions or we ask other people for their opinions on an identity [4]. When the decision is solely based on our own opinion with no external influence, the response, positive or negative, is associated with the strength of likes and dislikes that person has. When the decision has influences from others, the strength of your likes and dislikes can increase or decrease by

others' responses, and your decision will be affected by others' dominating preferences.

Human perspective can be viewed as an infectious disease where people are affected by both positive and negative influences created by others' dominating preferences toward an identity. With the positive and negative influences from others, the person can develop two possible perspectives to an identity: positive and negative. Based on the connection between perspective and response, we can predict a person's perspective toward an identity in respect to their response. In a population, a perspective has persisted when the associated response also has persisted over time. This response is supported by a number of individuals that are making same decisions based on the similar dominating preference caused by different influences that is either positive or negative. A persistent perspective is popular when there is an increase in the amount of response supporters by comparing the initial and final counts within a time interval. In this chapter, the persistence of human perspective will be modeled using epidemiological concepts on the spread, sustainability, and popularity of binary responses.

2.2 Formulation of the S^2S Model

The behaviors of human perspective share many similarities with the SIS Model when humans cannot be completely immune to another opinion given to them, and the influences of an opinion take action immediately regardless of their current preference. From the similarities between the SIS Model and human perspective, we will modify the SIS Model

based on the characteristics of human preference. Since human preference has two distinct factors, likes and dislikes, we will introduce a second infected class into the SIS Model to create a S^2S Model. We name the two infected classes with positive and negative to capture the characteristic of human preference. We will also refer to the S^2S Model as the Perspective Model. The Perspective Model will focus on the dynamics between positive and negative influences toward a person's response and perspective. In the real world, there are births and deaths in the population, and the birth and death counts will affect the spread of responses and the possibility of a perspective becoming persistent. It is essential to include this factor in the S^2S Model, so we will include average birth rate η and average death rate μ in the model. Since human response appears in a short duration of time, we will assume there are no significant changes to the total population size due to birth and death in a small time interval, $\eta > \mu$. The number of individuals in each class is denoted by $S(t)$, $I^+(t)$, and $I^-(t)$, where

- $S(t)$ represents the number of people who do not have knowledge of, forget about, or do not have a perspective toward the identity at the given time t but who are vulnerable to the influences.
- $I^+(t)$ represents the number of positive response supporters who are infectious and able to spread positive influences to a susceptible.
- $I^-(t)$ represents the number of negative response supporters who are infectious and able to spread negative influences to a susceptible.

The S^2S Model is formulated under the following premises:

- Premise 1: Since there are no significant changes to the total population size due to average birth and death rates in a small time interval, the total population size remains constant over the duration of time t . The total population size is denoted as N , where

$$S(t) + I^+(t) + I^-(t) = N$$

- Premise 2: We will assume there is no contradiction between a person's response and his or her perspective. All responses have equal amount of influences throughout the duration of the time t , so the parameters remain constant. The susceptible are converted at a rate proportional to the number of supporters in each response class.

- Premise 3: There are no interactions between the responses. The model will not have a new type of response during the duration of the time t .

- Premise 4: We will ignore any internal and external factors like age, race, environment, and sex that can affect the outcome significantly. New supporters are uniformly distributed among the susceptible class.

- Premise 5: The supporters will recover from the influences after some amount of time t , but they will receive no immunity to the influences when they recover. They are susceptible to the same influences immediately.

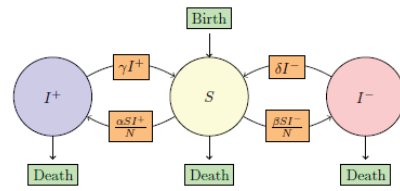


Figure 2.1: S^I^S Model Structure

We establish the differential equations form of the S^I^S Model from the premises, the standard SIS Model, and the visual representation of S^I^S Model. Parameters α and β are the positive and negative response influential rates. Parameters γ and δ are the positive and negative response neutralization rates. We will build the differential equations based on the behaviors of individuals entering and exiting in each class.

- In the susceptible class, the individuals are converted into positive response supporters at the rate of α , $-\frac{\alpha S I^+}{N}$, and negative response supporters at the rate of β , $-\frac{\beta S I^-}{N}$. The susceptible class also receives new individuals due to neutralization from both supporters. In addition, the susceptible class receives and loses individuals due to birth and death.

Thus, $\frac{dS}{dt} = -\frac{\alpha S I^+}{N} - \frac{\beta S I^-}{N} + \gamma I^+ + \delta I^- + \eta(S + I^+ + I^-) - \mu S$.

- The positive response class receives the new supporters, and it also loses supporters to the susceptible class at the rate of γ and due to death at the rate of μ .

Thus, $\frac{dI^+}{dt} = \frac{\alpha S I^+}{N} - \gamma I^+ - \mu I^+$.

- The negative response class receives the new

supporters, and it also loses supporters to the susceptible class at the rate of δ and due to death at the rate of μ .

Thus, $\frac{dI^-}{dt} = \frac{\beta SI^-}{N} - \delta I^- - \mu I^-$.

From the assumptions above we have

$$\frac{dS}{dt} + \frac{dI^+}{dt} + \frac{dI^-}{dt} = 0$$

Since the sum of the rates of change from all three classes is equal to 0, the population in the system remains as a constant. This confirms our premise 1 that $S(t) + I^+(t) + I^-(t) = N$. We can summarize the differential equations form of the S^2S Model as:

$$\begin{aligned}\frac{dS}{dt} &= -\frac{\alpha SI^+}{N} - \frac{\beta SI^-}{N} + \gamma I^+ + \delta I^- + \mu I^+ + \mu I^- \\ \frac{dI^+}{dt} &= \frac{\alpha SI^+}{N} - \gamma I^+ - \mu I^+ \\ \frac{dI^-}{dt} &= \frac{\beta SI^-}{N} - \delta I^- - \mu I^-\end{aligned}$$

2.2.1 Rescale to Proportional System

Define $s = \frac{S}{N}$, $i^+ = \frac{I^+}{N}$, $i^- = \frac{I^-}{N}$, $s = 1 - i^+ - i^-$.

After rescaling the system, we summarize the differential equations of the S^2S Model as follows:

$$\begin{aligned}\frac{ds}{dt} &= -\alpha(1 - i^+ - i^-)i^+ - \beta(1 - i^+ - i^-)i^- + \gamma i^+ + \delta i^- + \mu i^+ + \mu i^- \\ \frac{di^+}{dt} &= \alpha(1 - i^+ - i^-)i^+ - \gamma i^+ - \mu i^+ \\ \frac{di^-}{dt} &= \beta(1 - i^+ - i^-)i^- - \delta i^- - \mu i^-\end{aligned}$$

2.2.2 Reduce 3 x 3 System to 2 x 2 System

Since $s = 1 - i^+ - i^-$, the system (2.2) becomes

$$\begin{aligned}\frac{di^+}{dt} &= \alpha(1 - i^+ - i^-)i^+ - \gamma i^+ - \mu i^+ \\ \frac{di^-}{dt} &= \beta(1 - i^+ - i^-)i^- - \delta i^- - \mu i^-\end{aligned}$$

2.3 Equilibrium Analysis

Setting $\frac{di^+}{dt}$ and $\frac{di^-}{dt}$ equal to 0, we find all the possible equilibria. We classify the behavior around the equilibria using linearization and the Jacobian Matrix. In addition, we observe how the initial supporters I^+ and I^- will be affected by the equilibria.

Let $\frac{di^+}{dt} = \frac{di^-}{dt} = 0$. Then

$$\begin{aligned}\frac{di^+}{dt} &= \alpha(1 - i^+ - i^-)i^+ - \gamma i^+ - \mu i^+ \\ 0 &= \alpha(1 - i^+ - i^-)i^+ - \gamma i^+ - \mu i^+ \\ 0 &= i^+(\alpha(1 - i^+ - i^-) - \gamma - \mu)\end{aligned}$$

By solving $\frac{di^+}{dt} = 0$, we obtain two possible i^+ values for the equilibria.

$$\begin{aligned}i^+ &= 0 \text{ or } \alpha(1 - i^+ - i^-) - \gamma - \mu = 0 \\ 1 - i^+ - i^- &= \frac{\gamma + \mu}{\alpha} \\ i^+ &= 1 - i^- - \frac{\gamma + \mu}{\alpha}\end{aligned}$$

Also,

$$\begin{aligned} \frac{di^-}{dt} &= \beta(1 - i^+ - i^-)i^- - \delta i^- - \mu i^- \\ 0 &= \beta(1 - i^+ - i^-)i^- - \delta i^- - \mu i^- \\ 0 &= i^- (\beta(1 - i^+ - i^-) - \delta - \mu) \end{aligned}$$

By solving $\frac{di^-}{dt} = 0$, we obtain two possible i^- values for the equilibria.

$$\begin{aligned} i^- = 0 \text{ or } \beta(1 - i^+ - i^-) - \delta - \mu &= 0 \\ 1 - i^+ - i^- &= \frac{\delta + \mu}{\beta} \\ i^- &= 1 - i^+ - \frac{\delta + \mu}{\beta} \end{aligned}$$

Equilibria

- ① $i^+ = 0, i^- = 0 \Rightarrow (0, 0)$
- ② $i^+ = 0, i^- = 1 - i^+ - \frac{\delta + \mu}{\beta} \Rightarrow (0, 1 - \frac{\delta + \mu}{\beta})$
- ③ $i^+ = 1 - i^- - \frac{\gamma + \mu}{\alpha}, i^- = 0 \Rightarrow (1 - \frac{\gamma + \mu}{\alpha}, 0)$
- ④ $i^+ = 1 - i^- - \frac{\gamma + \mu}{\alpha}, i^- = 1 - i^+ - \frac{\delta + \mu}{\beta} \Rightarrow (i_0^+, 1 - i_0^+ - \frac{\gamma + \mu}{\alpha})$

There are infinitely many equilibria on the line $i^+ + i^- = 1 - \frac{\gamma + \mu}{\alpha}$. We will use i_0^+ as an arbitrary variable. **Note:** Equilibrium 4 exists only when $\frac{\alpha}{\gamma + \mu} = \frac{\beta}{\delta + \mu}$, constant k .

2.4 Linearization and the Jacobian Matrix

By linearizing the nonlinear 2x2 system (2.3), we reduce the amount of time spent in stability analysis. Using the Jacobian Matrix, we obtain the linear equations associated with an equilibrium point. Since the system is linearized, we use $\det(J - \lambda I) > 0$ to find

the eigenvalues and use the eigenvalues to identify stability behavior of the equilibrium. The following matrix is the Jacobian Matrix for the nonlinear system (2.3):

2.4.1 Equilibrium 1: $i^+ = 0, i^- = 0$

$$\begin{aligned} J(0, 0) &= \begin{bmatrix} \alpha(1 - 2 \cdot 0 - 0) - \gamma - \mu & -\alpha \cdot 0 \\ -\beta \cdot 0 & \beta(1 - 2 \cdot 0 - 0) - \delta - \mu \end{bmatrix} \\ &= \begin{bmatrix} \alpha - \gamma - \mu & 0 \\ 0 & \beta - \delta - \mu \end{bmatrix} \end{aligned}$$

Setting $|J(0, 0) - \lambda I| = 0$ and solving for λ ,

$$\begin{aligned} (\alpha - \gamma - \mu - \lambda)(\beta - \delta - \mu - \lambda) &= 0 \\ \lambda_1 &= \alpha - \gamma - \mu \\ \lambda_2 &= \beta - \delta - \mu \end{aligned}$$

2.4.2 Equilibrium 2: $i^+ = 0, i^- = 1 - \frac{\delta + \mu}{\beta}$

$$\begin{aligned} J(0, 1 - \frac{\delta + \mu}{\beta}) &= \begin{bmatrix} \alpha(1 - 2 \cdot 0 - (1 - \frac{\delta + \mu}{\beta})) - \gamma - \mu & -\alpha \cdot 0 \\ -\beta(1 - \frac{\delta + \mu}{\beta}) & \beta(1 - 2(1 - \frac{\delta + \mu}{\beta}) - 0) - \delta - \mu \end{bmatrix} \\ &= \begin{bmatrix} \alpha(\frac{\delta + \mu}{\beta}) - \gamma - \mu & 0 \\ -\beta + \delta + \mu & \beta(-1 + \frac{2(\delta + \mu)}{\beta}) - \delta - \mu \end{bmatrix} \end{aligned}$$

Setting $|J(0, 1 - \frac{\delta + \mu}{\beta}) - \lambda I| = 0$ and solving for λ ,

$$\begin{aligned} (\alpha(\frac{\delta + \mu}{\beta}) - \gamma - \mu - \lambda)(\beta(-1 + \frac{2(\delta + \mu)}{\beta}) - \delta - \mu - \lambda) &= 0 \\ \lambda_1 &= \alpha(\frac{\delta + \mu}{\beta}) - \gamma - \mu \\ \lambda_2 &= \beta(-1 + \frac{2(\delta + \mu)}{\beta}) - \delta - \mu \\ \lambda_2 &= -\beta + \delta + \mu \end{aligned}$$

2.4.3 Equilibrium 3: $i^+ = 1 - \frac{\gamma + \mu}{\alpha}$, $i^- = 0$

$$J(1 - \frac{\gamma + \mu}{\alpha}, 0) = \begin{array}{cc} \alpha(1 - 2(1 - \frac{\gamma + \mu}{\alpha}) - 0) - \gamma - \mu & -\alpha \cdot (1 - \frac{\gamma + \mu}{\alpha}) \\ -\beta \cdot 0 & \beta(1 - 2 \cdot 0 - (1 - \frac{\gamma + \mu}{\alpha})) - \delta - \mu \end{array}$$

$$= \begin{array}{cc} \alpha(-1 + \frac{2(\gamma + \mu)}{\alpha}) - \gamma - \mu & -\alpha + \gamma + \mu \\ 0 & \beta(\frac{2\gamma + \mu}{\alpha}) - \delta - \mu \end{array}$$

Setting $|J(1 - \frac{\gamma + \mu}{\alpha}, 0) - \lambda I| = 0$ and solving for λ ,

$$(\alpha(-1 + \frac{2(\gamma + \mu)}{\alpha}) - \gamma - \mu - \lambda)(\beta(\frac{2\gamma + \mu}{\alpha}) - \delta - \mu - \lambda) = 0$$

$$\lambda_1 = \alpha(-1 + \frac{2(\gamma + \mu)}{\alpha}) - \gamma - \mu$$

$$\lambda_2 = -\alpha + \gamma + \mu$$

$$\lambda_3 = \beta(\frac{2\gamma + \mu}{\alpha}) - \delta - \mu$$

2.4.4 Equilibrium 4: $i^+ = i_0^+$, $i^- = 1 - i_0^+ - \frac{\gamma + \mu}{\alpha}$

$$J(i_0^+, 1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) = \begin{array}{cc} \alpha(1 - 2i_0^+ - (1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) - \gamma - \mu & -\alpha i_0^+ \\ -\beta(1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) & \beta(1 - 2(1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) - i_0^+) - \delta - \mu \end{array}$$

$$= \begin{array}{cc} \alpha(-i_0^+ + \frac{\gamma + \mu}{\alpha}) - \gamma - \mu & -\alpha i_0^+ \\ -\beta(1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) & \beta(-1 + i_0^+ + \frac{2(\gamma + \mu)}{\alpha}) - \delta - \mu \end{array}$$

Setting $|J(i_0^+, 1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) - \lambda I| = 0$ and solving for λ ,

$$(\alpha(-i_0^+ + \frac{\gamma + \mu}{\alpha}) - \gamma - \mu - \lambda)(\beta(-1 + i_0^+ + \frac{2(\gamma + \mu)}{\alpha}) - \delta - \mu - \lambda) - \alpha i_0^+ (\beta(1 - i_0^+ - \frac{\gamma + \mu}{\alpha})) = 0$$

$$(-\alpha i_0^+ - \lambda)(-\beta + \beta i_0^+ + \frac{2\beta(\gamma + \mu)}{\alpha} - \delta - \mu - \lambda) - (\alpha \beta i_0^+ - \alpha \beta i_0^+ - \beta(\gamma + \mu)i_0^+) = 0$$

$$\beta \mu i_0^+ + \beta \gamma i_0^+ + \alpha \mu i_0^+ + \alpha \delta i_0^+ + \alpha i_0^+ \lambda + \beta \lambda - \beta i_0^+ \lambda - \frac{2\beta(\gamma + \mu)}{\alpha} \lambda + \delta \lambda + \mu \lambda + \lambda^2 = 0$$

$$\lambda^2 + \lambda(\alpha i_0^+ - \beta i_0^+ + \beta - \delta - \mu) + \lambda^2 + \lambda(\alpha i_0^+ - \beta i_0^+ + \beta - \delta - \mu) = 0$$

Let $a_1 = \alpha i_0^+ - \beta i_0^+ + \beta - \delta - \mu$

$$\lambda^2 + a_1 \lambda = 0$$

$$\lambda(\lambda + a_1) = 0$$

$$\lambda = 0, -a_1$$

2.5 Stability Analysis

There are three different possibilities for each eigenvalue λ : $\lambda > 0$, $\lambda < 0$, and $\lambda = 0$. All eigenvalues are real-values for this system. For each equilibrium, we have nine different possible combinations of types

of eigenvalues because we have two eigenvalues in this system. The nine combinations include repeats ($\lambda = +, -$ and $\lambda = -, +$) because one eigenvalue depends on α , γ , and μ and the other eigenvalue depends on β , δ , and μ . Equilibria 4 have only three possible combinations of eigenvalue ($\lambda = 0$, $\lambda = -a_1$) because Equilibria 4 exist only when $\alpha(\delta + \mu) = \beta(\gamma + \mu)$. After identifying the different eigenvalues, we begin to match the possible combinations of eigenvalues across the equilibria to form a general pattern. We discover there are nineteenth cases of different patterns across the equilibria based on the eigenvalues. Only nine cases have remaining supporters based on the population chart, so we organize the parameter and stability analysis in Table 2.1 and 2.2. For each case, we identify the stability behavior and include the result in Table 2.3.

We analyze each case based on the phase plane, population chart, equilibria, and stability behavior. In addition, we observe how the positive and negative response initial supporters are affected by the equilibria. Before we proceed with the analysis, we divide the cases into two sections: case study (2.6) and special case study (2.7). The reason behind the case study and the special case study is that we want to establish the relationship between parameters, eigenvalues, equilibria, stability analysis, and the responses, so we can identify any response with durability solely based on the influential rate and neutralization rate from the two responses. The purpose of the division of cases is that there are cases that are more likely to happen in real life than other cases, but we also study the cases that are less likely to happen in real life to understand the model abstractly. Based on the parameters, Cases 1, 2, 6, and 7 are the more likely to happen cases, and Cases 3, 4, 5, 8, and 9 are less likely to happen cases.

2.5.1 Analysis of Cases with Eigenvalue of Zero

While evaluating the possible eigenvalues from the parameter conditions, we have several cases that have eigenvalue of zero. We want to discover the relationship between the parameters and the eigenvalue of zero. In addition, the eigenvalue of zero is always special and complex in the study of stability. From our cases, we can reveal the connection between eigenvalue of zero, stability analysis, and equilibrium. We will discuss the stability analysis of the equilibria from these cases using the Jacobian Matrix and its parameter conditions. When a case has at least one zero eigenvalue, the case is defined as a degenerate or borderline case. The Jacobian Matrix for equilibrium 1 is

$$J(0,0) = \begin{pmatrix} \alpha - \gamma - \mu & 0 \\ 0 & \beta - \delta - \mu \end{pmatrix}$$

For Case 8 and 9, $\det(J) = 0$ and $\text{tr}(J) > 0$ using their parameter conditions, and the stability classification for equilibrium 1 is unstable degenerate. The Jacobian Matrix for equilibrium 2 is

$$J(0, 1 - \frac{\delta + \mu}{\beta}) = \begin{pmatrix} \alpha(\frac{\delta + \mu}{\beta}) - \gamma - \mu & 0 \\ -\beta + \delta + \mu & \beta(-1 + \frac{2(\delta + \mu)}{\beta}) - \delta - \mu \end{pmatrix}$$

Since all the cases with eigenvalue of zero have the condition $\beta(\gamma + \mu) = \alpha(\delta + \mu)$,

$$J(0, 1 - \frac{\delta + \mu}{\beta}) = \begin{pmatrix} 0 & 0 \\ -\beta + \delta + \mu & -\beta + \delta + \mu \end{pmatrix}$$

For Case 3, 4, and 5, $\det(J) = 0$ and $\text{tr}(J) > 0$ using their

parameter conditions, and the stability classification for equilibrium 2 is stable degenerate. For Case 9, $\det(J) = 0$ and $\text{tr}(J) > 0$ using their parameter conditions, and the stability classification for equilibrium 2 is unstable degenerate. The Jacobian Matrix for equilibrium 3 is

$$J(1 - \frac{\gamma + \mu}{\alpha}, 0) = \begin{pmatrix} \alpha(-1 + \frac{2(\gamma + \mu)}{\alpha}) - \gamma - \mu & -\alpha + \gamma + \mu \\ 0 & \beta(\frac{\gamma}{\alpha}) - \delta - \mu \end{pmatrix}$$

Since all the cases with eigenvalue of zero have the condition $\beta(\gamma + \mu) = \alpha(\delta + \mu)$,

$$J(1 - \frac{\gamma + \mu}{\alpha}, 0) = \begin{pmatrix} -\alpha + \gamma + \mu & -\alpha + \gamma + \mu \\ 0 & 0 \end{pmatrix}$$

For Case 3, 4, and 5, $\det(J) = 0$ and $\text{tr}(J) < 0$ using their parameter conditions, and the stability classification for equilibrium 3 is stable degenerate. For Case 8, $\det(J) > 0$ and $\text{tr}(J) > 0$ using their parameter conditions, and the stability classification for equilibrium 3 is unstable degenerate. The Jacobian Matrix for equilibrium 4 is

$$J(i_0^+, 1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) = \begin{pmatrix} \alpha(-i_0^+ + \frac{\gamma + \mu}{\alpha}) - \gamma - \mu & -\alpha i_0^+ \\ -\beta(1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) & \beta(-1 + i_0^+ + \frac{2(\gamma + \mu)}{\alpha}) - \delta - \mu \end{pmatrix}$$

Since all the cases with eigenvalue of zero have the condition $\beta(\gamma + \mu) > \alpha(\delta + \mu)$,

$$J(i_0^+, 1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) = \begin{pmatrix} -\alpha i_0^+ & -\alpha i_0^+ \\ -\beta(1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) & -\beta(1 - i_0^+ - \frac{\gamma + \mu}{\alpha}) \end{pmatrix}$$

For Case 3, $\det(J) > 0$ and $\text{tr}(J) < 0$ using their parameter conditions, and the stability classification for equilibrium 4 is stable degenerate. For Case 5, $\det(J) = 0$ and $\text{tr}(J) > 0$ using their parameter conditions, and the stability classification for equilibrium 4 is unstable

Conditions of Equilibria and Eigenvalues				
Case	E1 EVs (0,0)	E2 EVs (0, $1 - \frac{\delta+\mu}{\beta}$)	E3 EVs ($1 - \frac{\gamma+\mu}{\alpha}$, 0)	E4 EVs (i_0^+ , $1 - i_0^+ - \frac{\gamma+\mu}{\alpha}$)
1	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	
2	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	
3	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$	0 $a_1 > 0$
4	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$	0 $a_1 = 0$
5	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$	0 $a_1 < 0$
6	$\alpha < \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	$\alpha < \gamma + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	
7	$\alpha > \gamma + \mu$ $\beta < \delta + \mu$	$\beta < \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	
8	$\alpha = \gamma + \mu$ $\beta > \delta + \mu$	$\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	$\alpha = \gamma + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	
9	$\alpha > \gamma + \mu$ $\beta = \delta + \mu$	$\beta = \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	$\alpha > \gamma + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	

Table 2.1: Conditions of Equilibria and Eigenvalues

Note: E is an abbreviation for equilibrium, and EV is an abbreviation for eigenvalue. Each cell in EVs contains two conditions generating the classification for the eigenvalues corresponding to each equilibrium.

Conditions of Equilibria and Eigenvalues 2				
Case	E1 EVs λ Sign (0,0)	E2 EVs λ Sign (0, $1 - \frac{\delta+\mu}{\beta}$)	E3 EVs λ Sign ($1 - \frac{\gamma+\mu}{\alpha}$, 0)	E4 EVs λ Sign (i_0^+ , $1 - i_0^+ - \frac{\gamma+\mu}{\alpha}$)
1 (2.6.1)	+	-	-	
	+	-	+	
2 (2.6.2)	+	-	-	
	+	+	-	
3 (2.7.1)	+	-	-	0
	+	0	0	-
4 (2.7.2)	+	-	-	0
	+	0	0	0
5 (2.7.3)	+	-	-	0
	+	0	0	+
6 (2.6.3)	-	-	+	
	+	-	+	
7 (2.6.4)	+	+	-	
	-	+	-	
8 (2.7.4)	0	-	0	
	+	-	+	
9 (2.7.5)	+	0	-	
	0	+	-	

Table 2.2: Conditions of Equilibria and Eigenvalues 2

Note: E is an abbreviation for equilibrium, and EV is an abbreviation for eigenvalue. Each cell in λ Sign contains two eigenvalues signs corresponding to the two possible conditions of eigenvalues.

Stability Analysis				
Case	E1 Stability (0,0)	E2 Stability $(0, 1 - \frac{\delta+\mu}{\beta})$	E3 Stability $(1 - \frac{\gamma+\mu}{\alpha}, 0)$	E4 Stability $(i_0^+, 1 - i_0^+ - \frac{\gamma+\mu}{\alpha})$
1	Unstable Node	Stable Node	Saddle Point	
2	Unstable Node	Saddle Point	Stable Node	
3	Unstable Node	Stable Degenerate	Stable Degenerate	Stable Degenerate
4	Unstable Node	Stable Degenerate	Stable Degenerate	Neutrally Stable
5	Unstable Node	Stable Degenerate	Stable Degenerate	Unstable Degenerate
6	Saddle Point	Stable Node	Unstable Node	
7	Saddle Point	Unstable Node	Stable Node	
8	Unstable Degenerate	Stable Node	Unstable Degenerate	
9	Unstable Degenerate	Unstable Degenerate	Stable Node	

Table 2.3: Conditions of Equilibria, Eigenvalues, and Stability Analysis

Note: E is an abbreviation for equilibrium. Each cell contains the stability classification for the eigenvalues corresponding to each equilibrium.

degenerate. For Case 4, $\det(J) = \text{tr}(J) = 0$ and the matrix becomes a zero matrix using their parameter conditions. The stability classification for equilibrium 4 is neutrally stable. The results are summarized in Table 2.2 and 2.3.

2.5.2 Scenario

Scenario: There is a city located in California with 10,000 people. An American basic cable and satellite news television channel, Fox News, wants to predict the election outcome in the city for candidates Anthony Sanchez and Emma Johnson based on their survey results. From the survey, they discover 10% of the population said they like candidate Sanchez (i^+) and 15% of the population said they like candidate Johnson (i). The next mayor election will occur at the 4th year (about 1500 days) after the day they conducted the survey. The people that like candidate Sanchez have influential rate α and neutralization rate δ , and the people that like candidate Johnson have influential rate β and neutralization rate γ . The units for the influential rate and neutralization rate are $(\text{days})^{-1}$. The BBC News wants to know will any candidate surge in the small town at the election after the survey. During this period, the birth and death rate in this town are assumed to remain constant at 0.01% per day.

2.6 Case Study

2.6.1 Case 1

$\alpha = 0.15, \beta = 0.125, \gamma = 0.07, \delta = 0.055, \mu = 0.0001$
 Equilibrium 1 (0,0) Unstable Node
 Equilibrium 2 (0,0.5592) Stable Node
 Equilibrium 3 (0.5327,0) Saddle Point

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 2 (0,0.5592) as $t \Rightarrow \infty$.
 Thus, candidate Johnson is surging in the town at the 1500th day.

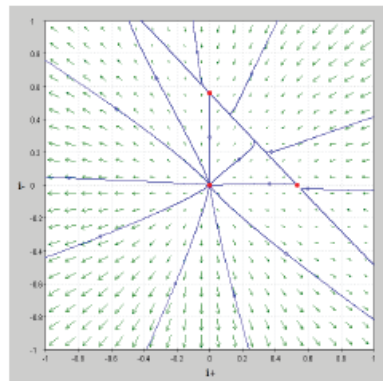


Figure 2.2: Phase Plane: Case 1

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 2 (0,0.5592) as $t \Rightarrow \infty$.

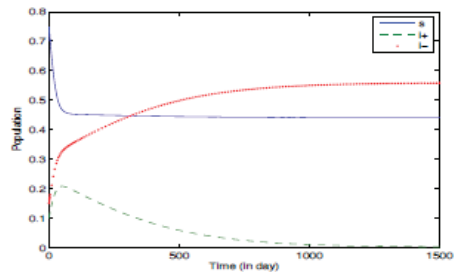


Figure 2.3: Population Chart: Case 1

After four years, the number of susceptibles decreases to 0.4411, the number of positive response supporters decreases to 0.0012, and the number of negative response supporters increases to 0.5577.

2.6.2 Case 2

$$\alpha = 0.15, \beta = 0.125, \gamma = 0.06, \delta = 0.065, \mu = 0.0001$$

Equilibrium 1 (0,0) Unstable Node

Equilibrium 2 (0,0.4792) Saddle Point

Equilibrium 3 (0.5993,0) Stable Node

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 3 (0.5993,0) as $t \Rightarrow \infty$.

Thus, candidate Sanchez is surging in the town at the 1500th day.

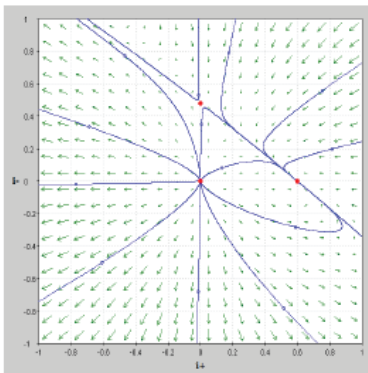


Figure 2.4: Phase Plane: Case 2

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 3 (0.5993,0) as $t \Rightarrow \infty$.

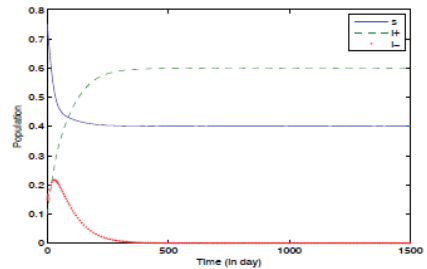


Figure 2.5: Population Chart: Case 2

After four years, the number of susceptibles decreases to 0.4007, the number of positive response supporters increases to 0.5993, and the number of negative response supporters decreases to 0.

2.6.3 Case 6

$$\alpha = 0.055, \beta = 0.15, \gamma = 0.07, \delta = 0.1, \mu = 0.0001$$

Equilibrium 1 (0,0) Saddle Point

Equilibrium 2 (0,0.3327) Stable Node

Equilibrium 3 (-0.2745,0) Unstable Node

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 2 (0,0.3327) as $t \Rightarrow \infty$.

Thus, candidate Johnson is surging in the town at the 1500th day.

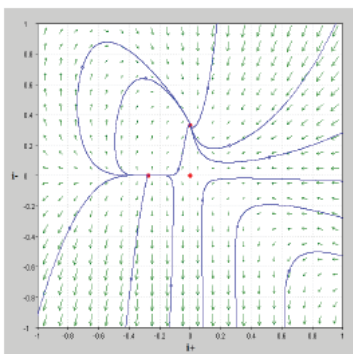


Figure 2.6: Phase Plane: Case 6

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 2 (0,0.3327) as $t \Rightarrow \infty$.

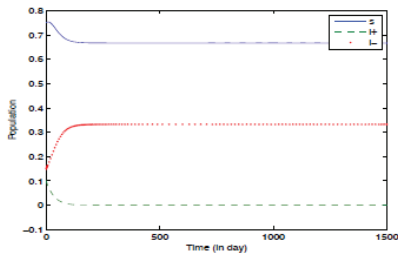


Figure 2.7: Population Chart: Case 6

After four years, the number of susceptibles decreases to 0.6674, the number of positive response supporters decreases to 0, and the number of negative response supporters increases to 0.3326.

2.6.4 Case 7

$$\alpha = 0.125, \beta = 0.055, \gamma = 0.07, \delta = 0.15, \mu = 0.0001$$

Equilibrium 1 (0,0) Saddle Point

Equilibrium 2 (0,-1.7291) Unstable Node

Equilibrium 3 (0.4392,0) Stable Node

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 3 (0.4392,0) as $t \Rightarrow \infty$.

Thus, candidate Sanchez is surging in the town at the 1500th day.

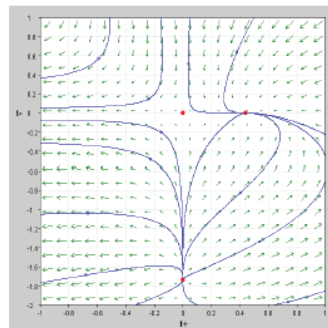


Figure 2.8: Phase Plane: Case 7

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 3 (0.4392,0) as $t \Rightarrow \infty$.

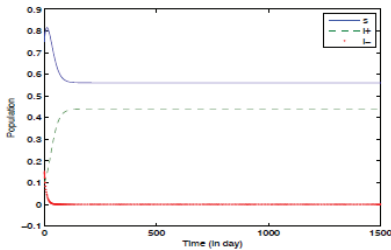


Figure 2.9: Population Chart: Case 7

After four years, the number of susceptibles decreases to 0.5608, the number of positive response supporters increases to 0.4392, and the number of negative response supporters decreases to 0.

2.7 Special Case Study

2.7.1 Case 3

$$\alpha = 0.15, \beta = 0.15, \gamma = 0.1, \delta = 0.1, \mu = 0.0001$$

Equilibrium 1 (0,0) Unstable Node

Equilibrium 2 (0,0.3327) Stable Degenerate

Equilibrium 3 (0.3327,0) Stable Degenerate

Equilibrium 4 $i_1^* + i_2^* = 0.3327$ Stable Degenerate

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 4 $i_1^* + i_2^* = 0.3327$ as $t \Rightarrow \infty$

Thus, candidate Sanchez and Johnson remain publicly aware in the town at the 1500th day.

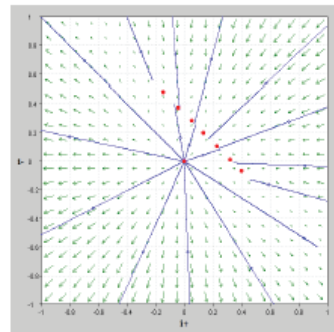


Figure 2.10: Phase Plane: Case 3

All the non-trivial initial number of supporters will move toward Equilibrium 2, 3, 4 and end up at Equilibrium 4 $i_1^* + i_2^* = 0.3327$ as $t \Rightarrow \infty$. The equilibrium point will be different depending on the initial conditions.

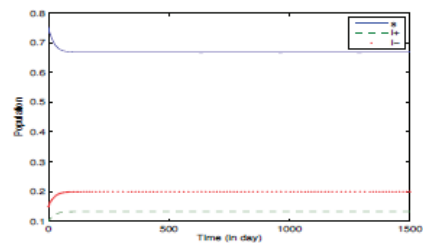


Figure 2.11: Population Chart: Case 3

After four years, the number of susceptibles increases to 0.6673, the number of positive response supporters increases to 0.1331, and the number of negative response supporters increases to 0.1996.

2.7.2 Case 4

$\alpha > 0.0975, \beta > 0.1225, \gamma > 0.0954102, \delta > 0.119899995, \mu > 0.0001$
 Equilibrium 1 (0,0) Unstable Node
 Equilibrium 2 (0,0.0204) Stable Degenerate
 Equilibrium 3 (0.0204,0) Stable Degenerate
 Equilibrium 4 $i_1^* + \bar{i}_1 = 0.0204$ Neutrally Stable
 Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 4 $i_1^* + \bar{i}_1 = 0.0204$ as $t \Rightarrow \infty$.
 Thus, candidate Sanchez and Johnson remain publicly aware in the town at the 1500th day.

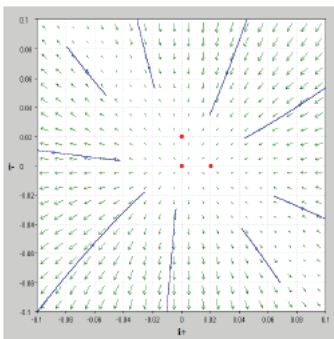


Figure 2.12: Phase Plane: Case 4

All the non-trivial initial number of supporters will toward Equilibrium 2 and 3 and end up at Equilibrium 4 $i_1^* + \bar{i}_1 = 0.0204$ as $t \Rightarrow \infty$. The equilibrium point will be different depending on the initial conditions.

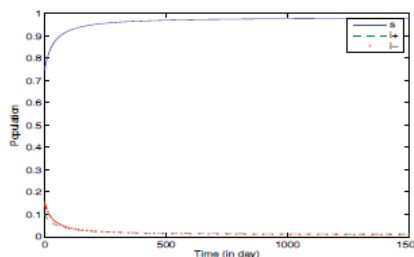


Figure 2.13: Population Chart: Case 4

After four years, the number of susceptibles increases to 0.9789, the number of positive response supporters decreases to 0.0113, and the number of negative response supporters decreases to 0.0097.

2.7.3 Case 5

$\alpha = 0.15, \beta = 0.305, \gamma = 0.145031145, \delta = 0.295, \mu = 0.0001$
 Equilibrium 1 (0,0) Unstable Node
 Equilibrium 2 (0,0.0325) Stable Degenerate
 Equilibrium 3 (0.0325,0) Stable Degenerate
 Equilibrium 4 $i_1^* + \bar{i}_1 = 0.0325$ Unstable Degenerate
 Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 4 $i_1^* + \bar{i}_1 = 0.0325$ as $t \Rightarrow \infty$.
 Thus, candidate Sanchez and Johnson remain publicly aware in the town at the 1500th day.

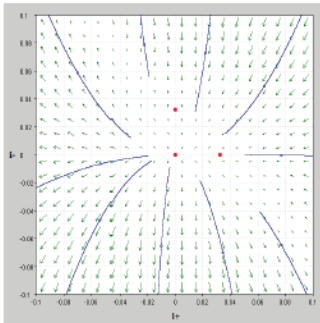


Figure 2.14: Phase Plane: Case 5

All the non-trivial initial number of supporters will move toward Equilibrium 2 and 3 and end up at Equilibrium 4 $i_1^* + i_2^* = 0.0325$ as $t \Rightarrow \infty$. The equilibrium point will be different depending on the initial conditions.

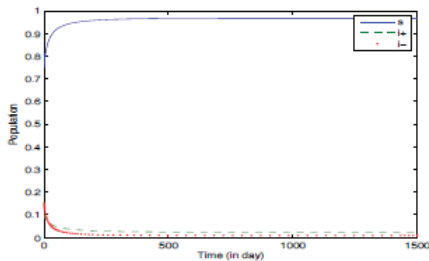


Figure 2.15: Population Chart: Case 5

After four years, the number of susceptibles increases to 0.9675, the number of positive response supporters decreases to 0.0241, and the number of negative response supporters decreases to 0.0083.

2.7.4 Case 8

$\alpha = 0.1505, \beta = 0.15, \gamma = 0.1504, \delta = 0.1, \mu = 0.0001$

Equilibrium 1 (0,0) Unstable Degenerate

Equilibrium 2 (0,0.3327) Stable Node

Equilibrium 3 (0,0) Unstable Degenerate

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 2 (0,0.3327) as $t \Rightarrow \infty$.

Thus, candidate Johnson is surging in the town at the 1500th day.

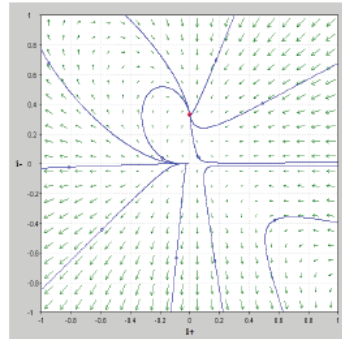


Figure 2.16: Phase Plane: Case 8

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 2 (0,0.3327) as $t \Rightarrow \infty$.

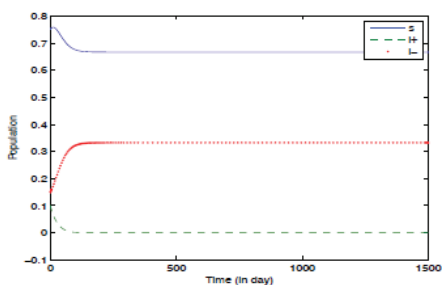


Figure 2.17: Population Chart: Case 8

After four years, the number of susceptibles decreases to 0.6673, the number of positive response supporters decreases to 0, and the number of negative response supporters increases to 0.3327.

2.7.5 Case 9

$\alpha = 0.15, \beta = 0.1505, \gamma = 0.1, \delta = 0.1504, \mu = 0.0001$

Equilibrium 1 (0,0) Unstable Degenerate

Equilibrium 2 (0,0) Unstable Degenerate

Equilibrium 3 (0.3327,0) Stable Node

Initial Supporters (0.1,0.15) \Rightarrow Equilibrium 3

(0.3327,0) as $t \Rightarrow \infty$.

Thus, candidate Sanchez is surging in the town at the 1500th day.

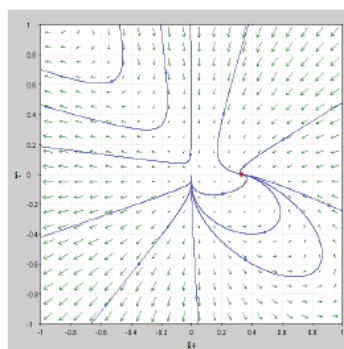


Figure 2.18: Phase Plane: Case 9

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 3 (0.3327,0) as $t \Rightarrow \infty$.

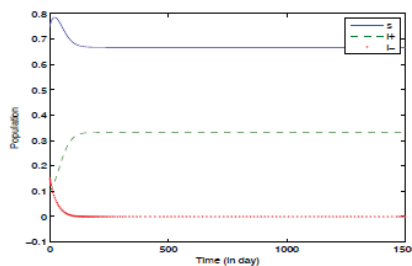


Figure 2.19: Population Chart: Case 9

After four years, the number of susceptibles decreases to 0.6673, the number of positive response supporters increases to 0.3327, and the number of negative response supporters decreases to 0.

2.8 Final Supporters Count

The final supporters for Case 1.9 are found using equilibrium analysis. We want to find the final supporters, i_1^+ and i_1^- for both the positive and negative responses in 1.1 Case 3, 4, and 5. We know the initial supporters i^+ and i^- cannot be equal to 0 from premise 6. We have that

$$\begin{aligned}\frac{di^+}{dt} &= \alpha(1 - i^+ - i^-)i^+ - \gamma i^+ - \mu i^+ \\ \frac{di^-}{dt} &= \beta(1 - i^+ - i^-)i^- - \delta i^- - \mu i^+\end{aligned}$$

Thus,

$$\begin{aligned}\frac{di^+}{di^-} &= \frac{\alpha(1 - i^+ - i^-)i^+ - \gamma i^+ - \mu i^+}{\beta(1 - i^+ - i^-)i^- - \delta i^- - \mu i^+} \\ \frac{di^+}{di^-} &= \frac{i^+ \alpha ((1 - i^+ - i^-) - \frac{\gamma + \mu}{\alpha})}{i^- \beta ((1 - i^+ - i^-) - \frac{\delta + \mu}{\beta})}\end{aligned}$$

Since equilibrium 4 only exists when $\frac{\gamma + \mu}{\alpha} = \frac{\delta + \mu}{\beta}$

$$\frac{di^+}{di^-} = \frac{i^+ \alpha}{i^- \beta}$$

We will use equation (2.5) to generalize for two cases, $\alpha = \beta$ and $\alpha \neq \beta$, for the final supporters. For $\alpha = \beta$,

$$\frac{di^+}{di^-} = \frac{i^+}{i^-}$$

Solving the differential equation,

$$\begin{aligned}\frac{1}{i^+} di^+ &= \frac{1}{i^-} di^- \\ \ln(i^+) &= \ln(i^-) + C \\ i^+ &= e^C i^-\end{aligned}$$

Using arbitrary initial conditions i_1^+ and i_1^- ,

$$\begin{aligned}i_1^+ &= e^C \cdot i_1^- \\ \frac{i_1^+}{i_1^-} &= e^C \\ C &= \ln \frac{i_1^+}{i_1^-}\end{aligned}$$

Applying the result to the Equilibrium 4 equation,

$$\begin{aligned}
 i_F^+ + i_F^- &= 1 - \frac{\gamma}{\alpha} \\
 i_F^+ + \frac{i_I^-}{i_I^+} i_F^+ &= 1 - \frac{\gamma + \mu}{\alpha} \\
 1 + \frac{i_I^-}{i_I^+} i_F^+ &= 1 - \frac{\gamma + \mu}{\alpha} \\
 i_F^+ &= \frac{1 - \frac{\gamma + \mu}{\alpha}}{1 + \frac{i_I^-}{i_I^+}} \\
 i_F^+ &= \frac{i_I^+(1 - \frac{\gamma + \mu}{\alpha})}{i_I^+ + i_I^-}
 \end{aligned}$$

And,

$$\begin{aligned}
 \frac{i_I^+}{i_I^-} i_F^- + i_F^- &= 1 - \frac{\gamma + \mu}{\alpha} \\
 \frac{i_I^+}{i_I^-} + 1 i_F^- &= 1 - \frac{\gamma + \mu}{\alpha} \\
 i_F^- &= \frac{1 - \frac{\gamma + \mu}{\alpha}}{\frac{i_I^+}{i_I^-} + 1} \\
 i_F^- &= \frac{i_I^-(1 - \frac{\gamma + \mu}{\alpha})}{i_I^+ + i_I^-}
 \end{aligned}$$

So,

$$\begin{aligned}
 i_F^k &= \frac{i_I^k(1 - \frac{\gamma + \mu}{\alpha})}{i_I^m + i_I^k} \\
 k &= \text{"+"}, m = \text{"-"} \text{ or} \\
 k &= \text{"-"}, m = \text{"+"}
 \end{aligned}$$

For $\alpha = \beta$,

$$\frac{di^+}{di^-} = \frac{i^+\alpha}{i^-\beta}$$

Solving the differential equation

$$\begin{aligned}
 \frac{1}{\alpha} \frac{1}{i^+} di^+ &= \frac{1}{\beta} \frac{1}{i^-} di^- \\
 \frac{1}{\alpha} \ln(i^+) &= \frac{1}{\beta} \ln(i^-) + \frac{C}{\beta} \\
 i^{+\alpha-1} &= e^{\frac{C}{\beta}} i^{-\beta-1}
 \end{aligned}$$

Using arbitrary initial conditions i and $i-I$,

$$\begin{aligned}
 i_I^{+\alpha-1} &= e^{\frac{C}{\beta}} i_I^{-\beta-1} \\
 \frac{i_I^{+\alpha-1}}{i_I^{-\beta-1}} &= e^{\frac{C}{\beta}} \\
 i^{+\alpha-1} &= \left(\frac{i_I^{+\alpha-1}}{i_I^{-\beta-1}} \right) i^{-\beta-1}
 \end{aligned}$$

Applying the result to the Equilibrium 4 equation,

$$i_F^+ + i_F^- = 1 - \frac{\gamma + \mu}{\alpha}$$

$$\left(\frac{i_F^-}{i_F^{+\beta\alpha-1}} \right) i_F^{+\beta\alpha-1} + i_F^+ = 1 - \frac{\gamma + \mu}{\alpha}$$

And,

$$\left(\frac{i_F^+}{i_F^{-\alpha\beta-1}} \right) i_F^{-\alpha\beta-1} + i_F^- = 1 - \frac{\gamma + \mu}{\alpha}$$

So,

$$\left(\frac{i_F^m}{i_F^{kyx-1}} \right) i_F^{kyx-1} + i_F^k = 1 - \frac{\gamma + \mu}{\alpha}$$

$k = "+"$, $x = \alpha$, $m = "-"$, $y = \beta$ or

$k = "-"$, $x = \beta$, $m = "+"$, $y = \alpha$

Both the positive and negative response final supporters, i_F^+ and i_F^- , for $\alpha = \beta$ and $\alpha = \beta$, match with our numerical results from Case 3, 4, and 5.

2.8.1 Result

Result

Result			
Case	Parameter Conditions	Durable Response	Final Supporters i_F
1	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	Negative	$i_F^- = 1 - \frac{\delta + \mu}{\beta}$
2	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	Positive	$i_F^+ = 1 - \frac{\gamma + \mu}{\alpha}$
3	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 > 0, \alpha = \beta$	Both	$i_F^k = \frac{i_I^k(1 - \frac{\gamma + \mu}{\alpha})}{i_I^m + i_I^k}$
3	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 > 0$	Both	$\frac{i_I^m}{i_I^k y^{x-1}} i_F^{k y^{x-1}} + i_F^k = 1 - \frac{\gamma + \mu}{\alpha}$
4	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 = 0$	Both	$\frac{i_I^m}{i_I^k y^{x-1}} i_F^{k y^{x-1}} + i_F^k = 1 - \frac{\gamma + \mu}{\alpha}$
5	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 < 0$	Both	$\frac{i_I^m}{i_I^k y^{x-1}} i_F^{k y^{x-1}} + i_F^k = 1 - \frac{\gamma + \mu}{\alpha}$
6	$\alpha < \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	Negative	$i_F^- = 1 - \frac{\delta + \mu}{\beta}$
7	$\alpha > \gamma + \mu$ $\beta < \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	Positive	$i_F^+ = 1 - \frac{\gamma + \mu}{\alpha}$
8	$\alpha = \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	Negative	$i_F^- = 1 - \frac{\delta + \mu}{\beta}$
9	$\alpha > \gamma + \mu$ $\beta = \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	Positive	$i_F^+ = 1 - \frac{\gamma + \mu}{\alpha}$

Table 2.4: Case Study and Special Case Study Result

Case Study and Special Case Study Result 2			
Case	Parameter Conditions	Popular Response	Supporter Conditions
1 (2.6.1)	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	Negative	$i_I^- < 1 - \frac{\delta + \mu}{\beta}$
2 (2.6.2)	$\alpha > \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	Positive	$i_I^+ < 1 - \frac{\gamma + \mu}{\alpha}$
3 (2.7.1)	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 > 0$	Positive Negative Both	$i_I^+ < i_F^+$ $i_I^- < i_F^-$ $i_I^+ < i_F^+, i_I^- < i_F^-$
4 (2.7.2)	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 = 0$	Positive Negative Both	$i_I^+ < i_F^+$ $i_I^- < i_F^-$ $i_I^+ < i_F^+, i_I^- < i_F^-$
5 (2.7.3)	$\alpha > \gamma + \mu, \beta > \delta + \mu$ $\beta(\gamma + \mu) = \alpha(\delta + \mu)$ $a_1 < 0$	Positive Negative Both	$i_I^+ < i_F^+$ $i_I^- < i_F^-$ $i_I^+ < i_F^+, i_I^- < i_F^-$
6 (2.6.3)	$\alpha < \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	Negative	$i_I^- < 1 - \frac{\delta + \mu}{\beta}$
7 (2.6.4)	$\alpha > \gamma + \mu$ $\beta < \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	Positive	$i_I^+ < 1 - \frac{\gamma + \mu}{\alpha}$
8 (2.7.4)	$\alpha = \gamma + \mu$ $\beta > \delta + \mu$ $\beta(\gamma + \mu) > \alpha(\delta + \mu)$	Negative	$i_I^- < 1 - \frac{\delta + \mu}{\beta}$
9 (2.7.5)	$\alpha > \gamma + \mu$ $\beta = \delta + \mu$ $\beta(\gamma + \mu) < \alpha(\delta + \mu)$	Positive	$i_I^+ < 1 - \frac{\gamma + \mu}{\alpha}$

Table 2.5: Case Study and Special Case Study Result 2

Note: For Case 3, 4, and 5, there are three possible popular responses based on the different supporter conditions.

2.9 Basic Reproductive Number R_0

The response influence dies out when $R_0 < 1$ when each supporter converts, on average, less than one new supporter. The response becomes sustained response when $R_0 > 1$ when each supporter converts more than one new supporter. We will create R_0 like thresholds using the differential equations form (2.2) of the S^2S Model we created in section 2.1. A sustained response occurs when the number of supporters increases, $\frac{di^+}{dt} > 0$ or $\frac{di^-}{dt} > 0$. Our model is

$$\begin{aligned}\frac{ds}{dt} &= -\alpha si^+ - \beta si^- + \gamma i^+ + \delta i^- + \mu i^+ + \mu i^- \\ \frac{di^+}{dt} &= \alpha si^+ - \gamma i^+ - \mu i^+ \\ \frac{di^-}{dt} &= \beta si^- - \delta i^- - \mu i^-\end{aligned}$$

Setting $\frac{di^+}{dt} > 0$ and $s \approx 1$ in an entirely susceptible population at the formation of a sustained response,

$$\begin{aligned}\alpha i^+ - \gamma i^+ - \mu i^+ &> 0 \\ \alpha i^+ &> \gamma i^+ + \mu i^+ \\ R_0^+ &= \frac{\alpha}{\gamma + \mu} > 1\end{aligned}$$

We have derived our expression for R_0^+ . Setting $\frac{di^-}{dt} > 0$ and $s \approx 1$ in an entirely susceptible population at the formation of a sustained response,

$$\begin{aligned}\beta i^- - \delta i^- - \mu i^- &> 0 \\ \beta i^- &> \delta i^- + \mu i^- \\ R_0^- &= \frac{\beta}{\delta + \mu} > 1\end{aligned}$$

We have derived our expression for R_0^- . If $R_0^+ < 1$ and $R_0^- < 1$, we will have responses fading out. If $R_0^+ > 1$ and $R_0^- < 1$, we will have sustained a positive response. If $R_0^+ < 1$ and $R_0^- > 1$, we will have a sustained negative response. If $R_0^+ > 1$, $R_0^- > 1$, $R_0^+ > R_0^-$, then we will have a sustained positive response. If $R_0^+ > 1$, $R_0^- > 1$, $R_0^+ < R_0^-$, then we will have a sustained negative response. If $R_0^+ > 1$, $R_0^- > 1$, $R_0^+ = R_0^-$, then we will have both sustained positive and negative responses. The results of basic reproductive numbers, R_0^+ and R_0^- , confirm our stability analysis results in Table 2.4.

2.10 Discussion

From the phase portrait of each case, we can see that in the cases with degenerate stability it is very difficult to see the stability behavior around the equilibrium. Since each equilibrium affects the direction field, we may not have a clear phase portrait that shows all the stability from each equilibrium. In addition, the distance between each equilibrium also affects how the direction field moves. It is not reliable to judge the stability of each equilibrium solely based on the phase portrait. By using equilibrium analysis, the Jacobian Matrix, and the phase portrait, we have a clear understanding of the stability of each equilibrium even if we do not see it in the phase portrait. It is very difficult to confirm our stability analysis with phase portrait because there are multiple equilibria that

affect the overall phase portrait. The stability analysis focuses on the stability of each equilibrium, and phase portrait focuses on the stability of all the equilibria. Regardless, the phase portrait must agree with the population chart because the phase portrait shows how the number of initial supporters changes when they are affected by the equilibria. This model has (0,0) stable and the result of responses fading away when positive and negative response influential rates are both less than or equal to their corresponding neutralization rates.

By analyzing the stability of each equilibrium based on the parameter conditions and the basic reproductive number R_0 , we establish the relationship between the stability analysis and R_0 . We can predict the parameter conditions and stability behavior based on R_0 , and vice versa. In order for a response to become a sustained response, $R_0 > 1$, or the ratio of influential rate to neutralization rate plus death rate has to be greater than one. This means there are more supporters entering in the supporter class than leaving, which will lead to a stable growth of the supporter class or a sustained response. In our S^2S Model, we can see a similar concept apply to the two responses. Since the total population is a constant, the supporters in one response will affect another. When one response has higher R_0 than another response and both responses have $R_0 > 1$, this supporter class will draw more supporters from the susceptible class and lower the number of supporters entering the other supporter class when the susceptible class becomes infected at a rate proportional to the number of supporters. As time increases, the response with higher R_0 will become a sustained response, and the other response will not become a sustained response due to lack of new supporters entering the class. The parameter μ represents

the death rate in the model and the removal rate in terms of supporters. If μ increases, then it becomes harder for a perspective to persist since the number of supporters is decreasing due to death. We discover an interesting result that we can have two sustained responses when both responses have the same R_0 and $R_0 > 1$. We understand this result may only exist in our model because it is very difficult for two responses to have the same R_0 in the physical world. Our S^2S Model addresses both the possible and rare phenomena in the physical world and reveals the behaviors of two responses in the same population with equivalent birth and death rates.

By observing the population chart, we discovered that time is essential to the study of social influence. In terms of biological diseases, we may look at the time of the highest and lowest infected population and the result of the epidemic (no epidemic, low infected epidemic, or high infected epidemic). Different from the biological diseases, we may look at the time depending on the context of the problem. In our scenario, we may look at the particular time because there are significant events that take place like a press conference on funding a local school or a sex scandal. Influences will not behave as stable as the biological diseases, since the parameters can change dramatically at a particular time. Therefore, the result of an influence may change according to the changes from the parameter. In addition, we do not look at the result of the influences, but we do look at the time and result in terms of context. From our scenario, we may look before and at the time when the election takes place to ensure that we have a sustained response from our voters. We do not care about the behavior of the influence from after the election. In terms of influence, we look at a time interval and specific time instead of the

behavior of the whole population chart with duration time t . This contributes to the difference in usage of this model between the sociologists and epidemiologists when the focus of the context and analysis is different.

2.11 Conclusion

This chapter investigates the formation of human perspective based on two distinct responses, positive or negative, in a fixed population. The positive or negative of a response is in reference to the context of reaction of an individual decision. Since human perspective and response are connected, human perspective shares similar characteristics, persistence and popularity, as human response. By using an epidemiological model, S^2S Model, created from the classical SIS Model, we are able to establish different conditions that produce a popular and/or persistent perspective in a fixed population. We summarize the conditions as follows:

- A response will become sustained if the rate of change for supporters is large
- Between two responses, one response will become sustained if it has higher rate of change for supporters
- If the average death rate is high, it becomes difficult for any response to be sustained
- A perspective is persistent as long as its associated response is sustained.

Our results offer insights on how two responses interact in a fixed population and the creation of a popular and/or persistent perspective from this interaction. The

relationship between human preference and perspective is established in this chapter where we drew the connection between dominating preference and response. In addition, we can predict the formation of a popular and/or persistent perspective based on the initial supporters, final supporters, the chance of people making the similar response, and the time length where people retain their decision. We understand that the complexity in decision making and formation of a popular and/or persistent response cannot be modeled accurately, but our model offers a simple logical reasoning for the phenomenon happening in decision making and formation of a popular and/or persistent perspective.

Chapter 3 Radicalization Model

3.1 Introduction

An American singer Stefani Joanne Angelina Germanotta, also known as Lady Gaga, is a powerful icon for both the fashion and music industries. At the beginning of her music career in 2005, Lady Gaga was a local singer that performed in bar, music festival, and club where she could express her passion for music. On January 2009, her lead single "Just Dance" from *The Fame* earned her the first Grammy Award nomination for Best Dance Recording. The album became one of the best selling singles worldwide. Her fame achieved the next level when "Poker Face" from *The Fame* won the award for Best Dance Recording at the 52nd Annual Grammy Awards with nominations for Song of the Year and Record of the Year [6]. Later, her other albums *Born This Way*, *Artpop*, and *Cheek to Cheek* also earned her many awards and nominations where she accumulated more fans and fame globally. Her albums

also show the expansion of her music genres and her developments as an artist. She is remembered by her audiences for her memorable unique live performances and powerful music talent. Being a leading singer in the music industry, Lady Gaga is named as the “Queen of Pop” for her music achievements and has millions of fans across the globe that support her and her music.

Not only known for her music, Lady Gaga is also a symbol of uniqueness. On 2009, Lady Gaga shocked the world with the bloody performance “Paparazzi” at the MTV VMAs. One year after, Lady Gaga showed up at the VMA with a meat dress and instantly became popular in the media and among people. During the 2011 VMA, Lady Gaga came at a red carpet event inside an egg and again became the most discussed topic around the globe [7]. Lady Gaga truly stands out from other artists for her creativity. Lady Gaga is also known for her activism in helping victims of the 2010 Haiti earthquake, 2011 Tohoku earthquake and tsunami, donating \$1 million dollars to the American Cross to help the victims of Hurricane Sandy, and contributes in the fight against HIV and AIDS. She created the Born This Way Foundation, a non-profit organization, that focuses on youth empowerment in 2012. Lady Gaga is a high activist for the LGBTQ+ rights across the globe, and she delivered a speech at the National Equality March rally on the National Mall on October 11, 2009. From her dedications, Lady Gaga had become a fierce advocater for the LGBTQ+ community [11]. It is her unconventionality and passions that acquired enormous amounts of fans that absolutely love and support her.

Being an extreme fan toward their favorite artist is quite common in one’s life. We will scream for the new album that is coming and instantly pre-order the album online. After receiving it in the morning, we

quickly play the album and enjoy every beat and word from the songs. You will defend your artist without a doubt when someone tries to criticize their music. During their concert, you feel your blood boil as the music notes fly on the stage, and you sing loudly with your favorite artist when you know every single song lyric by heart. The artist is your love. Their music is your life. You are an extreme fan for your favorite artist. Radicalization does not exist only in fans praising their artist but in all forms of life like political, religious, and social economic ideology. Besides the complex forms of radicalization, we can be radical toward simple identity like our sport teams or ice cream flavor. There are similarities in terms of radical behaviors despite the differences in subject or identities. The effects of radicalization can be found in individuals, groups of individuals, nations, or societies [10].

One does not simply become a radical toward an identity, but there is an advancement of affection from low to high that results in radicalization. Radicalization can be viewed as infectious disease where people are affected by other affection toward an identity. One can be affected by other’s affections. When someone develops an affection, the strength of likes overpowers dislikes and results in a dominating preference. We define radicalization as a three step process from not knowing anything about the identity to creating a low affection after being introduced to the identity and from a low affection develop a high affection. We identify low affection individuals as people that like the identity but have no intention to persuade other people into the same belief. We associate high affection individuals as people that like the identity and want to convert other people into liking the same identity. In this chapter, the progression of radicalization will be modeled using epidemiological concepts on the

spread of high affection through human affection and the transformation of an individual from uninformed about the identity to extreme behaviors toward the identity after exposed.

3.2 Formulation of the *SLH* Model

The behaviors of human radicalization share many similarities with the *SIS* Model when humans are affected by other people's beliefs, and the influences of another belief instantly alter the current state of their belief. The influences of a belief may be large impacts or small changes, but it does affect the strength of your likes and dislikes toward a belief. Human affection can spread from the high behaviors of a person. From the similarities between the *SIS* Model and human affection, we will modify the *SIS* Model based on the characteristics of human affection.

Since human affection has two levels of strength, low and high, we will separate the infected class into low infected class and high infected class. We will focus on the dynamic between susceptible, low infecteds, and high infecteds. We will also refer to the *SLH* Model as the Radicalization Model. The Radicalization Model will capture the transition from being a susceptible to a high infected and the change of human affection. In the real world, there are births and deaths in the population, and birth and death counts will affect the spread of human affection and the possibility of a belief becoming a radicalization. It is important to include this factor in the *SLH* Model, so we will include average birth rate η and average death rate μ in the model. Since human affection appears in a short duration of time, we will assume there are no significant changes to the total population size due to birth and death in a small time interval, $\eta = \mu$. The

number of individuals in each class is denoted by $S(t)$, $L(t)$, and $H(t)$, where

- $S(t)$ represents the number of people who do not have knowledge or forget about the belief at the given time t but who are vulnerable to the affection.
- $L(t)$ represents the number of low affection upholders who are infectious and not able to spread the belief to a susceptible.
- $H(t)$ represents the number of high affection upholders who are infectious and able to spread the belief to a susceptible.

The *SLH* Model is formulated under the following premises:

- Premise 1: Since there are no significant changes to the total population size due to average birth and death rates in a small time interval, the total population size remains constant over the duration of time t . The total population size is denoted as N , where

$$S(t) + L(t) + H(t) = N$$

- Premise 2: All affections have equal amount of influence throughout the duration of the time t , so the parameters remain constant. The susceptible class becomes infected at a rate proportional to the number of high affection upholders.
- Premise 3: We will ignore any internal and external factors like age, race, environment, and sex that can affect the outcome significantly. New upholders are uniformly distributed among the susceptible class.

- Premise 4: The upholders will recover from the influences after some amount of time t , but they will receive no immunity to the influences when they recover. They are susceptible to the same influences immediately.

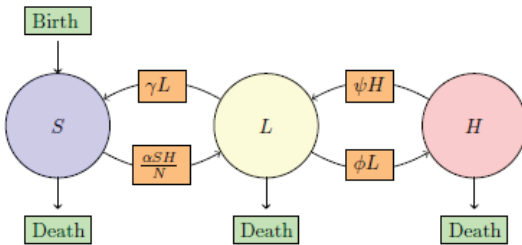


Figure 3.1: *SLH* Model Structure

We establish the differential equations form of the *SLH* Model from the premises, the standard *SIS* Model, and the visual representation of *SLH* Model. Parameters α is the influential rate, and γ is the neutralization rate, ϕ is the progression rate, and ψ is the regression rate. We will build the differential equations based on the behaviors of individuals entering and exiting in each class.

- In the susceptible class, the individuals move to the low affection class at the rate of α , $-\frac{\alpha SH}{N}$. The susceptible class also receives new individuals due to neutralization from the affection. In addition, the susceptible class receives and loses individuals due to birth and death.

Thus, $\frac{dS}{dt} = -\frac{\alpha SH}{N} + \gamma L + \eta(S + L + H) - \mu S$.

- The low affection class receives the new upholders from the susceptible and high affection class. It also loses upholders to the susceptible class at the

rate of γ , the high affection class at the rate of ϕ , and death at the rate of μ .

Thus, $\frac{dL}{dt} = \frac{\alpha SH}{N} + \psi H - \gamma L - \phi L - \mu L$.

- The high affection class receives the new upholders from the low affection class at the rate of ϕ , and it also loses upholders to the low affection class at the rate of ψ and death at the rate of μ .

Thus, $\frac{dH}{dt} = \phi L - \psi H - \mu H$.

From the assumptions above we have

$$\frac{dS}{dt} + \frac{dL}{dt} + \frac{dH}{dt} = 0$$

Since the sum of the rates of change from all three classes is equal to 0, the population in the system remains as a constant. This confirms our premise 1 that $S(t) + L(t) + H(t) = N$. We can summarize the differential equations form of the *SLH* Model as:

$$\begin{aligned} \frac{dS}{dt} &= -\frac{\alpha SH}{N} + \gamma L + \eta(S + L + H) - \mu S \\ \frac{dL}{dt} &= \frac{\alpha SH}{N} + \psi H - \gamma L - \phi L - \mu L \\ \frac{dH}{dt} &= \phi L - \psi H - \mu H \end{aligned}$$

3.2.1 Rescale to Proportional System

Define $s = \frac{S}{N}, l = \frac{L}{N}, h = \frac{H}{N}, s = 1 - l - h$. After rescaling the system, we summarize the differential equations of the *SLH* Model as follows:

$$\begin{aligned}\frac{ds}{dt} &= -\alpha(1-l-h)h + \gamma l + \eta(s+l+h) - \mu s \\ \frac{dl}{dt} &= \alpha(1-l-h)h + \psi h - \gamma l - \phi l - \mu l \\ \frac{dh}{dt} &= \phi l - \psi h - \mu h\end{aligned}$$

3.2.2 Reduce 3 x 3 System to 2 x 2 System

Since $s = 1 - l - h$, the system (3.2) becomes

$$\begin{aligned}\frac{dl}{dt} &= \alpha(1-l-h)h + \psi h - \gamma l - \phi l - \mu l \\ \frac{dh}{dt} &= \phi l - \psi h - \mu h\end{aligned}$$

3.3 Equilibrium Analysis

Setting $\frac{dl}{dt}$ and $\frac{dh}{dt}$ equal to 0, we find all the possible equilibria. We classify the dt dt behavior around the equilibria using linearization and the Jacobian Matrix. In addition, we observe how the initial upholders l and h will be affected by the equilibria.

Let $\frac{dl}{dt} = \frac{dh}{dt} = 0$. Then

$$\begin{aligned}\frac{dh}{dt} &= \phi l - \psi h - \mu h \\ 0 &= \phi l - \psi h - \mu h \\ \phi l &= \psi h + \mu h \\ l &= \frac{h(\psi + \mu)}{\phi}\end{aligned}$$

Let $K = \frac{\psi + \mu}{\phi}$. Then $l = Kh$.

$$\begin{aligned}\frac{dl}{dt} &= \alpha(1-l-h)h + \psi h - \gamma l - \phi l - \mu l \\ 0 &= \alpha(1-Kh-h)h + \psi h - \gamma Kh - \phi Kh - \mu Kh \\ 0 &= \alpha(1-Kh-h)h + \psi h - \gamma Kh - \psi h - \mu h - \mu Kh \\ 0 &= \alpha(1-Kh-h)h - \gamma Kh - \mu h - \mu Kh \\ 0 &= h(\alpha(1-Kh-h) - \gamma K - \mu - \mu K) \\ h = 0 \text{ or } \alpha(1-Kh-h) - \gamma K - \mu - \mu K &= 0 \\ \alpha - \alpha Kh - \alpha h - \gamma K - \mu - \mu K &= 0 \\ \alpha Kh + \alpha h &= \alpha - \gamma K - \mu - \mu K \\ h &= \frac{\alpha - \gamma K - \mu - \mu K}{\alpha(K+1)}\end{aligned}$$

Equilibria

$$\begin{aligned}\textcircled{1} \quad l = 0, h = 0 &\Rightarrow (0,0) \\ \textcircled{2} \quad l = Kh, h &= \frac{\alpha - \gamma K - \mu - \mu K}{\alpha(K+1)} \Rightarrow \frac{K(\alpha - \gamma K - \mu - \mu K)}{\alpha(K+1)}, \frac{\alpha - \gamma K - \mu - \mu K}{\alpha(K+1)}\end{aligned}$$

3.4 Linearization and the Jacobian Matrix

By linearizing the nonlinear 2x2 system (3.3), we reduce the amount of time spent in stability analysis. Using the Jacobian Matrix, we obtain the linear equations associated with an equilibrium point. Since the system is linearized, we use $\det(J - \lambda I) > 0$ to find the eigenvalues and use the eigenvalues to identify stability behavior of the equilibrium. The following matrix is the Jacobian Matrix for the nonlinear system (3.3)

3.4.1 Equilibrium 1: $l=0, h=0$

$$J(0,0) = \begin{array}{cc} -\alpha \cdot 0 - \gamma - \phi - \mu & \alpha(1 - 2 \cdot 0 - 0) + \psi \\ \phi & -\psi - \mu \end{array}$$

$$= \begin{array}{cc} -\gamma - \phi - \mu & \alpha + \psi \\ \phi & -\psi - \mu \end{array}$$

Setting $|J(0,0) - \lambda I| > 0$ and solving for λ

$$(-\gamma - \phi - \mu - \lambda)(-\psi - \mu - \lambda) - \phi(\alpha + \psi) = 0$$

$$\lambda^2 + (\gamma + \phi + \psi + 2\mu)\lambda + (\gamma\psi + \gamma\mu + \phi\mu + \psi\mu + \mu^2 - \alpha\phi) = 0$$

$$(\lambda + \frac{\gamma + \phi + \psi + 2\mu}{2})^2 + (\gamma\psi + \gamma\mu + \phi\mu + \psi\mu + \mu^2 - \alpha\phi) - \frac{(\gamma + \phi + \psi + 2\mu)^2}{4} = 0$$

$$\lambda = -\frac{\gamma + \phi + \psi + 2\mu}{2} \pm \sqrt{\frac{(\gamma + \phi + \psi + 2\mu)^2}{4} - ((\gamma + \mu)(\psi + \mu) + \phi\mu - \alpha\phi)}$$

3.4.2 Equilibrium 2: $l = Kh, h = \frac{\alpha - \gamma K - \mu - \mu K}{\alpha(K+1)}$

$$J(l,h) = \begin{array}{cc} -\alpha h - \gamma - \phi - \mu & \alpha(1 - 2h - Kh) + \psi \\ \phi & -\psi - \mu \end{array}$$

Setting $|J(0,0) - \lambda I| > 0$ and solving for λ

$$(-\alpha h - \gamma - \phi - \mu - \lambda)(-\psi - \mu - \lambda) - \phi(\alpha - 2\alpha h - \alpha Kh + \psi) = 0$$

$$\lambda^2 + (\alpha h + \gamma + \phi + \psi + 2\mu)\lambda + ((\gamma + \mu)(\psi + \mu) + \phi\mu - \alpha\phi + \alpha h(\psi + \mu + 2\phi + \phi K)) = 0. \text{ We have}$$

$$\text{Let } C = (\gamma + \mu)(\psi + \mu) + \phi\mu - \alpha\phi + \alpha h(\psi + \mu + 2\phi + \phi K)$$

$$(\lambda + \frac{\alpha h + \gamma + \phi + \psi + 2\mu}{2})^2 + C - \frac{(\alpha h + \gamma + \phi + \psi + 2\mu)^2}{4} = 0$$

$$\lambda = -\frac{\alpha h + \gamma + \phi + \psi + 2\mu}{2} \pm \sqrt{\frac{(\alpha h + \gamma + \phi + \psi + 2\mu)^2}{4} - C}$$

3.5 Eigenvalue Analysis

By using the disease-free equilibrium, we analyze the possible eigenvalues and its associated stability behaviors based on the parameter condition. In addition, we are looking at when Equilibrium 1 is sta-

ble and the critical value where Equilibrium 1 changes from stable to unstable. The eigenvalues for Equilibrium 1 are

$$\lambda = -\frac{\gamma + \phi + \psi + 2\mu}{2} \pm \frac{(\gamma + \phi + \psi + 2\mu)^2}{4} - ((\gamma + \mu)(\psi + \mu) + \phi\mu - \alpha\phi)}$$

Since $\alpha, \gamma, \phi, \psi, \mu > 0$, $-\frac{\gamma + \phi + \psi + 2\mu}{2} < 0$. We have four possible eigenvalue types: all real negative, real negative and positive, complex with real part negative, and repeated real negative, where the eigenvalue type depends on the expression inside the square root. We will analyze the expression

$$\frac{(\gamma + \phi + \psi + 2\mu)^2}{4} - ((\gamma + \mu)(\psi + \mu) + \phi\mu - \alpha\phi)$$

$$\frac{\gamma^2 + \phi^2 + \psi^2 + 2\gamma\phi + 2\gamma\psi + 2\phi\psi}{4} + \alpha\phi - \gamma\psi$$

$$\gamma^2 + \phi^2 + \psi^2 + 2\gamma\phi - 2\gamma\psi + 2\phi\psi + 4\alpha\phi$$

$$(\gamma - \psi)^2 + \phi^2 + 2\gamma\phi + 2\phi\psi + 4\alpha\phi$$

We realize the expression is positive since $(\gamma - \psi)^2 + \phi^2 + 2\gamma\phi + 2\phi\psi + 4\alpha\phi > 0$, so we cannot have eigenvalue type complex with real part negative. We will set the expression equal to zero and solve for α .

$$(\gamma - \psi)^2 + \phi^2 + 2\gamma\phi + 2\phi\psi + 4\alpha\phi = 0$$

$$4\alpha\phi = -(\gamma - \psi)^2 - \phi^2 - 2\gamma\phi - 2\phi\psi$$

$$\alpha = \frac{-(\gamma - \psi)^2 - \phi^2 - 2\gamma\phi - 2\phi\psi}{4\phi}$$

This contradicts with $\alpha > 0$. Thus, we cannot have eigenvalue type of repeated real negative. Now, we have only two possible eigenvalue types, all real negative

and real negative and positive. The sign of eigenvalues depends on whether the square root term is greater in magnitude than the real negative term, which can be determined by looking at the following:

$$\begin{aligned}
 (\gamma + \mu)(\psi + \mu) + \phi\mu - \alpha\phi &= 0 \\
 \alpha\phi &= (\gamma + \mu)(\psi + \mu) + \phi\mu \\
 \frac{\alpha\phi}{(\gamma + \mu)(\psi + \mu) + \phi\mu} &= 1 \\
 \text{Let } W &= \frac{\alpha\phi}{(\gamma + \mu)(\psi + \mu) + \phi\mu}
 \end{aligned}$$

If $W > 1$, then the eigenvalues are real positive and negative resulting in saddle point. If $W = 1$, then the eigenvalues are 0 and real negative resulting in stable degenerate, since $\det(J) = 0$ and $\text{tra}(J) < 0$. If $W < 1$, then the eigenvalues are all real negative resulting in stable node.

$$\begin{aligned}
 W &= \frac{\alpha}{\frac{(\gamma + \mu)(\psi + \mu)}{\phi} + \mu} \\
 \text{Let } M &= \frac{(\gamma + \mu)(\psi + \mu)}{\phi} \\
 W &= \frac{\alpha}{M + \mu}
 \end{aligned}$$

By analyzing W , we see that large values for W occur when α and ϕ are maximized and γ , ψ , and μ are minimized. In addition, α plays a very prominent role in maximizing the W value, since α has a direct effect on W compared to the other two factors, M and μ . Since α is the influential rate, it has direct relationship to the number of new supporters. If we reduce α , the number of new supporters will decrease, and hence the chance

for a response to become durable will also decrease. Similarly, we can increase α to achieve the opposite effect. Since M is restricted by three parameters, M plays a less dominating role in maximizing W . Also, μ is considered as stable, hard to control, and small, so μ has less influence in maximizing W than α .

3.6 Basic Reproductive Number R_0

Radicalization behaviors die out when $R_0 < 1$ when each affection upholder converts, on average, less than one new upholder. Radicalization behaviors become persistent when $R_0 > 1$ when each affection upholder converts more than one new upholder. We will create R_0 -like thresholds using the differential equations form (3.2) of the *SLH* Model we created in section 3.1 and next generation matrix G . Our model is

$$\begin{aligned}
 \frac{dl}{dt} &= \alpha sh + \psi h - \gamma l - \phi l - \mu l \\
 \frac{dh}{dt} &= \phi l - \psi h - \mu h
 \end{aligned}$$

We separate gains and losses in both classes.

Gains to l : αsh

Gains to h : 0

Losses to l : $-\psi h + \gamma l + \phi l + \mu l$

Losses to h : $-\phi l + \psi h + \mu h$

Then, we create the F (gains) matrix and evaluate it at the disease-free equilibrium.

$$\begin{aligned}
 F &= \begin{pmatrix} \frac{\partial}{\partial l}(\alpha sh) & \frac{\partial}{\partial h}(0) \\ \frac{\partial}{\partial h}(\alpha sh) & \frac{\partial}{\partial h}(0) \end{pmatrix} \\
 &= \begin{pmatrix} 0 & 0 \\ \alpha & 0 \end{pmatrix}
 \end{aligned}$$

And, we create the V (losses) matrix and evaluate it at the disease-free equilibrium.

$$V = \begin{array}{cc} \frac{\partial}{\partial h}(-\psi h + \gamma l + \phi l + \mu l) & \frac{\partial}{\partial h}(-\phi l + \psi h + \mu h) \\ \frac{\partial}{\partial h}(-\psi h + \gamma l + \phi l + \mu l) & \frac{\partial}{\partial h}(-\phi l + \psi h + \mu h) \end{array}$$

$$= \begin{array}{cc} \gamma + \phi + \mu & -\phi \\ -\psi & \psi + \mu \end{array}$$

Next, we calculate next generation matrix G by FV^{-1} .

$$V^{-1} = \begin{bmatrix} \frac{\psi + \mu}{(\gamma + \mu)(\psi + \mu) + \phi\mu} & \frac{\phi}{(\gamma + \mu)(\psi + \mu) + \phi\mu} \\ \frac{\psi}{(\gamma + \mu)(\psi + \mu) + \phi\mu} & \frac{\gamma + \phi + \mu}{(\gamma + \mu)(\psi + \mu) + \phi\mu} \end{bmatrix}$$

$$G = \begin{array}{cc} 0 & 0 \\ \frac{\alpha(\psi + \mu)}{(\gamma + \mu)(\psi + \mu) + \phi\mu} & \frac{\alpha\phi}{(\gamma + \mu)(\psi + \mu) + \phi\mu} \end{array}$$

Setting $|G - \lambda I| > 0$ and solving for λ_{\max} ,

$$R_0 = \lambda_{\max} = \frac{\alpha\phi}{(\gamma + \mu)(\psi + \mu) + \phi\mu}$$

By using the next generation matrix G , we calculate out the basic reproductive number R_0 . From linearization and the Jacobian Matrix, we discover the two eigenvalues for both Equilibria 1 and 2. From eigenvalue analysis, we can see the direct connection between R_0 and stability analysis, since $R_0 = W$. We can use both R_0 and stability analysis to generalize the behavior of Equilibrium 1 based on the parameter conditions. When $R_0 < 1$, the radicalization behavior dies out. From the stability perspective, the eigenvalues for Equilibrium 1 are forced to be both negative, resulting in stability of stable node. When $R_0 > 1$, the radicalization behavior dies out. From the stability perspective, the eigenvalues for Equilibrium 1 are forced to be zero and negative,

resulting in stability of stable degenerate. When $R_0 > 1$, the radicalization behavior becomes persistent. From the stability perspective, the eigenvalues for Equilibrium 1 are forced to be positive and negative, resulting in stability of saddle point. From stability analysis, we can see how $R_0 > 1$ causes the radicalization behavior to become persistent. The results in eigenvalue analysis validate the behavior of disease-free equilibrium described by R_0 .

3.6.1 Scenario

Scenario: There is a city located in Milan with 10,000 people. A new rising star fashion designer, Alexander Smith, releases his new Fall 2016 Collection in Milan during Fashion Week. The editor-in-chief of Vogue wants to include an article about Alexander Smith and his fashionable sense, but she only includes Alexander if he is the current hot topic in the Fashion Week. A team is sent to collect public interest after Alexander's Fashion Show for Fall 2016 Collection. From the survey, they discover 10% of the population said they like Alexander (i^+) and 15% of the population said they love Alexander and would share his name with other people (i^-). The Fashion Week lasts for another 21 days (roughly 500 hours). The units for the influential, neutralization, progression, and regression rate are (hours)⁻¹. During this period, the birth and death rate in this town are assumed to remain constant at 0.01% per hour. The editor-in-chief want to know if Alexander will remain famous after the Fashion Week.

3.7 Case Study

3.7.1 Case 1

$\alpha = 0.03, \gamma = 0.07, \phi = 0.01, \psi = 0.08, \mu = 0.0001$

Equilibrium 1 (0,0) Stable Node

Equilibrium 2 (0,0.4792) Saddle Point

Initial Upholders (0.1,0.15) \Rightarrow Equilibrium 1 (0,0) as $t \Rightarrow \infty$.

Thus, designer Alexander Smith is forgotten by the public after Fashion Week.

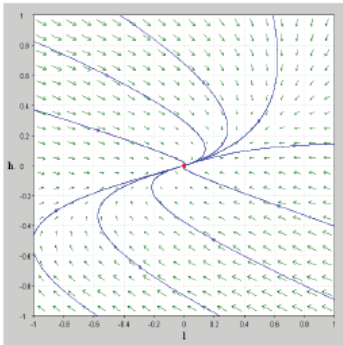


Figure 3.2: Phase Plane: Case 1

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 1 (0,0) as $t \Rightarrow \infty$.

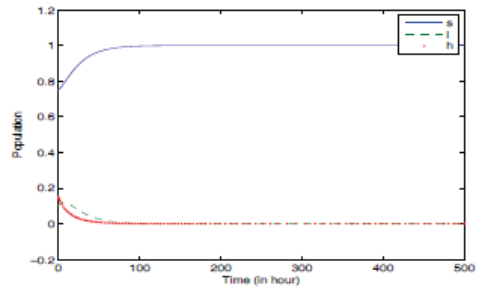


Figure 3.3: Population Chart: Case 1

After 500 hours, the number of susceptibles increases to 1, the number of low affection upholders decreases to 0, and the number of high affection upholders decreases to 0.

3.7.2 Case 2

$\alpha = 0.07, \gamma = 0.05, \phi = 0.03, \psi = 0.01, \mu = 0.0001$

Equilibrium 1 (0,0) Saddle Point

Equilibrium 2 (0.1908,0.5668) Stable Node

Initial Upholders (0.1,0.15) \Rightarrow Equilibrium 2 (0.1908,0.5668) as $t \Rightarrow \infty$.

Thus, designer Alexander Smith is considered as famous after Fashion Week.

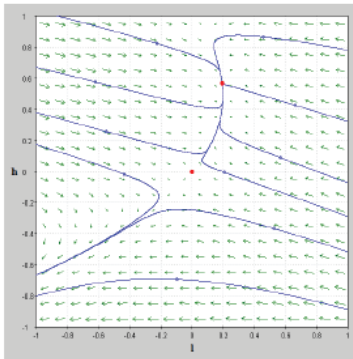


Figure 3.4: Phase Plane: Case 2

All the non-trivial initial number of supporters will move toward and end up at Equilibrium 2 $(0.1908, 0.5668)$ as $t \Rightarrow \infty$.

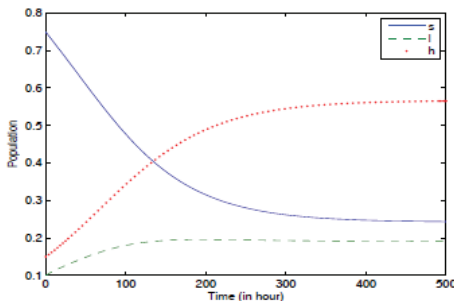


Figure 3.5: Population Chart: Case 2

After 500 hours, the number of susceptibles decreases to 0.2437, the number of low affection upholders increases to 0.191, and the number of high affection

upholders decreases to 0.5654.

3.8 Discussion

By taking a closer look at W and R_0 , we realize that α has a major impact on them. It is easier to increase or decrease influential rate α to control a radicalization compared to M and μ . In order to contain a radicalization through M , we need to increase neutralization rate γ and regression rate ψ and decrease progression rate ϕ . Without the accurate knowledge of parameters, we do not have the ability to control all three parameters. In addition, we do not have a clear understanding of the relationship between the parameters γ , ψ , and ϕ , so an increase on one parameter may impact the other parameters. Rather than analyzing three parameters, we can just study α to achieve effective control of a radicalization in a short amount of time, since α has direct effect on W and R_0 . Although μ has its effect on W and R_0 , it is impossible to control the death rate of a population, so we will focus on the study of α instead of the other parameters. The study of μ and M can provide a new understanding in controlling radicalization. The relationship between γ , ψ , and ϕ can be if ϕ increases, then ψ and γ decreases. One way to explain is ψ and ϕ have opposite relationship and high progression rate means people are more likely to become more attracted than losing their attraction. If we expand the death rate including people leaving the population, then we can control μ and also a radicalization. We have seen police arrests protesters during a social movement, and this action can be viewed as a form of controlling μ . They may able to stop a radicalization of a social movement by putting protesters in jail, but their action will also anger the population and may increase ϕ and decrease γ and ψ .

Case Study Result				
Case	Conditions	Persistent Radicalization	Final Low Affection Upholders l_F	Final High Affection Upholders h_F
1 (3.7.1)	$R_0 < 1$	No	0	0
2 (3.7.2)	$R_0 > 1$	Yes	$\frac{K(\alpha - \gamma K - \mu - \mu K)}{\alpha(K+1)}$	$\frac{\alpha - \gamma K - \mu - \mu K}{\alpha(K+1)}$

Table 3.1: Case Study Result

We need to remember that the relationship between parameters is very complex and that we need to take into consideration the effect on other parameters when we are modifying one parameter.

3.8.1 Result

The final supporters for Case 1 and 2 are found using equilibrium analysis.

3.9 Conclusion

This chapter investigates the formation of radicalization based on two distinct affections, low and high, in a fixed population. A low and high human affection is in reference to the behaviors associated with their dominating preference, likes and dislikes, toward an identity. The formation of persistent radicalization is modeled by assuming relationship between the spread of human affection and extreme behaviors. By using an epidemiological model, *SLH* model, created from the classical *SIS* Model, we are able to establish different conditions that produce a persistent radicalization in a fixed population. We summarize the conditions as follows:

- In a fixed population, a radicalization becomes persistent if the rate of change for high affection upholders is large.
- If the influential rate is large, then a radicalization is more likely to happen.
- If the progression rate is large, then a radicalization is more likely to happen.
- If radicalized people are dying too fast, then radicalization will not persistent.

Our results offer insights on how two levels of affections interact in a fixed population and the progression of radicalization from this interaction. In this chapter, we drew the connection between human affection and radicalization. In addition, we can predict the formation of a persistent radicalization based on the influential, neutralization, progression, and regression rates. We understand that the complexity in human affection and the development of persistent radicalization cannot be modeled accurately, but our model offers a simple logical reasoning for the phenomenon happening in radicalization.

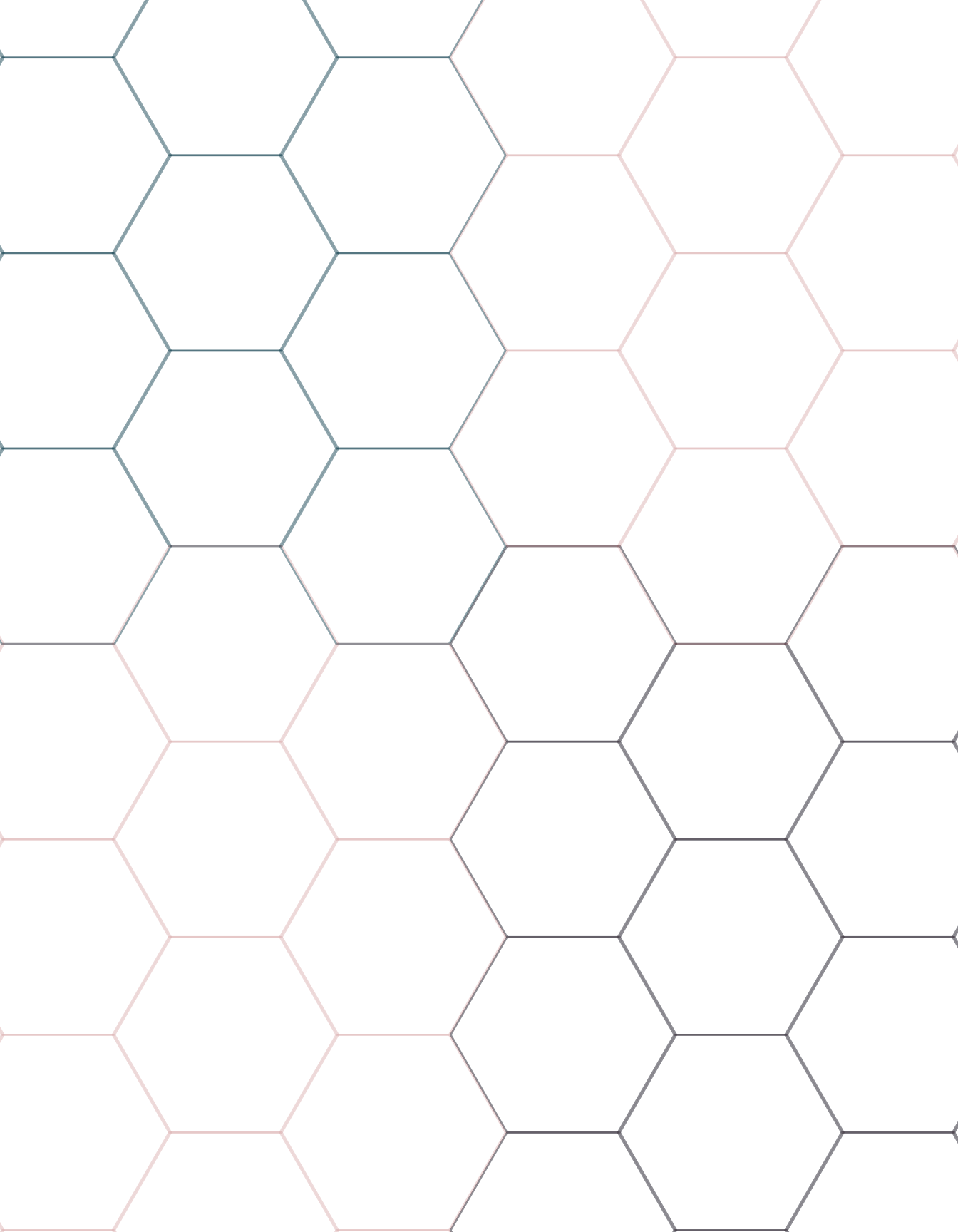
Chapter 4 Remark

Our research focuses on the development, maintenance, and progression of an idea in terms of human mind and behavior. The relationship between mind and body is of ten connected, so we utilize this fundamental association as a prediction for the changes of an idea in human mind through their behavior. In Chapter 1, we analyze the existence of an idea through classification formed by recognitions. In Chapter 2, we explore the persistence of an idea through establishment of sustainability and popularity of responses. In Chapter 3, we study the progression of an idea through radicalization of human affections. We construct the concepts of modeling the process of an idea in human mind through behavior. We divide up the process of an idea in human mind through three individual models, but an idea is created, maintained, and progressed in the human mind continuously in reality. The relationship between each model may also establish additional uncertainty, since we do not fully understand the process of an idea in the human mind. Further study in the process of an idea in the human mind is needed

to increase accuracy in prediction. In addition, the structure of each process of an idea needs to capture additional characteristics of human mind and behavior. The creation of a continuous human mind model is also an area to explore through using the existing individual models. All the models have arbitrary parameters that are not specific and cannot be precisely measured. One can modify the models in terms of contexts to capture the realistic characteristics of the different processes of an idea in the human mind. Each model needs to be created from the context, identify significant parameters and establish method for measurement, develop individual models and a joint model, and establish a system for updating the model with live time data. From the research, we develop the foundation for mathematical modeling of the human mind through the usage of epidemiological concepts. We hope other researchers will continue mathematical modeling on the human mind using our research and explore other interdisciplinary areas to further the prediction of the human mind.

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Hsien-Te Kao Gender Dichotomy in Horror Characters

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Abstract

The United States has increased the awareness for gender fluidity through social expressions and movements. The horror community as a subspace of American society reflects the practice of gender fluidity. The horror community utilizes the diverse platforms of book, film and the internet to create horror characters and stories. Slenderman was a gender neutral horror character developed in 2009 that transformed into a gendered character through fanfictions and fan arts. We discover the gendered transformation of Slenderman from comparison analysis of original and fan-based Slenderman in addition to fanfictions text mining. We examine the history of horror characters with the analysis of Frankenstein, Freddy and Ring and text mining on the word selections between female and male author in 100 horror books and 100 horror movie scripts. We discover the existence of gender binary structure throughout the history of horror characters. The gender dichotomy in the horror community reveals the inconsistency between the practice and awareness of gender fluidity in the United States.

Keywords: gender dichotomy, horror character, text mining

Introduction

The horror community has successfully created famous horror characters in book and film that establish numerous outbreaks of fear. The Frankenstein, a creature of an unorthodox scientific experiment, was a classical horror character in 1818 that played on the fear of scientific experiment on human

body and resurrection [24]. The signature horror character was replaced in 1984 by Freddy Krueger of *A Nightmare on Elm Street*. Freddy was known for the psychological and physical torture on his victim in their dream, and he represented the fear of a serial killer, unknown in a dream and darkness [23]. In 2002, a Japanese supernatural horror character Ring stormed the United States with a massive fear of television [18]. A horror character Slenderman emerged from the internet in 2009, and it started from the fascination of photoshopped pictures and fanfictions [19]. A horror character has transformed dramatically from a scientific creature in book or film to a darkness creature on the internet. We are becoming attractive to the horror characters because of the contradiction of pleasure caused by the interchanging emotional spark of fear and thrill.

Our behaviors are affected by these horror characters unconsciously. On May 31, 2014, two 12-year-old girls in Waukesha, Wisconsin allegedly lured their friend into the woods and stabbed her 19 times in a blood sacrifice to earn Slenderman's protection according to the police report [6]. One of the girls discovered Slender Man in a Minecraft video, a sandbox game, and became engaged with Slenderman fanfictions on Creepypasta, a collection of user-generated horror fan sites [17]. She told the police that Slenderman really exists from the evidences on Creepypasta, and the polices found more than 50 drawings of Slenderman with phrases like "NEVER ALONE" and "HE STILL SEES YOU" in the bedroom [21]. The public became concerned of the violent influence from the internet horror community after this stabbing case, but they failed to recognize the gender dichotomy in the horror characters. Slenderman is one of many iconic horror characters that reinforces gender dichotomy

through its story and character.

The original creation of Slenderman was a gender neutral monster without a story, and a new type of Slenderman emerged from fanfictions and fan arts after the original became popular in the horror community. The internet horror community integrates their individual gendered experience into their Slenderman fanfictions and art works and collectively created a collective Slenderman with gender binary images and stories. This process reflects the fans subconsciously applies gender binary into their stories and characters, even though the society has increased its awareness in gender fluidity. The analysis on the history of horror characters in terms of Frankenstein (1818), Freddy (1984) and Ring (2002) reveals the similar gender binary structure in character and story development compared to the Slenderman. The history of horror characters since the 1800s shows the continuity of gender stereotype in the horror community. This result reflects the inconsistency between the practice and awareness of gender fluidity in the United States.

Methodology

We study the gender stereotypes in horror characters to reveal how gender binary is expressed visually and contextually in horror book and film. We collect 100 horror books and 100 horror movie scripts with equal male and female author for both categories, and apply text mining to show the existence of gender dichotomy in horror book and film. Our text mining method is based on unique word count in male and female author written works, and we only consider a word if it exceeds the unique word count threshold and does not appear in both male and female author written works. We establish the unique word count threshold

at 20, since we assume roughly 80% of the gender dichotomy in horror book and film comes from 20% of unique word occurrence based on Pareto principle. We define a male word as a word that satisfies the unique word count threshold and appears only in male author written works, and we define a female word similarly. We use text mining result on male and female words to show the existence of gender dichotomy in horror book and film. Transiting to an internet horror character, we examine the origin of Slenderman and Slenderman as a collective character. We collect 100 anonymous Slenderman fanfictions and apply text mining to reveal the selection of words. We use the text mining result on Slenderman fanfictions to show the creation of an internet horror character corresponds with the gender dichotomy in horror book and film.

Gender Stereotype in Horror Characters

We investigate three iconic horror characters, Frankenstein (1818), Freddy (1984) and Ring (2002), and their story to understand how gender stereotypes were integrated into horror book and film and character in various time period. We focus on the development and social interaction of male and female characters in addition to how the main horror character was portrayed through the story. These three horror characters reveal how horror characters have changed from 1800s to 2000s except for the gender stereotypes.

Frankenstein 1818

Victor Frankenstein and the monster are two male characters that contribute to the gender dichotomy in the book. Victor is described as an intelligent, ambitious and innovative scientist that challenges the

boundary of science by creating a monster from human remains. Men are often associated with science and creativity compared to women [22]. The monster is eight-foot-tall male creature that is intelligent and sensitive, and he wants to integrate into society by learning human social patterns. He can analyze, understand and adapt social patterns because men are capable of complex thinking [16]. Victor does not admit that he created the monster even when his youngest brother, best friend and wife were murdered by the monster. Victor does not admit he is wrong because men do not believe their decision is wrong [8]. The monster becomes angry toward Victor from being abandoned, and he uses his massive strength to revenge Victor. Men do not accept rejection and respond negatively through aggressive behaviors [14]. The personality and social interaction of Victor and the monster follow the gender stereotypes for men.

The female characters as a whole reinforce the gender binary in the book through their personality and interaction with other characters. Caroline Beaufort is a mother that dies from taking care of her adopted daughter Elizabeth Lavenza devotedly when she is sick. Caroline contributes selflessly to her family because women are expected to serve her family without questions [11]. Justine Moritz is a happy grateful servant that represents kindness in the Frankenstein family. Justine represents women are natural house workers and they enjoy these tasks [1]. Justine confesses for the death of William Frankenstein under crowd pressure, and the monster is one that set her up. Her confession shows that women cannot protect themselves under pressure and stand up for themselves against the crowd [4]. Elizabeth Lavenza waits patiently for Victor's attention, but she is also murdered by the monster. Women are stereotyped as they need

constant love and attention from men [9]. The female characters act according to the gender stereotypes for women.

A Nightmare on Elm Street 1984

Freddy Krueger is the main character that creates the gender binary in the film. Freddy brutally murdered small animals at a young age. Men are often described as aggressive and brutal to show their manhood [3]. Freddy kidnapped and murdered 23 children from 1975 to 1977. Freddy is demonstrating his power through massive killing similar to how men prove their masculinity through power control [27]. Freddy became a demon after his death and revenge on the parents of Springwood. Freddy is angry and wants a violent revenge correspond with men respond with only action not reason under anger [7]. Freddy loves to play with his victim by making them think they have escaped and defeated him, but he will torture them again some other time. His action represents an establishment of power from his victim, and this is associated with men desire power and control [11]. Freddy reinforces the gender stereotypes for men through his action and personality in the film.

The female characters in the film are victims that maximize the effect of gender dichotomy. The female victims often do not fight back against Freddy in their dream. Women are often viewed as weak, so they cannot fight back against men [28]. They are mostly alone before encountering Freddy in the dream. This shows that women are powerless without her family or male figure [4]. The female victims usually run away from Freddy and scream helplessly. Women are stereotyped as someone who has a poor judgment and cannot make rational decision under pressure [5]. The

female victims are majority young and rebellious. This represents that women should obey their family and male figure and stay at home to avoid trouble [26]. The female characters in the film reflect the influence of gender stereotype for women.

The Ring 2002

Rachel Keller is the main character that establishes the gender dichotomy in the film. Rachel decides to investigate the cursed video after her niece Katie's mysterious death. Rachel cares deeply for her family because women are selfless when it comes to their family regardless how dangerous it is [11]. She watch the cursed video alone to find out what happen after the video. Rachel knew the video is cursed but decides to watch because women are stereotyped for poor judgment and make irrational decision [15]. She asks her ex-boyfriend Noah, a video analyst, for help to figure out what happen in the video. This shows women are helpless in a critical situation, and they need a man to assist them to overcome the situation [10]. Rachel makes a copy of the cursed video to save her son Aidan under pressure. This again represents women care deeply for their family and they are willing to do anything to save them [11]. Rachel's role shows how gender stereotypes for women are integrated in a horror film.

Anna Morgan and her adopted daughter Samara are the horror characters that enhance the gender stereotypes. Anna, a horse breeder, become depressed after being involved in the mysterious massive deaths of horses. This shows women are emotional and cannot get pass a failure in life [23]. She suicided due to depression. Anna's death is connected to how women are stereotyped as weak and cannot help

themselves under pressure and emotion [13]. Samara possessed nensha, and this power allows her to burn images onto objects and into the minds of people and animals. Women are often viewed negatively when they are single or does not have a family [12]. Samara created the curse video to kill other people. Samara represents evil because women are stereotyped for being easy to give in so they are more likely to be evil [23]. Anna and Samara are governed by the gender stereotypes for women.

Textual Analysis of Horror Book and Movie Script

We use text mining on 100 horror books and 100 horror movie scripts with equal male and female author for both categories, and we show the existence of gender dichotomy through the comparison of unique words and unique word counts in male and female author written works. We divide our text mining result on 100 horror books and 100 horror movie scripts as male and female words. We divide male words into three groups, aggressiveness, normality and external negativity and female words into three groups, family, satisfaction and internal negativity. We show five words for each group as examples. The category frequency measures the unique word occurrences in horror book or horror film, so the total is 2. The frequency measures the unique word occurrences in horror book and movie script, and hence the total is 100 for both male and female authors. We discover the difference between male and female authors for horror book and movie script in terms of word selection at frequency of 20 based on Pareto principle.

Word	C. Freq.	Freq.
Kicked	2	42
Choking	2	35
Attack	2	27
Brutal	2	27
Battered	2	26

Table 1: Male Word: Aggressiveness

These words correspond with the gender stereotype of men being aggressive.

Word	C. Freq.	Freq.
Oddly	2	38
Awkwardly	2	36
Insane	2	36
Monsters	2	35
Bizarre	2	27

Table 2: Male Word: Normality

These words correspond with the gender stereotype of men are normal enforcers.

Word	C. Freq.	Freq.
Damned	2	35
Isolated	2	30
Nasty	2	27
Helplessly	2	26
Suspiciously	2	26

Table 3: Male Word: External Negativity

These words correspond with the gender stereotype of men experience negativity externally.

Word	C. Freq.	Freq.
Daughters	1	22
Husbands	1	21
Orphan	1	19
Childs	1	18
Parent	1	16

Table 4: Female Word: Family

These words correspond with the gender stereotype of women prioritize family.

Word	C. Freq.	Freq.
Bliss	1	20
Gratification	1	20
Compliments	1	18
Proudly	1	18
Approbation	1	16

Table 5: Female Word: Satisfaction

These words correspond with the gender stereotype of women are mentally satisfied.

Word	C. Freq.	Freq.
Defiance	1	19
Condemn	1	17
Repressed	1	17
Dejection	1	15
Disdain	1	12

Table 6: Female Word: Internal Negativity

These words correspond with the gender stereotype of women experience negativity internally.

We discover male authors often use the same word to express the same meaning or feeling resulted in a higher category frequency and frequency and female authors often use similar word to express the same meaning or feeling resulted in a lower category frequency and frequency. These word groups, aggressiveness, normality and external negativity, reflect the gender socialization for men in the public sphere. Men need to prove their masculinity through aggressive behaviors, men need to reinforce the normality in a patriarchal society and men need to establish its power without empathy during the gender socialization [2]. These word groups, family, satisfaction and internal negativity, reflect the gender socialization for women in the private sphere. Women have marital responsibilities such that family is their number one priority, women are often told that they are satisfy with their gender status and women during the gender socialization [11]. These gendered experiences have a significant impact for both male and female authors of horror book and movie script. When they write, they unconsciously or consciously selected these words to support gender dichotomy in horror book and film.

Creation of Slenderman

Eric Knudsen created a fictional supernatural character Slenderman for Creepypasta internet meme in Something Awful forum during 2009. Knudsen posted two faked mid-1980s photographs that show a tall, evil, slender and alien-like creature hiding behind a group of children, and he added for context that 14 young people and the photographer had gone missing. The original design of Slenderman was gender neutral, since the photoshopped pictures and the context showed no gender. In addition, the word man is often

used in English to refer to a human being, so the name Slenderman can simply represents a slender human being. Slenderman become popular in the internet horror community when people started to make drawings, photoshopped pictures and stories based on Knudsen's Slenderman. Slenderman is well-known in the public after it appears in video games and YouTube videos. Slenderman slowly grows into a collective internet horror character when its fans create their version of Slenderman and form a collective notion of Slenderman.

The original and collective Slenderman exhibit two different sets of characteristics. The iconic characteristics of collective Slenderman are masculine feature, numerous hands or tentacles and a black business suit. These three characteristics are associated with monstrous masculinity in horror films where the monster is often a male character, and this shows the fans assume Slenderman is man because he is a monster when they are recreating Slenderman. The tentacles or hands enhance the monstrosity and allow Slenderman to torture its victim, and the tentacles or hands are a sexual representation for male. The fans give Slenderman a black business suit because men are associated with the image of powerful and aggressive business leader and they assume Slenderman is a man. The original Slenderman is a dark alien-like creature, but the collective Slenderman is a powerful high-class business man. We discover the gender dichotomy in Slenderman based on the graphically analysis between the original and collective Slenderman.



Figure 1: Eric Knudsen's Slenderman



Figure 2: Slenderman on Comic Vine



Figure 3: Slenderman on Pinterest

Textual Analysis of Slenderman Fanfictions

We apply text mining on 100 anonymous Slenderman fanfictions to understand how the collective Slenderman is established by the fans and how the fans integrate the gender stereotypes into the collective Slenderman by analyzing their word selections. The frequency measures the unique word occurrences in Slenderman fanfictions, and the total is 100.

Word	Freq.
Forest	60
Hand	59
Suit	54
Ran	48
Watching	45
Girl	40
Scream	34
Kill	33
Child	32
Tentacles	27
Monther	26
Boy	21
Brother	21
Children	21
Kids	21
Game	20

Table 7: Slenderman Fanfictions Word Selection

The text mining result for 100 anonymous Slenderman fanfictions allow us to understand the different elements in the collective Slenderman fanfic-

tions. We can see majority of the fans pick the story setting in the forest. The lives in the forest is connected to the Mother Nature such that the forest symbolizes femininity. The unknown in the forest creates a mysterious atmosphere for the story. The people who enter the forest are attracted by the unknown, and they become vulnerable or powerless that corresponds with femininity. The fans mostly pick mother, girl, boy, brother, children, child and kids to enter the forest because these people are stereotyped as weak and has poor judgement. It is justified why these people are attracted by the unknown and why they are considered as extremely vulnerable. Slenderman slowly becomes a symbol of masculinity when the fans add the hand, suit and tentacles to its features. The fans form the gendered behaviors between Slenderman and its victims. Slenderman watch his victims, kill the victims directly with his tentacles and play game with them, and hence Slenderman establish its power and control over the victims to represent masculinity [18]. The victims often run away and scream instead of fighting back, so the victims follow feminine stereotypes of being weak and passive. The fans develop a gender dichotomy in their fan-fictions where Slenderman symbolizes masculinity and the setting and victims symbolizes femininity. These fan-fictions together create a collective Slenderman with gender dichotomy.

Discussion

The horror characters have expanded dramatically since 1800s. We have seen horror characters as scientific creature, evil villain, wicked spirit and dark creature in book, in film and on the internet. The gender dichotomy in horror book and film focuses on the character development and interaction. In Franken-

stein, we can look at the character development between Victor Frankenstein and the monster versus the female characters, and the interactions between them reveal the hidden gender stereotypes. Horror films use visual representations to reinforce gender binary in addition to the characteristics of horror book and film. Freddy in *A Nightmare on Elm Street* often tortures the victims with his blood claws, so these bloody scenes create men are aggressive and power hungry. Anna from *The Ring* climbs out from the television before she can murder her victim. This appearing method is considered as powerless compared to other male horror characters, and it also matches with the gender stereotypes for women of being weak. Internet horror characters have both characteristics from horror books and films, but the characters allow the fans to create a collective notion from the original character setup. The fans enhance the gender dichotomy in the character during the development of a collective character. The original and collective Slenderman show us how the gender stereotypes are infused in Slenderman when the fans create their version of Slenderman.

The character features and *modus operandi* reveal the influence of gender stereotypes. Male horror characters generally have the features that exhibit power where female horror characters are often viewed as weak. Frankenstein is an eight-foot tall monster with massive strength, and Freddy cannot die in the dream and has sharp claws. Slenderman wears a business suit with numerous tentacles. Ring wears a long white dress with no shoes, and she has a long messy hair and light skin. She looks very weak compared to Frankenstein, Freddy and Slenderman. The male horror characters are developed to look powerful through body size, weapon and power, and the female horror characters are developed to look weak using the

similar method. Male horror characters often kill their victims with direct contact, and female horror characters use more of indirect contact instead. Frankenstein suffocates the victims with his bare hand. Freddy enjoys playing a chasing game with his victims, and he kills them with his sharp claws. Slenderman suffocates the victims with his tentacles. Ring curses her victims to die after watching the video tape. The direct killing method creates a power control for the male horror characters, and the indirect killing method is viewed as weak by comparison. Gender dichotomy is integrated into the character development and modus operandi. Horror characters can come in different forms, but all of them have the structure of gender dichotomy.

Limitation

We study only four horror characters since the 1800s due to time restriction. There are other iconic horror characters after 1800s that we can research additionally to refine our result by examining the change in horror characters and continuity of gender dichotomy more accurately. We expand the horror genre to include gothic, thriller and supernatural for text mining because there are limited online text files of horror books and movie scripts. We assume the unique word count threshold using Pareto principle, but we can improve our result if we have a better estimation of this threshold. We cannot analyze the Slenderman fanfictions based on male or female author, since they are anonymous. We only focus on how gender dichotomy is expressed in terms of horror characters, but we also need to study how the public is affected by the gender dichotomy in horror characters to understand the influence of horror as a gender binary reinforcement in the society.

Conclusion

The horror community has established a new platform on the internet and developed a new type of horror characters based on the popular culture. A horror character in book and film is fixed by their author or director such that the character maintains a constant image. The author infuses the gender stereotypes into the horror character in book, and the director integrates the gender stereotypes into the visual representation of the horror character in film. Frankenstein (1818) represented the gender stereotypes in horror book, and Freddy (1984) and Ring (2002) showed the gender binary in horror film. An internet horror character is elastic when the original author set up the basic character characteristics, and the fans continue to develop a collective character through fanfictions, drawings, photoshopped pictures and memes. Knudsen, the original author of Slenderman, constructed a gender neutral horror character in 2009, and the fans continued to inject different gender stereotypes into the character and formed a collective gendered Slenderman. The increase of gender fluidity in the United States since the 1800s is not reflected by the continuity of gender dichotomy in horror characters. Our society is becoming aware of gender fluidity, but it is not completely integrating the notion into its culture.

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Appendix A. Horror Books

Male Author

1. Bierce, Ambrose – *An Occurrence at Owl Creek Bridge*
2. Bierce, Ambrose – *The Damned Thing*
3. Blackwood, Algernon – *Four Weird Tales*
4. Blackwood, Algernon – *The Damned*
5. Blackwood, Algernon – *The Wendigo*
6. Blackwood, Algernon – *The Willows*
7. Boyczuk, Robert – *Horror Story and Other Horror Stories*
8. Chambers Robert W. – *The Slayer of Souls*
9. Chambers, Robert W. – *The King in Yellow*
10. Dillon, Mark F. – *In a Season of Dead Weather*
11. Falkner, John M. – *The Lost Stradivarius*
12. Hodgson, William H. – *The Boats of the "Glen Carrig"*
13. Hodgson, William H. – *The House on the Borderland*
14. Hodgson, William H. – *The Night Land*
15. Irving, Washington – *The Legend of Sleepy Hollow*
16. James, Glynn – *Diary of the Displaced*
17. James, Henry – *The Turn of the Screw*
18. James, Montague R. – *A Thin Ghost and Others*
19. James, Montague R. – *Ghost Stories of an Antiquary*
20. James, Montague R. – *Ghost Stories of an Antiquary Part 2: More Ghost Stories*
21. Kadrey, Richard – *Butcher Bird*
22. Kafka, Franz – *Metamorphosis*
23. Kafka, Franz – *The Trail*
24. Le Fanu, Sheridan – *Carmilla*
25. Leroux, Gaston – *The Phantom of the Opera*
26. Lovecraft, Howard. P. – *The Shunned House*
27. Machen, Arthur – *The Great God Pan*
28. Machen, Arthur – *The House of Souls*
29. Maturin, Charles – *Melmoth the Wanderer*
30. Maugham, Somerset – *The Magician*
31. O'Donnell, Elliott – *Animal Ghosts Or, Animal Hauntings and the Hereafter*
32. O'Donnell, Elliott – *Scottish Ghost Stories*
33. O'Donnell, Elliott – *The Sorcery Club*

34. Onions, George O. – *Widdershins*
35. Poe, Edgar A. – *The Works of Edgar Allan Poe, Volume 1*
36. Poe, Edgar A. – *The Works of Edgar Allan Poe, Volume 2*
37. Poe, Edgar A. – *The Works of Edgar Allan Poe, Volume 3*
38. Poe, Edgar A. – *The Works of Edgar Allan Poe, Volume 4*
39. Poe, Edgar A. – *The Works of Edgar Allan Poe, Volume 5*
40. Polidori, John W. – *The Vampyre*
41. Prest, Thomas P. – *Varney the Vampire*
42. Stevenson, Robert L. – *The Strange Case of Dr. Jekyll and Mr. Hyde*
43. Stoker, Bram – *Dracula*
44. Stoker, Bram – *Draculas Guest*
45. Stoker, Bram – *Lair of the White Worm*
46. Stoker, Bram – *The Jewel of Seven Stars*
47. Stoker, Bram – *The Lady of the Shroud*
48. Stoker, Bram – *The Man*
49. Taylor, G. W. – *When Graveyards Yawn*
50. Viereck, George S. – *The House of the Vampire*

Female Author

1. Austen, Jane – *Northanger Abbey*
2. Bowen, Marjorie – *Black Magic*
3. Bowen, Marjorie – *The Bishop of Hell*
4. Bowen, Marjorie – *The Breakdown*
5. Bowen, Marjorie – *The Crown Derby*
6. Bowen, Marjorie – *The Fair Hair of Ambrosine*
7. Bowen, Marjorie – *The Folding Doors*
8. Bowen, Marjorie – *The Grey Chamber*
9. Cholmondeley, Mary – *Let Loose*
10. Corelli, Marie – *A Romance of Two Worlds*
11. Corelli, Marie – *Ardash*
12. Corelli, Marie – *The Master-Christian*
13. Corelli, Marie – *The Sorrows of Satan*
14. Crowe, Catherine – *Ghosts and Family Legends*
15. Dacre, Charlotte – *Zofloya*
16. Dunbar, Olivia H. – *The Long Chamber*
17. Dunbar, Olivia H. – *The Shell of Sense*
18. Edwards, Amelia B. – *How the Third Floor Knew the*

Potteries

19. Edwards, Amelia B. – *A Service of Danger*
20. Edwards, Amelia B. – *All Saints Eve*
21. Edwards, Amelia B. – *In the Confessional*
22. Edwards, Amelia B. – *Monsieur Maurice*
23. Edwards, Amelia B. – *The Phantom Coach*
24. Lamb, Caroline – *Glenarvon*
25. Loudon, Jane C. – *The Mummy!*
26. Nielsen, T. M. – *Heku*
27. Nielsen, T. M. – *Valle*
28. Oliphant, Margaret – *Salem Chapel*
29. Oliphant, Margaret – *The Open Door*
30. Oliphant, Margaret – *The Portrait*
31. Oliphant, Margaret – *The Wizards Son*
32. Parsons, Eliza – *The Castle of Wolfenback*
33. Perrin, Teresa – *The Ice Cream Memories of Charlotte Rowe*
34. Radclie, Ann – *A Sicilian Romance*
35. Radclie, Ann – *The Castles of Athlin and Dunbayne*
36. Radclie, Ann – *The Italian*
37. Radclie, Ann – *The Mysteries of Udolpho*
38. Radclie, Ann – *The Romance of the Forest*
39. Reeve, Clara – *The Old English Baron*
40. Scarborough, Dorothy – *The Imperishable Ghost*
41. Scarborough, Dorothy – *The Supernatural in Modern English Fiction*
42. Shelley, Mary – *Frankenstein*
43. Shelley, Mary – *Lodore*
44. Shelley, Percy B. – *Zastrozzi*
45. Wilkins Freeman, Mary E. – *Luella Miller*
46. Wilkins Freeman, Mary E. – *The Lost Ghost*
47. Wilkins Freeman, Mary E. – *The Shadows on the Wall*
48. Wilkins Freeman, Mary E. – *The Southwest Chamber*
49. Wilkins Freeman, Mary E. – *The Vacant Lot*
50. Wilkins Freeman, Mary E. – *The Wind in the Rose Bush*

Appendix B. Horror Movie Scripts

Male Author

1. Bach, Danilo – *April Fool's Day*
2. Briggs, Peter – *Alien vs. Predator*
3. Briggs, Peter – *Freddy vs. Jason*
4. Callaway, Trey – *I Still Know What You Did Last Summer*
5. Cameron, James – *Aliens*
6. Cody, Diablo – *Jennifers Body*
7. Columbus, Chris – *Gremlins*
8. Eisner, Philip – *Event Horizon*
9. Farmer, Todd – *Jason X*
10. Farrands, Daniel – *Halloween: The Curse of Michael Myers*
11. Goldman, William – *Misery*
12. Goodman, Cory – *Priest*
13. Goyer, David S. – *Blade*
14. Goyer, David S. – *Blade II*
15. Goyer, David S. – *Blade: Trinity*
16. Gutierrez, Sebastian – *Gothika*
17. Haas, Charlie – *Gremlins 2*
18. Hanlon, Mark – *Ghost Ship*
19. Hedden, Rob – *Friday the 13th Part VIII: Jason Takes Manhattan*
20. Johannessen, Chip – *The Crow Salvation*
21. Johnson, David L. – *Orphan*
22. Jones, Andrew – *The Amityville Asylum*
23. Kelley, David E. – *Lake Placid*
24. Koepp, David – *Jurassic Park*
25. Koepp, David – *Jurassic Park: The Lost World*
26. Landis, John – *American Werewolf in London*
27. Lynch, David – *Mulholland Drive*
28. Markwalder, Matter – *American Psycho*
29. Miller, Victor – *Friday the 13th*
30. Millov, Travis – *Pandorum*
31. Noxon, Marti – *Fright Night*
32. Pickett, Rex – *Alien 3*

33. *Protosevich, Mark – The Cell*
34. *Rocko, Adam – I Spit on Your Grave*
35. *Romero, George A. – Dawn of the Dead*
36. *Romero, George A. – Day of the Dead*
37. *Romero, George A. – Land of the Dead*
38. *Schow, David – The Crow*
39. *Selden, Ken – Cherry Falls*
40. *Spielberg, Steven – Poltergeist*
41. *Susco, Stephen – The Grudge*
42. *Tarantino, Quentin – From Dusk Till Dawn*
43. *Walker, Michael – Chasing Sleep*
44. *Waller, Anthony – Mute Witness*
45. *Whedon, Joss – Alien: Resurrection*
46. *Whedon, Joss – Buy the Vampire Slayer*
47. *Wood, Ed – Orgy of the Dead*
48. *Wright, Ray – Case 39*
49. *Zaillian, Steven – Hannibal*
50. *Zombie, Rob – House of 1000 Corpses*

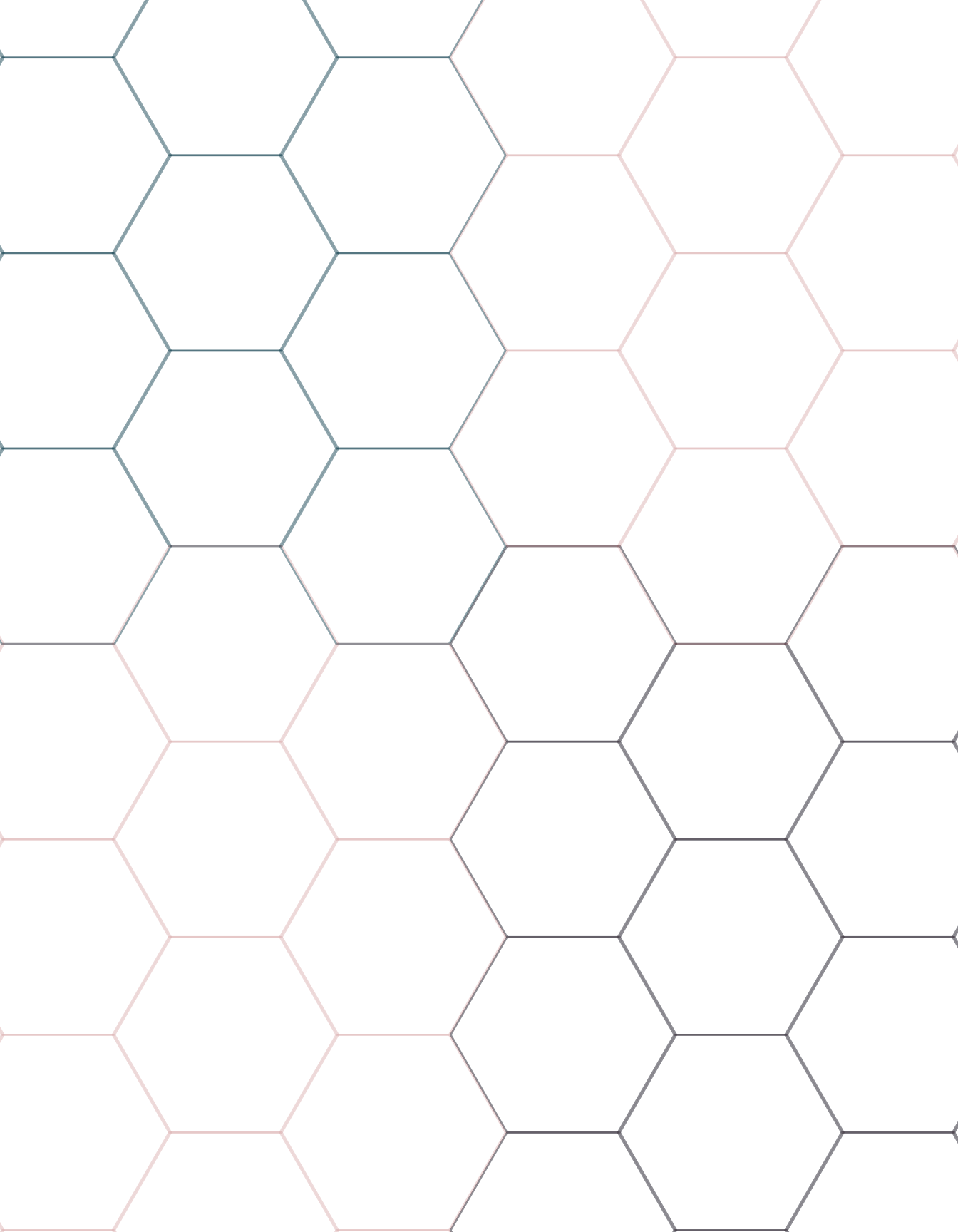
Female Author

1. *Anderson, Charmaine – Z-mart*
2. *Angelica, Kyia – Jin*
3. *Austin, Niki – Small Town Lies*
4. *Bealer-Wynton, Cheryl – Murder Burger*
5. *Bialystock, Rebecca – Don't Wake the Dead*
6. *Bohem, Leslie – Nightmare on Elm Street 5: Dream Child*
7. *Dixon, Leslie – Limitless*
8. *Elaine – Heart Attacks*
9. *Floyd, Kyha J. – Love in Manifest*
10. *Fordham, Rhonnie – All-American*
11. *Gillis, Sandy – Absolutely Hypnotic*
12. *Isdandarova, Khamanna – Demon Within*
13. *Izzy – Conspiracy HIV*
14. *Jones, Amy H. – The Relic*
15. *Joyson, Renee – The Doorway to Hell*
16. *Karman, Michelle – Pine Valley*
17. *Keller, Cindy L. – Masquerade*
18. *Keller, Cindy L. – The Shadow of Her Smile*
19. *Khouri, Callie – Thelma & Louise*
20. *Kirwan, Eilis and Larysa Kondracki – The Whistleblower*
21. *Lister, Marnie M. – The Clearing*
22. *Lizz – What Comes Around*
23. *McKinnon, Dena – Dead Cell*
24. *McKinnon, Dena – The Bunker*
25. *Mendoza, Oney – Misfortune*
26. *Mendoza, Oney – Willie12*
27. *Montford, Susan – While She Was Out*
28. *Oshea, Lsyla – Heed the Slighted*
29. *Owen, Brianna – S.O.C Son of Charlie*
30. *Raerty, Alanah – Redwater*
31. *Rasi, Mahyar – Shutdown*
32. *Rice, Anne – Interview with the Vampire*
33. *Rice, Anne – The Witching Hour*
34. *Rodriquez, Katrina – The Coming*
35. *Rosenberg, Melissa – New Moon*
36. *Rosenberg, Melissa – Twilight*
37. *Seitz, Hillary – I, Robot*
38. *Seitz, Hillary – Insomnia*
39. *Self, Brandi – Perfect*
40. *Singleton, Julian – Outbreak*
41. *Singleton, Julian – Snowstorm*
42. *Sorrentino, Shanna – The Bargain*
43. *Tadjedin, Massy – The Jacket*
44. *Thompson, Caroline – The Nightmare before Christmas*
45. *Thompson, Megan – Home Movie*
46. *Walton, Karen – Ginger Snaps*
47. *Wells, Shannon – Small Dark Planets*
48. *Wendel, Mishelle – Apocrypha*
49. *Wilson, Erin C. – Chloe*
50. *Wojtowicz-Vosloo, Agnieszka – After Life*

Appendix C. Slenderman Fanfictions

1. AgentMaryland93 – *Fear the Man*
2. Akakyoak – *Slenderman*
3. Ange0cturnal – *The Child of Slenderman*
4. Appa-appa-away – *Shaun vs the Slenderman*
5. Arcanineryu – *Sexual Oenerman Fanfic Part 1*
6. AuntieJamima – *Slednerman!*
7. Bunny30091 – *How Slenderman Began*
8. Cain Boudicca – *Common Suits*
9. Chibi StarLyte – *Becoming the Monster*
10. Crazybird101 – *I Know What I Saw*
11. Crazybird101 – *I Know What I Saw 2*
12. Creepypasta – *Trick or Eat*
13. Darren-The-Nerd – *Slender: The Truth*
14. Doitsu's Storyteller – *Caught at Last*
15. Drizt1138 – *Master of the Shadows*
16. DRRRLover1224 – *Slender in Ikebukuro*
17. EastCoastGamer13 – *Meet the Slenders: Enderman's Return*
18. ElvenAC 14 – *Oswald's Tale of Slenderman*
19. EvenIfYouLoseYourMind – *Slenderman*
20. FlossSwallower – *Are You an Angel?*
21. Forthehellofit – *Horror Addiction: Slenderman*
22. FunnyLover 13 – *Friends Forever*
23. FunnyLover13 – *Hosonagai*
24. FunnyLover13 – *My Imaginary Friend*
25. GracefullPhantom – *Worth, I Have None*
26. Greenlightning72 – *Slendermans House*
27. Ink Reservoir – *Reasons*
28. Itzkia – *Darkness*
29. Jorus Cbaoth – *Grand Admiral Thrawn and the Slenderman*
30. Jpbake – *The Legend of the Slenderman*
31. Just 2 Dream of You – *My Slender*
32. Kama Kounsoulour – *The Last Words of My Life*
33. Kerbubbles – *Misunderstood*
34. Kitten1313 – *Angel in the Darkness*
35. Kitten1313 – *Her Soul to Take*
36. KyubiChan 95 – *The Child Born of Snow*
37. Lackingcutiepie6 – *Darkness*
38. Lady Dragonite – *Slender Puzzle*
39. Lilybean10 – *The Tall, Faceless Man*
40. Literature from the Leuchovius – *Slenderman Cometh*
41. LittleMissYuki – *ElfenSlender*
42. Lolita Westmore – *Hopeless Romantic*
43. Lovelyfma – *Slenderman Hunt*
44. Lycans Are Gods Gift To Furrys – *When I met Slenderman*
45. LynxOnSmoothies – *Slendermans Victims*
46. LynxOnSmoothies – *Something Neither Brother will Tolerate*
47. Massive Times – *Bold and Daring Creepypasta Sequel*
48. Massive Times – *Cold and Dark Creepypasta*
49. Midnightworlf72 – *Slenderman Attacks*
50. MKPhelps – *The Origins of Slenderman*
51. Morgibee – *Slenderman Short*
52. MrCreepyPasta101 – *An Interview with Slenderman*
53. MrCreepyPasta101 – *Mr. Slenderman*
54. MrCreepyPasta101 – *Slender Encounter*
55. MrCreepyPasta101 – *Slenderman and the Rake*
56. Ms. Whatsitoya – *Fulfill Your Destiny*
57. Nightowlofdoom – *Darkling*
58. Nightowlofdoom – *If I had a Heart*
59. Noniplod – *Der Ritter*
60. Otorisosa-Kan – *Slender: Power*
61. PastaStalker – *Let's Kill Tonight*
62. Perle-de-lune – *Love has Become Hate*
63. Pockypokemongirl – *Slender and Reader: Lost in the Woods*
64. Potosw – *A Slenderman Christmas*
65. ProfessorRed – *My Friend Slendy*
66. Punklovergirl68 – *Don't Walk Alone at Night*
67. Raspberry Snow – *Tea with Slenderman*
68. Red Crayon Embassy – *Eight Pages*
69. ReoundedRevelations – *Everyone has a History*
70. Riddelly – *With Ice Cold Hands*
71. RiniNyan – *Slenderman Story Chap 1*
72. RisingDawn66 – *Tormented Soul*

73. RLHemming – *The Slenderman Based on the Myth*
74. Rocker4Life – *SlendermanxReader Who Could've Guessed?*
75. Rogue IV – *The Slenderman Files*
76. RuBard Pie – *Only a Joke*
77. Savanna-Does-A-Thing – *Become One with the Faceless*
78. Sayjay1995 – *The Pale One*
79. Seclinalunica – *Slender: Find the Eight Pages They Said*
80. Shell780 – *Slenderman*
81. SimTeXa – *Slender: The Lost City*
82. Smiles-That-Are-Big – *Your Worst Nightmare*
83. SorrowMystery – *A Slender Friend*
84. Sparkylove14 – *The Tale of Mr. Slenderman*
85. Spike the Dragoniod – *My Tall Man*
86. TammyHybrid21 – *Slenderman: User Guide and Manual*
87. Tashilover – *One Door Over*
88. Tashilover – *Worse than Raccoons*
89. TexasDiva – *The Forest*
90. The Blue-eyed Storiier – *The Slenderman Mystery*
91. The Critic's Realm – *The Eight Pages of an Everlasting Nightmare*
92. The Death of Heaven – *Don't Look*
93. The London Write – *Sherlock Finds Slenderman*
94. VivianVandam – *Black Roses Red*
95. Vivi-ntvg – *Slender Seeds*
96. William Box 58 – *Einrich's Story*
97. Witch of Alternate Universes – *Not Anymore*
98. Wolfboydude52 – *The Origin of Slenderman*
99. Yaoimelody – *Finally*
100. Zaraerivia – *Misunderstood Spectors*



Kristin Kawecki The Beat That Has Gone On...and On
 Dr. S. Rodriguez-Drissi

The Beat Generation was a chaotic, self-imploding, drug-enthused artistic blur of resistance to America's conformist post-war culture. Their movement, while so antithetical to the American precept of normalcy for the times, became the foundation for much of what we hold as culturally "American" today. The Beats represent the shift from old to new in their recycling of both liberal politics and artistic forms into something that was entirely their own, yet a movement which rippled out into many others, and whose effects reverberate to this day.

The name "Beats" was coined by Jack Kerouac when he claimed that they were a "beaten" generation; beaten by the oppression of the culture of their times. In response to the McCarthyist 1950's culture's drive to "return to normalcy" after the war, the Beats produced works which Beat artist Kenneth Rexroth explains "tirelessly pointed out that there was nothing normal about us," engaging themselves in just about everything that was in direct opposition of the conforming majority—from drug-use to homo-sexuality, as well as in the content and form of their creative acts. The main thread then which united the Beat movement was their ideology of rebellion informing their "cultural practices". In their repudiation of homogeneity, the Beats helped bring about an "avant-garde" to the artistic community which included music, painting and the plastic arts, as well as, of course, literature. However, as Mel van Elteren notes in "The Subculture of the Beats: A Sociological Revisit", the Beats tapped into the preexisting Bohemian movement's connotation with an "underworld of art", and the artistic tie to unconventionality.

In their movement of resistance, the Beats borrowed from an array of sources that fit outside of mainstream American culture, including previous

artistic and arguably Bohemian movements, such as Romanticism and Transcendentalism. The Romantic influence is clear in the melodramatic Beat ideal of unadulterated self-sacrifice to their arts, and their "extreme passions aimed towards a goal that was ultimately unattainable as well as unsustainable," (Elteren 72). The Romantic impulse to expose one's feelings is visible in the style of the prose itself; for while the Beat's free verse poems and stream of consciousness novels daringly break convention, they also reflect a desire to capture spontaneity and the exact emotion one had experienced. The influence of Transcendentalist philosophy manifests in the Beats' appropriation of the ideal of self-reliance in their absorption with the individual, and emphasis on a "pure" process of creative invention. Additionally the Beats, particularly Allen Ginsberg, idolized Transcendental poet Walt Whitman, who gave to the Beats a tradition of poetry which celebrated uninhibited homosexuality, "and also a general proclivity towards what may be seen as "shocking" (Artifice). Romantic and Transcendental poetry also imbued the Beat Movement with a "romantic primitivism," or belief in the superiority of a simple way of life close to nature, as well as in the superiority of pre-industrial societies and peoples to those of the present," (80). This is often manifested in the Beat Generation's idealization of a transient lifestyle, such as in Jack Kerouac's "On the Road", which is said to have "romanticized hitchhiking and the American road to readers and travelers around the world," (Artifice).

Besides Romantic influence, the Beats' attraction to an idealized pre-industrial world is the result of the insurgence of Zen ideology. To some critics the "Zen Kick" was nothing more than a superficial trend for this egocentric group, claiming that Zen "gave a sense of intellectual, even religious justification to the

Beats' deep natural impulse to freedom, their wish to stay unattached and on the move" (94). While it is true that only a few Beat Artists stayed highly dedicated to Zen, one must differentiate between practice and influence, as Zen inarguably made great impact upon the philosophy of the Beats. One of the greatest manifestations of this was not in the content, but in the form of their poetry, as is especially clear in the "hybrid-mantic aesthetic," attributed to Ginsberg. (Pawlik 100).

One of the greatest influences on the form of Beat poetry was Surrealism, for As Joanna Pawlik explains in "Surrealism, Beat Literature and the San Francisco Renaissance" the appeal of surrealism is that it allowed for an alternative model to display "queertalk" or "hiptalk" (100), The Beats shared with the Surrealists the "quest for pure psychic automatic" and "unrevised composition" (99). Moreover, the Surreal aesthetic "bequeathed to American writers a fascination with mental derangement, destructiveness, and the darker recesses of the mind," (99) all major themes in Beat poetry. However, to many critics the Beats had an "unmistakable and at times lamentable" proximity to Surrealism (98), which lent it a "perceived capacity to either legitimate or corrupt New American Poetry" (98). The Beats themselves reeled from claims that they were reincarnating the Surrealist tradition, believing that the irrationality of the Surrealists was inadequately serious in a Post-War Era still reeling from Fascism and the atomic bomb (Pawlik 100-101), due to Surrealism's perceived connotations of artificiality, decadence and lack of restraint," (99). However, today's critics do not describe the Beats as initiating a new wave of Surrealism, but rather as applying 'surrealistic' features to their writing, for the purpose of incorrigibly intense reflection and examination of the self, (Pawlik 101). In the context of the Beats' move-

ment of dissent Surrealism functioned as a means for the ideal of freedom, and critique of conformist values to manifest itself in the form of their works.. Pawlik explains that, "a 'language of resistance' emerged through the combin[ation of] nonlinear representation, queer identity and Buddhist study and practice," (100) "provid[ing] [the Beats] with an... antilogic which perfectly suited their notion of what was sane behaviour". In effect, many view the Beats to be the initiators of the Post-Modernist Aesthetic: through their alternative form the Beats ushered in an attack on the hegemony of the New Critics and the idea of the text as a hegemonic form, thus fostering a flowering of post-structuralism (Pawlik 99; 104). The Beat Generation is argued to have encapsulated the transition between the Modern and the Post-Modern.

This act of rebellion against the hegemonic standard through borrowing from an earlier form parallels their approach to liberal ideology, as in repudiation of the McCarthyist culture of conformity, the Beats reshaped Old Left Ideology into the Leftist platform that flourished in the 1960's and is still recognizable today. Although not too many years earlier communism had been surprisingly widespread, after the second world war a hostility, and at best, cynical view of communism was ushered in through a war of ideology and influence, the Cold War (Harrison 104; Lee 373). While repressed by the sentiment of anti-liberalism and ensuing ant-intellectualism coursing throughout the country, many, including the Beats, were also heavily disillusioned, believing the Old Left politics of their parents' generation to be obsolete and unachievable in this post-war world (Lee 373). However, within much of Beat poetry gleams a nostalgia for the Old Left, as demonstrated prominently in Allen Ginsberg's Howl and Carl Solomon's "I Was a Communist Youth," (Lee

372-75). Ben Lee in "Howl and Other Poems: Is There Old Left In These New Beats?" contends that these "melancholic attachments to the Old Left generate even greater rhetorical energy" towards liberalism within the Beats poetry, "creat[ing] a temporal disjunction, calling up a past social identity at once buried under cynicism and exposed to justify it but which cannot be exposed without simultaneously underscoring a position of resistance both to that cynicism and to the post-Fordist, Cold War forces that produce it," (Lee 374). Their works, Ginsberg's especially, frequently manifest the desire to find a balance "'between the Scylla of Stalinism and the Charybdis of anti-Stalinism,'" (Lee 382). Coupled with a Zen infused proclivity towards non-violence, Lee contends that the Romanticist leanings of the Beats were also prominent in this reformation of liberalism, the conflation of all three movements visible for instance in the effect Ginsberg's Howl has of "tak[ing] the reader from the initial desolation of the industrial space, emptied out and militarized, to a Blakean vision of the blessed and beautiful form within all creatures," (Lee 378). The Beats gave to America a new liberal vision dominated by the Romantic idealization of a pre-industrialized world, a world which was without the bomb; believing that big industry and big science sponsored by a capitalist government was inherently linked to violence (Harrison 104). While the Beats themselves were not revolutionaries in their political action, they were revolutionary and rebellious in their creative acts, as evinced in their "war" against conformity which manifested itself through their post-modern form and the controversial content of their works. This method of rebellion reflected a more-pacifistic, Zen-inspired liberalism than their predecessors; and while they themselves took little political action, the Beat's rejection of the McCarthyist

ideologies and those that started the war provided a foreground for one of the most revolutionary eras of American history. Significantly the Beats initiated the notion of a cultural and ideological battle involving the mistaken old against the righteous young. The theme of the liberal movement as intimately connected to youth culture, was sourced from their glorification of the life free from the constraints of the dominant culture; the Beat's romanticization of self-sacrifice to one's beliefs in freedom of expression and resistance against conformity (Elteren 72), reverberated in the "sense of a fatal connection to youth martyrs, of death, [that] ran strong through all the phases of sixties' culture," (107). The Beats emphasis on the value of expression, particularly dissent, is demonstrated in their excoriation of the "quiet" generation who did not speak up against the violence of Fascist regimes or even the American government, and thus were partially to blame for the war, (Harrison 102-103); this stress on the value of speech continued in the vocal nature of the protests of the succeeding era.

The entire counter-culture of the Sixties, so well-known and to some degree celebrated today, is indebted to the Beats in general. Before the hippies' "Summers of sex, drugs, and rock and roll" the Beats made popular these aspects of counterculture in their desire to understand the limits of human experience and express themselves as truthfully as possible, as well as defy the main stream which denied them these expressions. Fascinatingly, in their quest to reject the culture of conformity they borrowed many of the cultural practices from the pre-existing counter-culture of Black Americans whom, in a form of romanticized racism, the Beats idealized as an idyllic pre-industrial group (Elteren 81). The Beats primary appropriations from Black culture were jazz and drug-use, predomi-

nantly marijuana; some critics even arguing that the Beats' popularization of marijuana use amongst White culture was "the Beats' "most enduring imprint on American culture,"" (Elteren 94). Although inarguably the Sixties as we know it would not have existed without a flourishing of drug-use by White middle class Americans, the Black musical tradition had a much more potent effect upon the shaping of the form of Beat poetry. Jazz became the Beat's music of choice, and the influence of the rhythm and style of Jazz is apparent in the works of the Beat poets. Moreover, the bluesy manner and concert-like setting in which Beat poetry was read emulate the predominantly African-American jazz scene. The opening up of jazz to White Middle Class America would consequently have a profound impact on the musical scene as well.

In the Beats' quest for expression also came a desire to open up about sexuality and to include topics of sexuality—considered taboo by the general public—in their creative works (The Beat Generation). While homosexuality dominated within the prime members of the Beat Generation, sex in general was one of the major themes within their poetry (Artifice). While homosexuality became less important of a topic to the hippies of the Sixties, the Beats' influence upon their idealization of sexual expression and what came to be known as "free love" was clearly powerful.

The Beats efficacious mainstreaming of the counter-culture world of jazz, drugs, and sex helped issue forth the emerging genre of Rock music, the effects of Beat influence especially poignant in the musical icons of Elvis Presley and Bob Dylan. Dylan is sometimes considered a "Beat" himself; Ginsberg is said to have wept while exalting that Dylan was carrying on the Beat Movement through capturing the Beat ideals, giving them to a new generation through his poetic

music.

The Beats passed on to the Sixties much, including their ideology, the Sixties appropriating their dabblings in Zen, transcendentalism, their romantic outlook on the pre-industrial world coupled with a nostalgia for the Old Left, and the Beats' desire for total freedom in expression which itself resulted in the explosion of post-modernism that is yet upon us. The Beat movement exemplified the most potent form of protest against post-war conservatism and homogeneity: they made counter-culture cool. Our world—artistically, culturally, and ideologically—would not be the same without the Beats, their views and aesthetic merging into the common, so that by diffusion, the movement spread to much of American and world culture...and so the beat goes on.

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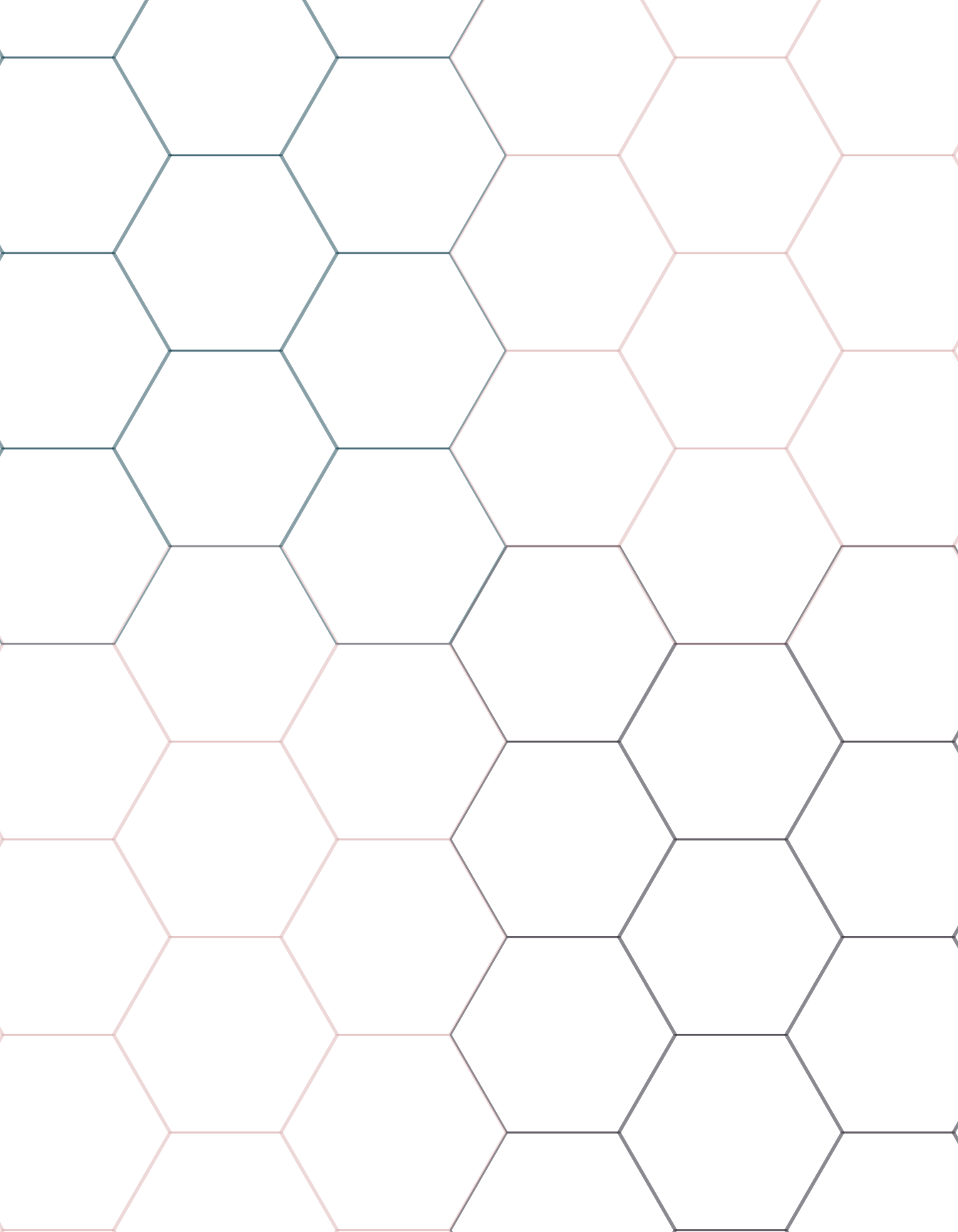
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The Aerodynamic Effects of Dimples on Fuselage of an Aircraft

Abstract

Modern society is characterized by its mobility and connectivity, both of which have been facilitated by modern aviation. Not only do aircraft provide transportation to millions of people across the entire world, but they are also used in transporting valuable goods, which contributes significantly to the world economy. Modern jet-aircraft suffer from parasite drag, however, which directly contributes to reduced fuel efficiency and increased operating costs.

The purpose of this study is to analyze the aerodynamic effects of dimples on the fuselage of an aircraft in an effort to reduce the total parasitic drag. Due to the large surface area of the fuselage, it contributes considerably to the overall drag of the aircraft. Previous studies have shown that dimples can reduce the overall drag of a body significantly; however, there have been no applications of dimples to an aircraft fuselage.

By modeling an aircraft fuselage using a 3-D CAD program, a CFD (Computational Fluid Dynamics) analysis can be conducted to select an ideal dimpling pattern that results in the largest drag reduction. Using a 3-D printer, two aircraft models will be made: one without dimples and a second one with dimples. These two models will be subjected to a wind tunnel test to determine the coefficients of drag, lift, and pitching moment. Comparing the data from the two models would reveal if the dimpling caused any drag reduction.

Objectives

Given the potential of significant increases in fuel efficiency, the purpose of this wind tunnel study is to analyze the effects of adding dimples to the aircraft

fuselage with the purpose of reducing the overall skin friction drag.

Background

To some people, golf seems like a dreary, boring sport, but in terms of the aerodynamics involved, particularly the aerodynamics of the golf ball, a very interesting phenomenon occurs. Common sense and reasoning both lead us to believe that a smooth surface is more aerodynamic than a rough surface, which is true as long as the flow is laminar. Realistically, though, it is impossible (with current technology) to maintain laminar flow along the entirety of a surface. At some location along the surface, the boundary layer begins to transition from laminar to turbulent flow as a result of the air viscosity and the microscopic roughness of even the smoothest surface. This onset of turbulent flow creates an area of low pressure, generating parasitic skin friction drag. The result of this drag, in terms of golf, is reduced ball velocity, range, and accuracy. By adding dimples, however, as seen on a typical golf ball, the transition to turbulent flow occurs earlier and keeps the flow attached to the surface longer, generating a smaller low-pressure wake (Scott, 2005). As a result, the ball can travel much further with higher velocity and accuracy. Applications of this principle to aviation in an attempt to reduce drag have proven beneficial as can be seen with the use of vortex generators, such as attaching blades to the wings. As of yet though, dimples have not been incorporated into the fuselage which might have a beneficial effect in reducing the overall aircraft drag.

Literature Review

Research on the aerodynamic effects of dimples on aircraft is relatively scarce and mainly focuses on the application of dimples on the wings. Studies tailored specifically to aircraft fuselage dimpling are virtually nonexistent. In a 2012 study by Deepanshu Srivastav titled "Flow Control over Airfoils using Different Shaped Dimples," it was shown that an airfoil with inward dimples had a smaller coefficient of drag than a conventional airfoil, as seen in Figure 2 (Srivastav, 2012).

This study was purely theoretical, however, and no experiment was actually conducted; all the results were obtained by using CFD analysis. Also, Srivastav only analyzed a small section of the wing with only one dimple. More recently, a group of aerospace engineering students at Cal Poly Pomona expanded upon

Srivastav's research, theoretically and experimentally studying a model wing with a linear dimpling pattern along the leading edge. Titled "Passive Flow Control on an Airfoil by Use of Various Dimples," the students, led by team leader Simon Abdou under the mentorship of Dr. Ali Ahmadi, discovered that the dimples increased the stall angle by 2 degrees and resulted in a drag reduction of 30% at a Reynolds number of 300,000; 20% at Re of 500,000, and 10% at 700,000 (Abdou et al, 2013). Another discovery was that variations in the diameter of the dimple, be it 1% or 2% of the chord, had no noticeable effect. Additionally, it was discovered that the coefficient of lift was also reduced at all speeds (Abdou et al, 2013). Although the reduction in the coefficient of lift would deter application of dimples on airfoils, it should have no effect on the fuselage since the fuselage is not generally used to generate lift.

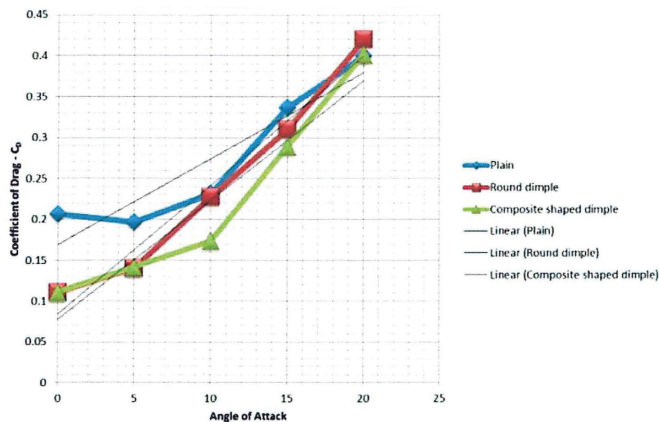


Figure 2: Lift Coefficient vs. Angle of Attack and Drag Coefficient vs. Angle of Attack

Method

Sample

This study will analyze the aerodynamic effects of dimples on the fuselage of a Boeing 787 Dreamliner using a 3-D printed subscale model. Although the aerodynamics being studied are somewhat independent of the specific aircraft as long as the geometries of the planes are similar, the Dreamliner was chosen due to the large amount of information available and due to its composite construction. From a manufacturing point-of-view, it is much easier to add dimples to a graphite epoxy structure when compared to an aluminum structure. Even though the manufacturing and application process of dimples is irrelevant for this study, it would be more realistic, and therefore more applicable, to conduct the experiment on the ideal aircraft.



Figure 3: 3-D CAD Model of Un-dimpled 787 Fuselage

Materials and Equipment:

- Cal Poly Pomona Subsonic Wind Tunnel
- Wind tunnel data collection computer
- 3-D printer
- 2 subscale Boeing 787 models
- CFD program (AutoDesk CFD, SolidWorks CFD, or Ansys CFD depending on availability)
- 3-D CAD program (AutoDesk Inventor or SolidWorks depending on program availability)
- Microsoft Office (Excel, Word)

Procedure

In preparation for the experiment, a Boeing 787 will be modeled using a 3-D CAD program and its aerodynamic properties analyzed using a CFD program. By analyzing the flow around the fuselage, the most suitable dimpling pattern will be determined—adding dimples to entirety of fuselage or to the tail section only. In order to conduct the physical experiment, two different subscale models of the Boeing 787 will be 3-D printed; one will have a normal fuselage and the other will have a dimpled fuselage. First, a control will be established by measuring the lift, drag, and pitching moment of the un-dimpled 787 using the subsonic wind tunnel. These measurements will be taken at different angles of attack, ranging from 0 degrees to ± 14 degrees at a velocity of 50 ft/s, 100 ft/s, and 200 ft/s. The same measurements will then be examined for the dimpled 787 under the same conditions and the results compared.

Results

In order to study the effects of the dimples on the fuselage, a wind tunnel test will have to be conducted. However, as a prerequisite to the wind tunnel test, CFD testing was used to understand how the dimples affect the airflow. Figures 3 and 4 show the geometry and mesh of the un-dimpled fuselage that were used in ANSYS Fluent.

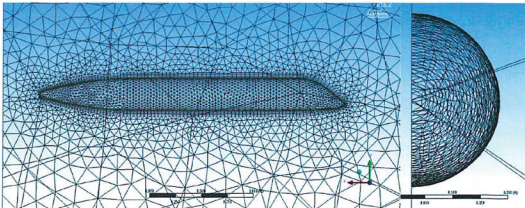


Figure 4: Un-dimpled Fuselage Mesh

In an effort to match a transport jet’s typical operating environment during cruise, the CFD analysis was conducted at zero degrees angle of attack at a velocity of 250 mis (~550 mph). This condition was used for both models in order to have a valid comparison. The results of the CFD test for the un-dimpled fuselage are tabulated below:

Coefficient	Value
C_D	0.11397
C_L	-0.016325
C_M	0.027063

Table 1: Un-dimpled Fuselage CFD Results

The dimpling pattern selected was a series of rows of dimples on the bottom half of the fuselage near the tail section. This pattern was selected because the tail is the most susceptible to flow separation, and therefore, is where the dimples should provide the most benefit. The dimpled fuselage geometry and mesh can be seen in Figures 5 through 8 below.



Figure 5: 3-D CAD Model of Dimpled Fuselage

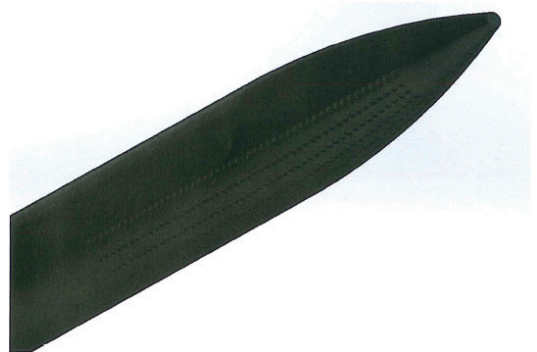


Figure 6: Dimple Pattern

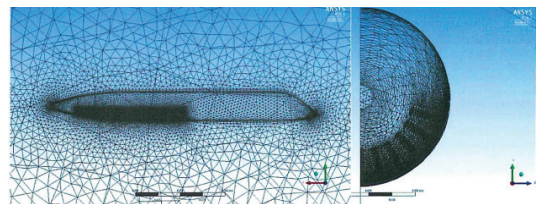


Figure 7: Dimpled Fuselage Mesh

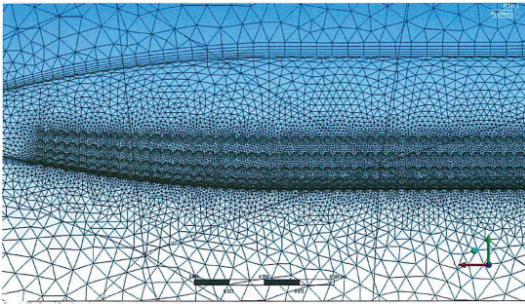


Figure 8: Dimple Pattern Mesh

The results for the dimpled CFD analysis are tabulated below:

Coefficient	Value
C_D	0.15733
C_L	-0.0065
C_M	0.027195

Table 2: Dimpled Fuselage CFD Results

To better understand how the airflow is interacting with the dimples, the contours of vorticity magnitude were generated, as shown in Figures 9 and 10.

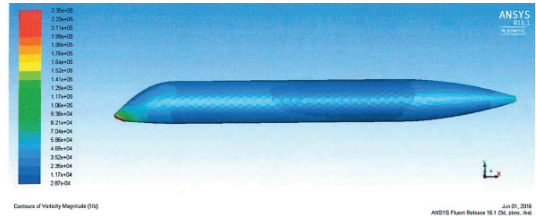


Figure 9: Vorticity Magnitude of the Un-dimpled Fuselage

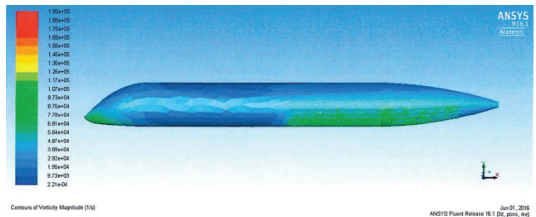


Figure 10: Vorticity Magnitude of Dimpled Fuselage

Discussion

By comparing the two results, it is clear that the dimples are not beneficial, and are ineffective at decreasing the total drag. Rather than decreasing the drag, the dimples actually caused the total drag to increase by over 30%. The magnitude of the total lift was decreased by 60%, while the total moment remained approximately constant. In regards to the changes in the lift coefficient, since the fuselage is generally not a lifting body and the magnitude of the lift coefficient is so small, the effects on the lift can be neglected. Also, since the moment coefficient is unchanged, then it can be neglected as well. However, due to the significant increase in drag, approximately 30%, it is clear that

the dimples are not beneficial. As can be seen in the Vorticity Magnitude Contours, Figures 9 and 10, the dimples are generating a large amount of vorticity in a region that would have otherwise had little vorticity. In other words, the dimples are creating turbulence in an area that does not suffer from flow separation. Although this dimpling pattern resulted in adverse effects, refining the dimpling pattern might improve their performance. Based on these results, the wind tunnel testing will be postponed until a more effective dimpling pattern is found.

Future Work

In order to proceed with the wind tunnel testing, further CFD testing is required to find a more suitable dimpling pattern. This will be accomplished by analyzing the flow around the undimpled fuselage more closely at a variety of conditions. By doing this, the dimpling pattern will be refined, both in regards to placement and density, until it shows a reduction in the total drag. With this new dimpling pattern, the two models will be 3-D printed, and wind tunnel tested.

Appendix

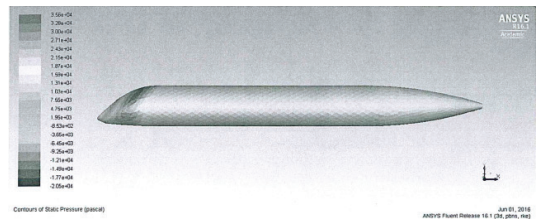


Figure 11: Coefficient of Pressure of Un-dimpled fuselage

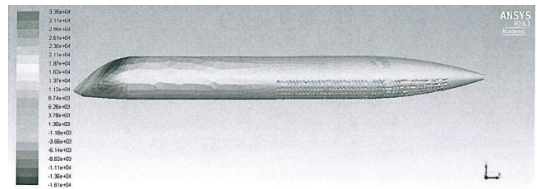


Figure 12: Coefficient of Pressure of Dimpled Fuselage

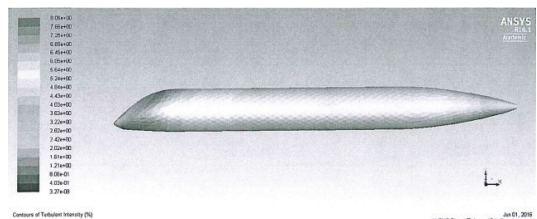


Figure 13: Turbulence Intensity Contour of Un-dimpled Fuselage

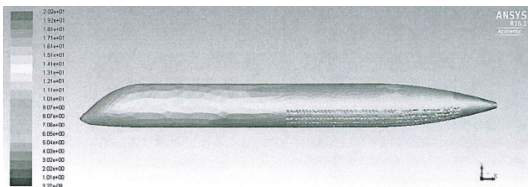


Figure 14: Turbulence Intensity Contour of Dimpled Fuselage

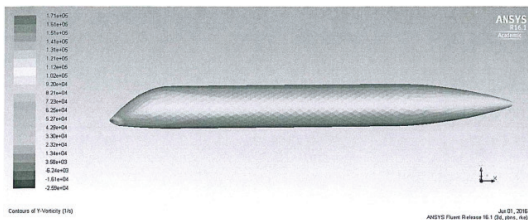


Figure 15: Y-Vorticity Contour of Un-dimpled Fuselage

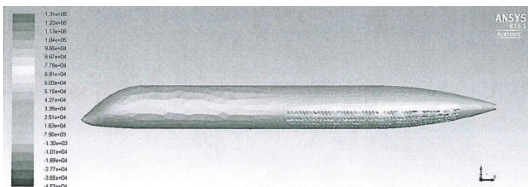
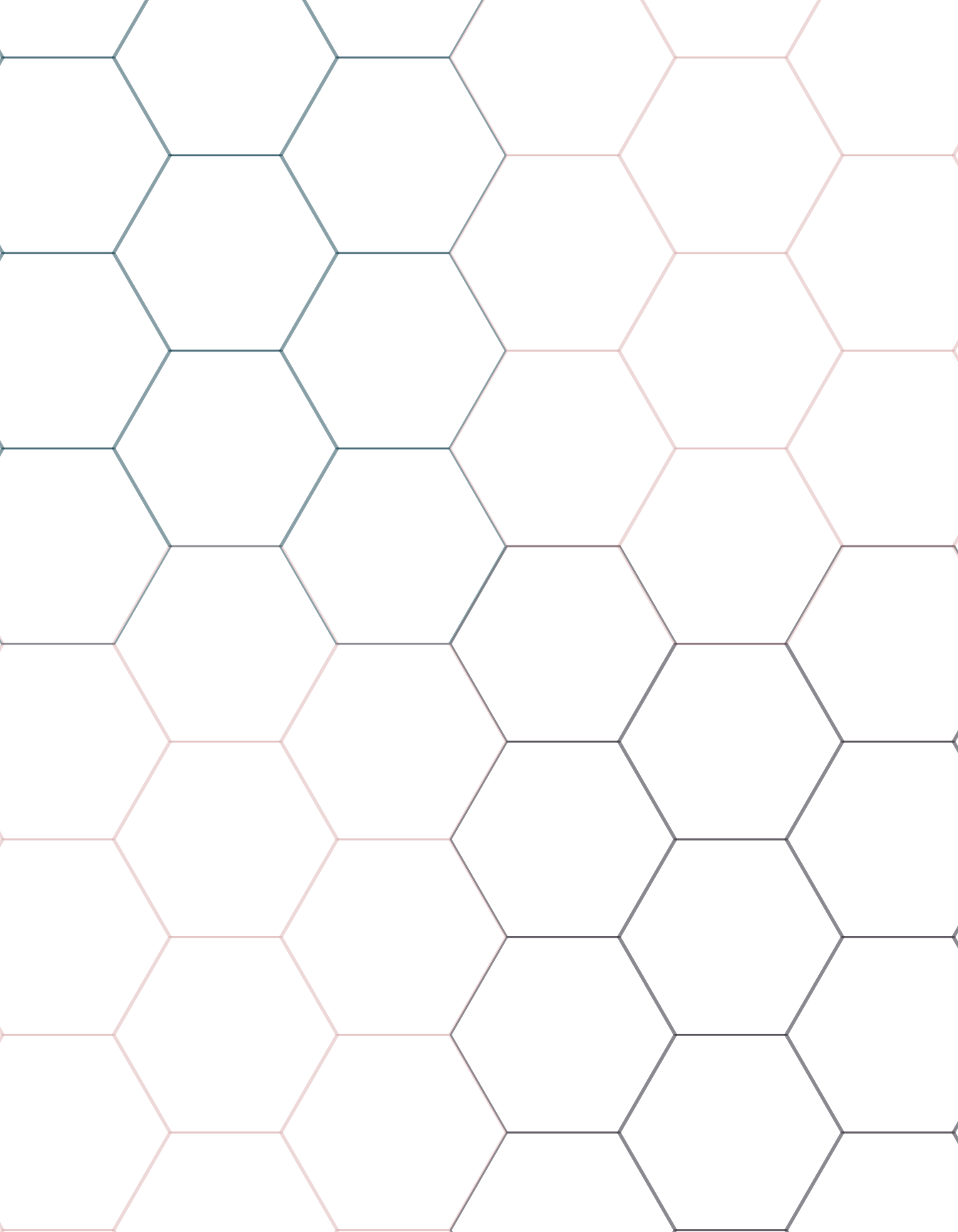


Figure 16: Y-Vorticity Contour of Dimpled Fuselage

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Identification of DNA Transposable Elements in the Tasmanian Devil (*Sarcophilus harrisi*) genome

Abstract

The Tasmanian devil (*Sarcophilus harrisi*) is a carnivorous marsupial residing in Tasmania. Its population is being driven to extinction by a transmissible cancer, devil facial tumor disease (DFTD), which has already caused a decline in the population by 60% since 1996 [4]. Very few transmissible cancers have been identified and include a non-fatal cancer in canines. By comparison DFTD is nearly 100% fatal [5]. As a result of their diminishing population, Tasmanian devils were classified as an endangered species in 2009 by the IUCN (International Union for Conservation of Nature). Efforts to repopulate Tasmanian devils are underway with a captive breeding program (Conservation Society of Australia). The possibilities of developing a vaccine may not be unreasonable because DFTD cells are genetically identical [4].

In order to understand DFTD, the genome of the Tasmanian devil (which has been sequenced and data are publicly available) needs to be better examined. Cancer may be associated with transposable elements [1]. Mobility of these DNA sequences may be associated with the development of cancers in human cell lines. Identification of transposable elements within the Tasmanian devil genome could be a step towards understanding of the causes DFTD and perhaps help save this species.

Objectives

The objective of this project is to identify potential DNA transposable element sequences in the Tasmanian devil genome using bioinformatic tools. In an effort to identify a wide range of possible elements with good accuracy the similarity of candidate

sequences to known transposable element sequences will be measured using the BLAST algorithm and evaluate parameters: 5E-2, 5E-4, and 5E-6.

Introduction

Transposable elements (TEs) are mobile segments of DNA that can transpose and invade genomes. The majority of TEs can be classified into two classes -Class I and Class II. These mobile segments of DNA make up a large percentage of mammalian genomes. Retrotransposons (Class I) move via an RNA intermediate while DNA transposons (Class II) move by a cut-and-paste mechanism directly from DNA to DNA. The staggered cut that is made at the target site, the site where the TE inserts into, creates a characteristic sequence duplication on either side of the newly inserted TE and are called Target Site Duplications (TSDs). In addition to TSDs, most class II TEs are also flanked by similar sequences but in reverse orientations, these are the Terminal Inverted Repeats (TIRs) [6]. The combination of TSDs and TIRs sequences may be used, in part, to identify the presence of a novel TE.

Even though TEs make up a large percentage of many genomes (approximately 45% of the human genome, [3]), they were in the past considered to be junk DNA. TEs have also been viewed as selfish genomic sequences, they do not function for the benefit of the host genome but rather for the replication and propagation of the TE within the genome [5]. TEs have the potential of contributing to the loss of genomic DNA by deleting or shifting segments of the genome.

Transposable elements can also transpose between different organisms -this is known as horizontal transfer. Though it is uncommon to observe, horizontal transfer is possible via vectors such as

external parasites. The method in which these TEs can be detected is by the sequence similarity of the TEs between the different taxa that are thought to have obtained the potential TE through horizontal transfer [8]. If the distribution of the TE does not follow known host phylogenetic patterns a case for horizontal transfer may be made.

Transposable elements may also be associated with diseases and cancers. Tumor cell environments favor the mobility of TEs in human genomes [1]. This may become particularly relevant when examining the causes of devil facial tumor disease (DFTD), a transmissible cancer affecting the Tasmanian devil population. Identification of TEs within the genome of the Tasmanian devil may provide some clues to a potential explanation of DFTD's origin.

Methods

The recently sequenced Tasmanian devil genome was searched using a variety of bioinformatics tools to generate three lists of possible transposable elements based on three different E-value parameters, 5E-2, 5E-4, and 5E-6. These three lists were generated using the following analysis pipeline. First, the genome was examined by the program RepeatModeler, a bioinformatics tool used to screen for low complexity DNA sequences and repeats, including TEs. The program produced a list of possible sequences for the Tasmanian devil. Second, the RepeatModeler output sequences were compared to the mammalian Repbase database, a database of published transposable elements, by using BLAST (Basic Local Alignment Search Tool) to produce a results table. Third, the BLAST results table was parsed by filtering out results with e-values higher 5E-2, 5E-4, and 5E-6 to create three

different lists. Finally, a previously published list of possible transposable elements (referred to below as the "Gallus elements") [2] was added to each list. The purpose behind the addition of the Gallus elements was to include previously identified TEs in the Tasmanian devil as well as to subject them to the same parameters as the ones that were produced by RepeatModeler.

RepeatMasker, another bioinformatics tool, was used to identify the location of the three list elements in the genome. The location information allowed sequences to be eliminated if they were found in very low copy number. Potential TE sequences were parsed based on length characteristics. Sequences that were less than 150 base pairs were eliminated immediately since transposable elements of that length were too short to be viable candidates. Sequences between 1,000 base pairs -2,500 base pairs were of greater interest as they could potentially be intact transposable elements but sequences less than that threshold were analyzed since they could be partial TE sequences.

The remaining sequences were then compared to the Repbase mammalian database by using BLAST. If the sequences did not have significant sequence alignment scores when aligned to known TEs, they were eliminated from the list of potential TEs. The sequences remaining from the parsing pipeline were then scored to determine the likelihood of being possible TEs by using BLAST to compare the sequences to the BLAST non-redundant database, a database of published sequences that does not contain simple repeats. The possible elements were summarized in a table (see Appendix) for each e-value parameter run.

Results

The genome of the Tasmanian devil was an-

alyzed three times, each time with a lower e-value parameter (5E-2, 5E-4, and 5E-6) to increase the accuracy of the list. The three lists were an attempt to find the right balance between accuracy and while capturing as many TE sequences as possible. The resulting tables of potential TEs included their location within the genome, the sequence it was most significantly similar to from the non-redundant BLAST database, and the transposable element it was most similar to from the Repbase database.

As three-value were lowered, each analysis produced fewer TE. Each successive run included elements from the previous run, as was expected, the ones being eliminated were parsed out due to the lower e-value parameter being used, as lowering the e-value outputs more significant results. This means that the likelihood of the element being due to random chance was lowered with each run.

While each run produced different amounts of possible transposable elements, the elements that were of significant interest remained the same. They needed to appear across the three lists, this included results from the RepeatModeler analysis as well as some of the sequences identified by Gallus et. al. (2015). From the seven transposable element groups that Gallus et. al. identified, three of the elements, hAT-I_MEu_Sh, Mariner I_MD_Sh and Mariner3_MD_Sh, were considered likely transposable elements at the end of this analysis. The remaining elements from the Gallus list, Charliel_Sh, Charlielb_Sh, and Charlie24_Sh, all exhibited properties of existing transposable elements but they were eliminated as a result of the non-redundant sequences they shared significant similarities to. They were identified as false positives when it came to their significant matches.

Discussion

An example of how elements were eliminated can be seen with the following element from the Gallus et al. (2015) list, Charlie24_Sh was eliminated as a possible element. It matched a known TE in the Repbase database but when aligned to the NR database, its most significant hit was an MHC class I antigen from *Crocodylus porosus*. Even though at first glance it would appear that Charlie24_Sh was a possible TE, the Tasmanian devil genome has low complexity regions of MHC class I antigens at the genomic level [7] -the significant hit against a *Crocodylus porosus* MHC class I antigen sequence is a likely explanation for this occurrence.

A possible case of horizontal transfer was observed in the case of Rnd-6_family1913_Sh. Horizontal transfer occurs when genetic material is moved between species. At first glance, this TE is significant when compared to hA T-I_MEu from the Repbase database but could be written off since when compared to the NR database, the most significant hit was a *Macropus eugenii* sequence. This would be true if the possibility horizontal transfer of a TE was neglected. Rnd-6_family-1913_Sh has a strong case for being a horizontal transfer between the two marsupial species and needs to be looked at in more detail in future research.

Rnd-5_family-400_Sh provided an interesting analysis. Even though it was a significant hit for MamRep434 from the Repbase database, it did not have any significant hits that were of interest when it came to the BLAST NR database. After looking at the RepeatMasker database, it was discovered that MamRep434 is found in marsupials and eutheria. This sparks the possibility of Rnd-5_family-400-Sh being a possible

transposable element candidate.

Mariner1_MD_Sh and Mariner3_MD_Sh both are significant since they both appeared in the three runs as well as were most significant to marsupial genomes when run against the NR database. Mariner1_MD_Sh was significant when compared to a Tasmanian devil mRNA sequence while Mariner3_MD_Sh is significant when compared to a *Monodelphis domestica* mRNA. These potential elements exhibit two traits of interest -they are both in marsupial genomes and are similar to mRNA sequences. The possible implications of having an active transposable element within a mRNA sequence allow for the possibility of the transposition of the element and altering the sequence altogether. This would likely result in a change to the protein it would express.

The majority of transposable elements sequences that remained at the end of the individual runs were either similar to *Homo sapiens* sequences or marsupial sequences. *Homo sapiens* sequence displayed similarities to known repeat regions as well as regions that had already been identified as transposable elements (e.g. md-4_family-65_Sh and its similarities to Charlie!, a known transposable element). This provided evidence that supported the sequences being produced by RepeatModeler as well as the sequences that Gallus et. al. (2015) had identified. With regard to the remaining sequences, the similarities to marsupial sequences were not surprising but should be further looked into. These similar repeat regions that were identified could be evolutionary impacting transposable elements. This could explain the consistency in having them appear in three different marsupial species, including the Tasmanian devil.

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Possible Sequence 5E-2	Sequence (NR DB)	TE (Repbase DB)
hAT-1_MEu GL857385.1:25267-27967	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
hAT-1_MEu GL841583.1:1253353-1255170	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
hAT-1_MEu GL849899.1:2802924-2804336	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
Mariner1_MD_Sh IGL841415.1:1059590-1062443	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner1_MD_Sh IGL861556.1:55743-56962	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner1_MD_Sh IGL841382.1:945142-946543	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner3_MD_Sh IGL849640.1:1031876-1034007	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
Mariner3_MD_Sh IGL849723.1:45280-47390	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
Mariner3_MD_Sh IGL856753.1:982150-984381	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
rnd-4_family-509_Sh IGL834618.1:21060-21311	<i>S_harrisii_seq</i>	hAT-1_MEu
rnd-4_family-509_Sh IGL834709.1:1483307-1483551	<i>S_harrisii_seq</i>	hAT-1_MEu
rnd-4_family-509_Sh IGL861689.1:755668-755913	<i>S_harrisii_seq</i>	hAT-1_MEu
rnd-4_family-65_Sh IGL841144.1:793341-793834	<i>Homo_sapiens_seq</i>	Charlie1
rnd-4_family-65_Sh IGL841412.1:832752-833246	<i>Homo_sapiens_seq</i>	Charlie1
rnd-4_family-65_Sh IGL867365.1:8303-8808	<i>Homo_sapiens_seq</i>	Charlie1
rnd-4_family-892_Sh IGL849127.1:2121-2321	<i>Macropus_eugenii_seq</i>	Mariner1_MD
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rnd-5_family-1563_Sh IGL841349.1:734188-736320	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL841396.1:1087623-1089717	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL849905.1:4293776-4295573	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-400_Sh IGL834477.1:3787155-3787574	No Significant Similarities	MamRep434
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rnd-5_family-400_Sh IGL841485.1:2116951-2117340	No Significant Similarities	MamRep434
rnd-5_family-443_Sh IGL834464.1:1523097-1523519	<i>Macropus_eugenii_seq</i>	Charlie1
rnd-5_family-443_Sh IGL867572.1:158687-159098	<i>Macropus_eugenii_seq</i>	Charlie1
rnd-5_family-443_Sh IGL867601.1:1532995-1533420	<i>Monodelphis_domestica_ncRNA</i>	Charlie1
rnd-5_family-58_Sh IGL834528.1:380846-381246	<i>Monodelphis_domestica_mRNA</i>	Charlie_family
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rnd-6_family-1913_Sh IGL834728.1:666326-667489_Sh	<i>Homo_sapiens_seq</i>	Cheshire-2_MD
rnd-6_family-1913_Sh IGL850633.1:143233-144400_Sh	<i>Homo_sapiens_seq</i>	Cheshire-2_MD
rnd-6_family-1913_Sh IGL856764.1:827446-828641_Sh	<i>Homo_sapiens_seq</i>	Cheshire-2_MD
rnd-6_family-332_Sh IGL841279.1:2021537-2022164_Sh	<i>Homo_sapiens_repeatregion</i>	Charlie7
rnd-6_family-332_Sh IGL849713.1:430547-431178	<i>Homo_sapiens_repeatregion</i>	Charlie7
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rnd-6_family-691_Sh IGL841349.1:941144-941403	<i>Homo_sapiens_clone</i>	Charlie1
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rnd-6_family-691_Sh IGL861628.1:72167-72419	<i>Homo_sapiens_clone</i>	Charlie1

Table 1. Transposable Elements 5E-2 run

A Summary of the transposable elements results from 5E-2 run. Bolded elements are *Gallus* elements and non-bolded elements are RepeatModeler elements.

Possible Sequence 5E-4	Sequence (NR DB)	TE (Repbase DB)
hAT-1_MEu GL857385.1:25267-27967	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
hAT-1_MEu GL841583.1:1253353-1255170	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
hAT-1_MEu GL849899.1:2802924-2804336	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
Mariner1_MD_Sh IGL841415.1:1059590-1062443	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner1_MD_Sh IGL861556.1:55743-56962	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner1_MD_Sh IGL841382.1:945142-946543	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner3_MD_Sh IGL849640.1:1031876-1034007	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
Mariner3_MD_Sh IGL849723.1:45280-47390	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
Mariner3_MD_Sh IGL856753.1:982150-984381	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
rnd-4_family-65_Sh IGL867365.1:8303-8808	<i>Homo_sapiens_chromosome16</i>	Charlie1
rnd-4_family-65_Sh IGL841412.1:832752-833246	<i>Homo_sapiens_chromosome16</i>	Charlie1
rnd-4_family-509_Sh IGL834618.1:21060-21311	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-4_family-509_Sh IGL861689.1:755668-755913	<i>S_harrisii_mRNA</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL841396.1:1087623-1089717	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL841254.1:722989-724692	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL849730.1:7364-8989	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-6_family-1913_Sh IGL850633.1:143233-144400	<i>Homo_sapiens_chromosome7</i>	CHESHIRE-2_MD
rnd-6_family-1913_Sh IGL834728.1:666326-667489	<i>Homo_sapiens_chromosome7</i>	CHESHIRE-2_MD
rnd-6_family-1913_Sh IGL856764.1:827446-828641	<i>Homo_sapiens_chromosome7</i>	CHESHIRE-2_MD

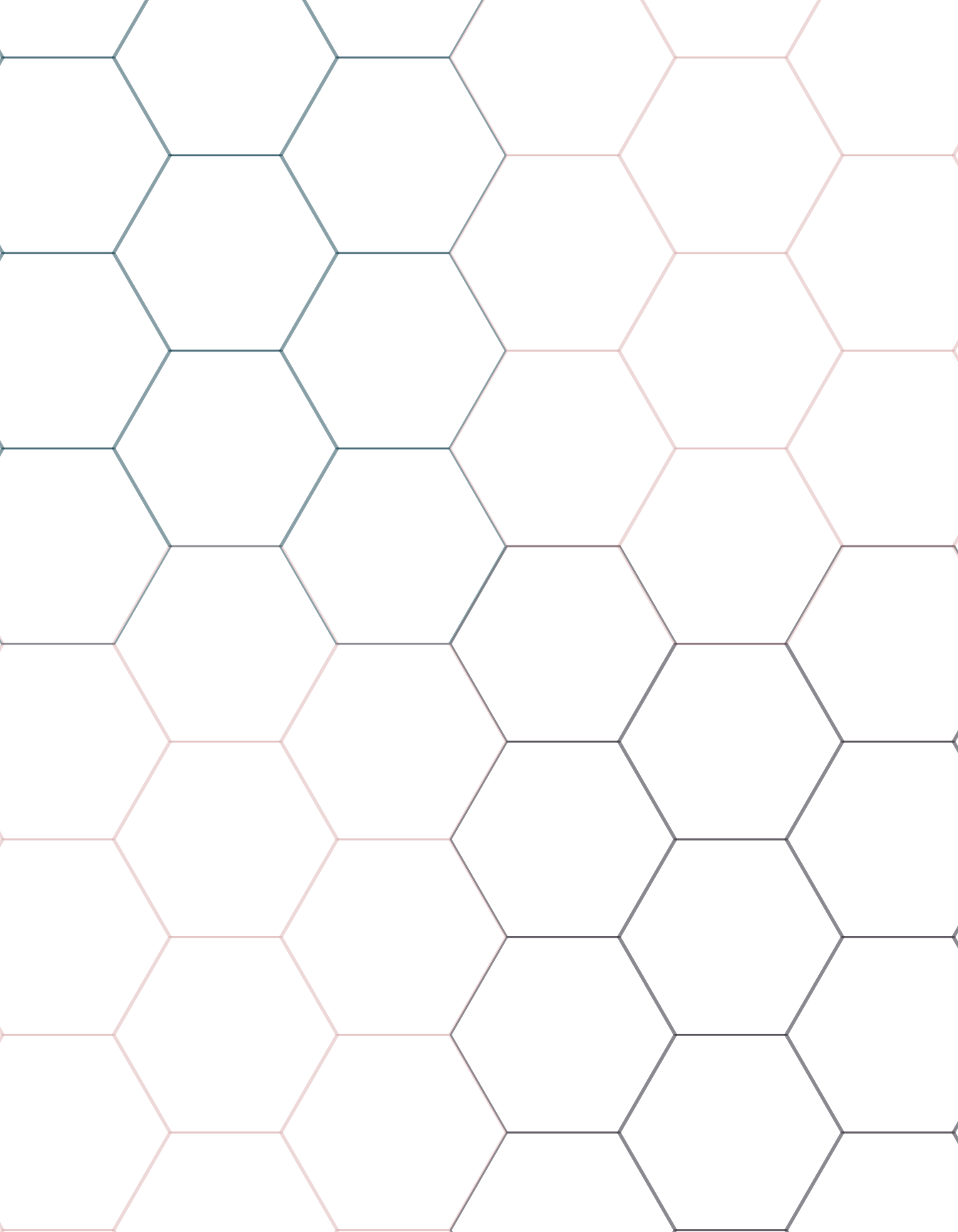
Table 2. Transposable Elements 5E-4 run

A Summary of the transposable elements results from 5E-4 run. Bolded elements are Gallus elements and non-bolded elements are RepeatModeler elements.

Possible Sequence 5E-6	Sequence (NR DB)	TE (Repbse DB)
hAT-1_MEu IGL857385.1:25267-27967	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
hAT-1_MEu IGL841583.1:1253353-1255170	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
hAT-1_MEu IGL849899.1:2802924-2804336	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
Mariner1_MD_Sh IGL841415.1:1059590-1062443	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner1_MD_Sh IGL861556.1:55743-56962	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner1_MD_Sh IGL841382.1:945142-946543	<i>S_harrisii_mRNA</i>	Mariner1_MD
Mariner3_MD_Sh IGL849640.1:1031876-1034007	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
Mariner3_MD_Sh IGL849723.1:45280-47390	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
Mariner3_MD_Sh IGL856753.1:982150-984381	<i>Monodelphis_domestica_mRNA</i>	Mariner3_MD
rnd-4_family-65_Sh IGL867365.1:8303-8808	<i>Homo_sapiens_chromosome16</i>	Charlie1
rnd-4_family-65_Sh IGL841412.1:832752-833246	<i>Homo_sapiens_chromosome16</i>	Charlie1
rnd-5_family-1563_Sh IGL841396.1:1087623-1089717	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL841254.1:722989-724692	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-5_family-1563_Sh IGL849730.1:7364-8989	<i>Macropus_eugenii_seq</i>	hAT-1_MEu
rnd-6_family-1913_Sh IGL850633.1:143233-144400	<i>Homo_sapiens_chromosome7</i>	CHESHIRE-2_MD
rnd-6_family-1913_Sh IGL834728.1:666326-667489	<i>Homo_sapiens_chromosome7</i>	CHESHIRE-2_MD
rnd-6_family-1913_Sh IGL856764.1:827446-828641	<i>Homo_sapiens_chromosome7</i>	CHESHIRE-2_MD

Table 3. Transposable Elements 5E-6 run

A Summary of the transposable elements results from 5E-2 run. Bolded elements are Gallus elements and non-bolded elements are RepeatModeler elements.



Bernice Monarrez An Integrative Outlook on Bum Survivors and Posttraumatic Growth

Dr. J. Fong

*McNair Scholar

Abstract

In 2015, the National Fire Protection Association issued a report that revealed how every 2 hours and 41 minutes a civilian fire death occurs. Civilian fire injuries occur every 33 minutes nationwide and 1,298,000 fires in the U.S were reported in 2014. Every year the community of bum survivors is increasing and those survivors after physically healing must learn to cope with a new reality. This research explores the community of bum survivors. Most of the current written literature focuses on PTSD after a bum injury or as educating material for bum injury specialist. Neglected by the social sciences, the community of bum survivors can help us understand why many develop an enthusiastic approach to life in spite of their experiences. The data, currently in the process of being collected, will help answer how burn survivors transcend the title of a victim and embrace the label of survivor, allowing them to experience posttraumatic growth. By employing a qualitative research method based on content analyses of in-depth focus group interviews, phone interviews, along with analyses of online forums that attend to bum survivors and their narratives, this study aims to answer a key question: What coping mechanisms allow burn survivors to overcome adversity, especially if they've encountered body disfigurement, amputations and ample scar tissues as a result of their experiences.

Major objective(s)

To highlight key existential themes that deal with the coping mechanism, outlooks on life, spirituality and the transcendent experiences that burn survivors go through in order to maintain an enriched meaningful life.

Background research with analysis and summary of literature review:

Although a rich literature base exists on the topic of posttraumatic growth, through classics such as Tedeschi and Calhoun's *The Posttraumatic Inventory: Measuring the Positive Legacy of Trauma* (1996) and Shaw, Joseph & Linley's *Religion, Spirituality and Posttraumatic Growth* (2005). The majority of them focus on posttraumatic stress disorder while literature does include research on posttraumatic growth like in case of cancer survivors, war veterans, and people living with serious medical conditions such as HIV/AIDS, burn survivors have had little representation in relation to posttraumatic growth. *A comparison of posttraumatic stress disorder between combat casualties and civilians treated at a military burn center* (2009). This research included the study of children and adult cancer survivors with PTSD, *Post-traumatic stress disorder in cancer: a review* (1999). Other literature focuses on the medical aspect of burns and its treatment and the readings are meant for physicians and burns nurse specialist. For example *Chronic Persistent Pain After Severe Burns: A Survey of 358 Burn Survivors.* *Pain Medicine* (2002), this research focuses on the characteristics and the effects of ongoing pain of a burn injury to determine the prevalence of this community. *Military and civilian burn injuries during armed conflicts* (2007) is one example from the various research that exist on burn survivors in the military. Military burn survivors are the most explored and are viewed in a heroic way by many including the media and the government for the most obvious reason that these burn survivors suffered their injuries as a result of serving in the military.

A Qualitative Exploration of the Experiences of Adult thermal Burn Survivors: The Navigation

Toward Recovery and Health (2013) addresses the experience of being a burn survivor in the midwestern regions of the United States by including the views of young and middle adults, using the resilience theory. My research will use snowball sampling. I intend to use the sociological perspective of symbolic interaction in comparison to the aforementioned research which has used resilience theory and it included eight total participants, seven of them being male and only one female and all were caucasian. The sample size did not include other participants with ethnic variations and having only one woman participant, did not represent other woman burn survivors.

The gap lies in the literature that explores burn survivors and their post-traumatic growth, their outlooks on life and their transcending journey to become a survivor and not a victim. Some literature like *Post-traumatic Growth and Spirituality in Burn Recovery* (2009) and *Restoring the Self: An Exploration of Young Burn Survivors' Narratives of Resilience* (2011) captures the positive emotions and experiences of burn survivors. With the increase of burn injuries per year in the U.S., recent or past burn survivors will understand that there is an optimistic approach to life after a traumatic burn injury and that there is research that demonstrates that fellow burn survivors have had positive attitudes towards life. My research will build on existing writings on the resilient character of burn survivors by including a represented sample of female and male participants from different ethnical background who will share their narrative perspectives on life from a survivor's perspective.

Please describe progress made this period towards your project's stated goals and objectives: (This section is a summary of what you have found out in your

experiment so far. Your data/result and discussion should be included here):

My recent IRB approval has made it possible for the consent forms to be sent out to participants, I will begin the interview process in two weeks during this time I will also be provided with a list of about 25 burn survivors who wish to be interviewed from the Alisa Ann Ruch Burn Foundation which is a burn survivor assistance program. Data collection is ongoing at this time. Since the progress report from February 2016 for purposes of time needed to interview and the time of my participants ability I have had to reduce the amount of participants to only 7. Since this is an exploratory research this amount of participants will be sufficient however, in the future I anticipate that I will continue this research to increase the number of participants.

At the time the research is ongoing and transcriptions are still in progress. On average each interview has taken 60 min but one took only 11 minutes and another interview took 2 hours. The transcriptions of interviews lasting 60 minutes have been turned into written form of 4.5 pages long and I am now in the process of inputting them into a meta-data software called wordle this analysis software will then generate an image that will highlight in single text form words that are indicative of a greater mention by appearing larger. All words sizes will be analysed, compared and contrasted with the wordle images of other participants and as a whole I will create a wordle for all participants to identify key existential themes. I have been doing this for the summer of 2016 and I have anticipated findings that suggest that the participants have developed psychological resilience that has allowed them the ability to better cope with stress and anxiety in other problemat-

ic events in their life. Also my preliminary findings suggest that if given the choice to live through their burn episodes again they would opt to relive it even with all the pain and troubles associated with burns, this is mainly for the sense of pride gained from being part of such a loving community of burn survivors. My last but not least anticipated finding suggests that 6 out of 7 participants believe that spirituality has been a contributor to their optimism and post-traumatic growth and that this spirituality inclination has not increased but remained the same after their burn injury.

Further analysis of the transcriptions and wordle images are needed and will continue to conclude this research study.

If your project has not advanced the way you had planned, identify the impediments to progress you encountered during this period? What steps have you taken to move your project forward?

The communication process between some of my participants have been time consuming as many of them live in the east coast and the three hour difference has contributed to a delay in the interview process. In order to move my research forward I will be meeting this Saturday 02/20/16 with a big group of them in order to physically explain the interview process to them and also collect the signed consent forms.

During the summer of 2016 interviews were concluded but transcriptions are still in the process as well as the wordle images due to unforeseen circumstances associated with some of my participants as well as myself. Transcriptions were longer than anticipated and have taken double the time that was planned for.

One transcription alone has taken more than 6 hours to type. Also for this reason I have had to reduce my participants from 25 to only 7. Another impediment that has slowed the progression of the research has been the time zone in which participants live. For example one lives in the UK while another lives in Georgia and another in Canada, trying to set up an ideal time for the interview a couple months ago was an issue that was resolved by setting up 2 interview sessions in order to accommodate for the time gap between myself and the participants. With one more month of summer vacation until the beginning of the fall quarter 2016 I foresee that the remaining 4 transcriptions and 5 wordle images will be generated in order to conclude my research study, with the superb mentorship of my mentor Dr. Jack Fong and the McNair community.

Bibliography

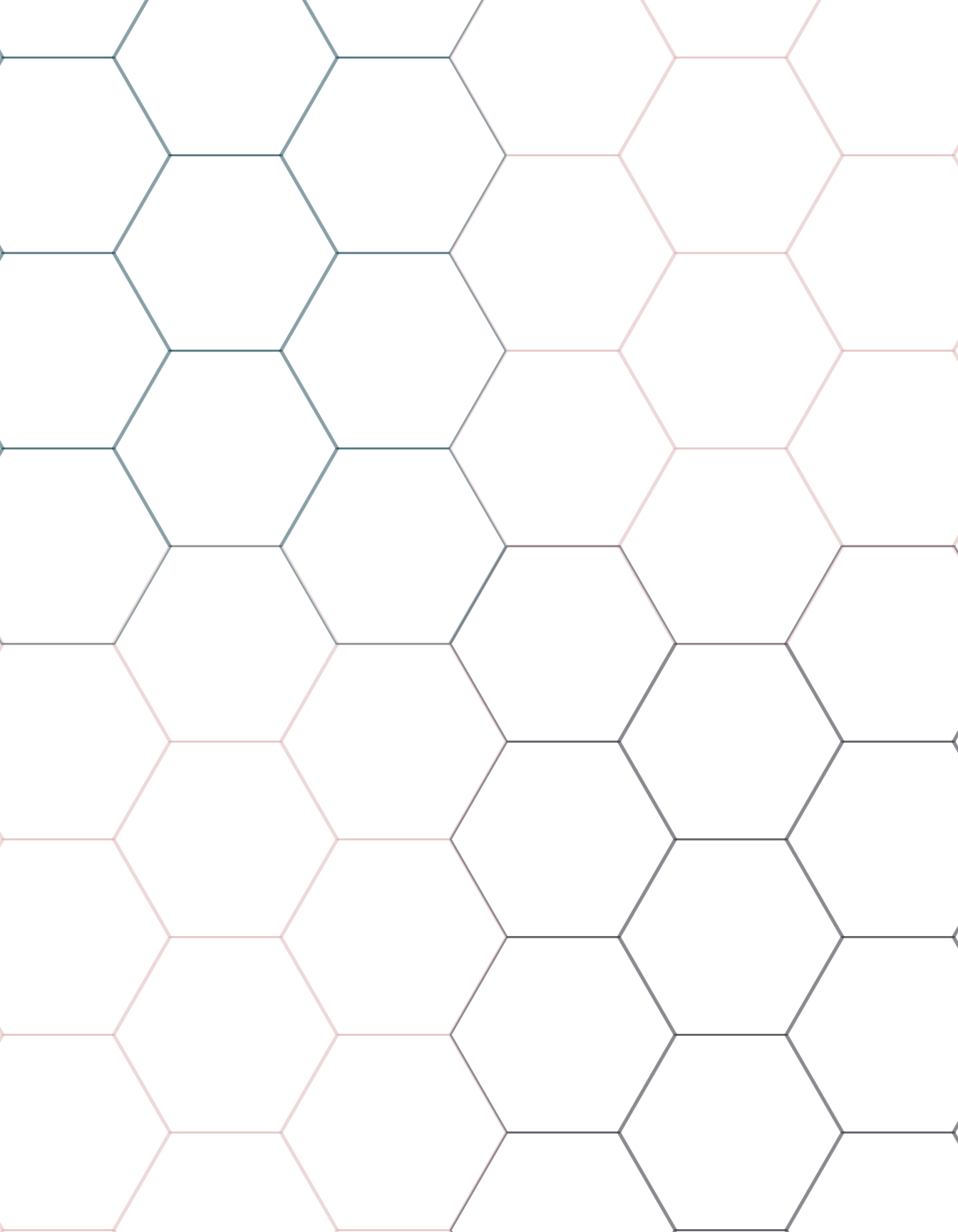
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"Chronic Persistent Pain After Severe Burns: A Survey of 358 Burn Survivors." *Pain Medicine*, 3(1), 6-17. <http://doi.org/10.1046/j.1526-4637.2002.02004.x> To determine the prevalence, characteristics, and effects of chronic persistent pain on burn survivors.

Lawrence, J. W., Fauerbach, J. A., & Thombs, B. D. (2006). "Frequency and Correlates of Depression Symptoms Among Long-Term Adult Burn Survivors." *Rehabilitation Psychology*, 51(4), 306-313. <http://doi.org/10.1037/0090-5550.51.4.306>

Lawrence, J. W., Fauerbach, J. A., Heinberg, L. J., Doctor, M., & Thombs, B. D. (2006). "The Reliability and Validity of the Perceived Stigmatization Questionnaire (PSQ) and the Social Comfort Questionnaire (SCQ) Among an Adult Burn Survivor Sample." *Psychological Assessment*, 18(1), 106-111. <http://doi.org/10.1037/1040-3590.18.1.106>

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Luis Morales Electrospun Nanofibers for Energy Storage and Conversion

Dr. Y. X Gan
*McNair Scholar

Abstract

In this work, we explore composite nanofibers that are manufactured through electrospinning for energy storage and conversion. The fibers will either be composed of a conductive composite or a ceramic composite, depending on application. For the ceramic nanofibers, their response to an external electromagnetic field is characterized to observe the heat generation in the fiber. In addition, we will also measure the current passing through the fiber under the polarization of DC potential. For the conductive nanofibers, the electrical resistance and thermal conductivity of the material will be measured under the polarization of DC potential. Based on previous research, for the ceramic nanofibers, it is found that the fiber has intensive heating behavior when it is exposed to the electromagnetic field. The temperature increases more than 5 degrees in Celsius scale, only after 5 seconds of exposure. The current-potential curve of the ceramic nano fibers confirms the hypothesized dielectric behavior. Based on previous research, for the conductive nanofibers, it is found that the electrical resistance is increased as thermal conductivity is reduced; therefore there must be a compromise between those two. It is concluded that the conductive nanofiber's thermoelectric property is increased significantly compared to the bulk reference material. It is also concluded that the ceramic nanofiber has the potential to be used for hyperthermia treatment in biomedical engineering or for energy conversions. Further research is currently being conducted to improve the efficiency of both, conductive and ceramic, nanofibers.

Objectives

The objective of our research is to create composite nanofibers through electrospinning, in order to use them for energy conversion and storage. Our goal is to create ceramic nanofibers for energy storage, as well as conductive nanofibers for energy conversion; however, the objective does not stop there, these nanofibers can serve a great application in the Biomedical Engineering field.

Background

Dr. Yong X. Gan has successfully achieved the goals of this research in the past. Through electrospinning, along-side his students Arturo Bautista and Juan Aguado, he created Sodium-Cobalt Oxide ceramic nanofibers. In addition, also through electrospinning, alongside his students Bruce Y. Decker and Sinclair Calderon, he created Bismuth Telluride Filled Silicone conductive nanofibers. We will be recreating these experiments, using different infused nanoparticles, base materials, and solvents, searching for an increase in the nanofiber's efficiency. Using the results from these past experiments, allows us to set a base for our research.

Electrospinning is one of multiple techniques, used for the fabrication of one-dimensional nanostructures. In 1934, a man named Anton Formhals, produced cellulose filaments with a device which used electrostatic repulsions between surface charges, which further developed electrospinning towards commercialization. The electrospinning process is a production method that uses electric force to draw charged threads of polymer solutions up to Nano sized fiber diameters. Electrospinning is one of the most versatile methods

capable of producing a controllable chemical and structural composition. In addition, this process is also cost effective and can be produced in large quantities. The electrospinning machine in our lab is set up, such that the electrospinning generates the nanofibers by the use of electrostatic repulsions between surface charges as found by Formhals. The system contains a syringe, which has a desired diameter, used to extrude the nanofiber fluid. The syringe has a metal tip, which is positively charged. There is a collector plate on the opposite end of the syringe, which is negatively charged. The opposing charges cause the nanofiber to be extruded towards the collector plate. Keep in mind that the collector does not necessarily have to be a plate, in fact, some electrospinning machines use rollers to collect the nanofibers. The system is powered by an electrical circuit, which runs on a required high power supply, due to the high resistance of the ambient air between the syringe tip and the collector tip. The voltage supplied is determined, based on the distance between the syringe tip and the collector. When setting up the electrospinning machine, there are a couple of additional things which should be considered, such as the room temperature and humidity in the room. The syringe's feed rate is also important, because this determines if the nanofiber solution is fully developed by the time that it exits the syringe.

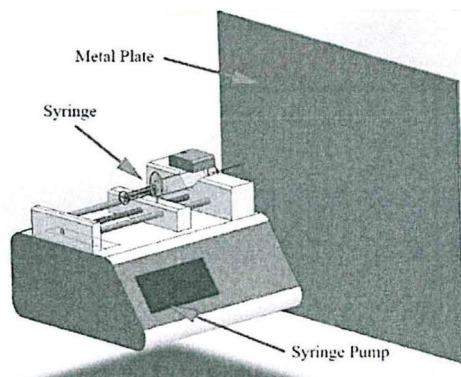


Figure 1: Electrospinning Machine Schematic

Electrospun nanofibers for energy conversion and storage is desired due to their large surface area to volume ratio, as opposed to a single crystal.

The objective of creating ceramic nanofibers is for them to behave just as a dielectric would behave. A dielectric material is an insulating material, which is a poor conductor of current. This nanofiber shall behave opposite to the behavior of a metal, where there should be no current flow, in other words, no loosely bond or free electrons are allowed to travel through the material. In Dr. Gan's previous research, when he created ceramic nanofibers, he used NaCo₂O₄. Analysis was performed on Sodium-Cobalt Oxide and it showed that enhancements were for the material's conductivity and thermoelectric power. These results pointed toward the application of the material in high temperature thermoelectric applications. The NaCo₂O₄ nanofibers were composed, by processing sodium acetate, cobalt acetate, and polyvinylpyrrolidone powder (PVP).

The objective of creating conductive nanofibers is to produce a flexible thermoelectric material for alternative energy applications. This composite material shall exhibit the Seebeck effect and reduce electrical resistance. The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. In other words, this is the direct conversion of temperature differences to electric voltage. In Dr. Gan's previous research, when he created conductive nanofibers, he used Bismuth Telluride as the additive nanoparticle and silicone rubber as the base material. Polymers such as silicone rubber, provide flexibility to the composite; however, due to its insulating behavior, it does hinder the Seebeck effect. In order to increase the conductivity of this material, the rubber matrix is filled with semiconductor bismuth telluride. The silicone rubber matrix can increase phonon scatters, which will reduce the thermal conductivity. Since silicone rubber possesses high heat resistance and thermal stability, it can be implemented in a large temperature gradient environment for thermoelectric applications. There is a drawback when adding fillers in the silicone rubber. The strength and flexibility of the composite will be sacrificed if fillers are added in large quantity. In order to further increase the conductivity of the silicone rubber composite, we can also heat treat the material. Heat treating this silicone rubber base material will increase the electrical conductivity, which is the opposite behavior of heat treating a conductive material, such as Aluminum. In a metal, such as Aluminum, when heat treated, the atoms are quenched or rapidly cooled in order to freeze. This distorts and stresses the structure, making the electron movement more difficult, thereby decreasing the electrical conductivity. This behavior is

opposite, when dealing with a silicone rubber matrix.

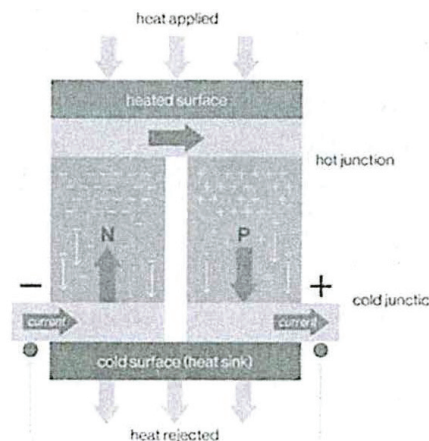


Figure 2: Illustration of Seebeck Effect

Methods, Procedures & Previous Research

Recall that the objective of our research is to create composite nanofibers through electrospinning, in order to use them for energy conversion and storage. Regardless of the application of the final application of these nanofibers, the overall set-up and process is relatively similar. The primary difference between creating a ceramic nanofiber and a conductive nanofiber is the infused nanoparticles that are implemented in the base material, which give the resulting nanofibers their unique properties.

In Dr. Gan's previous research, when making the sodium cobalt oxide nanofibers, the following steps were taken. First, the Polyvinylpyrrolidone powder

(PVP) was mixed with ethanol in a glass beaker. 0.375 grams of PVP and 5 milliliters of ethanol alcohol were used for the solution. After mixing the solution, 0.0683 grams of sodium acetate trihydrate was added. Finally, 0.0625 grams of cobalt (II) acetate tetrahydrate was added. The final solution was thoroughly mixed until the homogeneous solution was generated. The mixture was performed at room temperature, making sure that all solids were dissolved. After several minutes, the mixture was ready to be transferred into the syringe. The syringe was then mounted onto the electrospinning machine, where the syringe was controlled by a pump. As explained earlier, the tip of the syringe was connected directly with a positive electrode. The pump extruded the nanofiber solution onto the negative electrode, which was connected to an aluminum plate, directly in front of the needle. A clean white paper towel was mounted on the plate to catch the nanofiber. This experiment was performed at room temperature for several hours. Here are some pictures of the sodium-cobalt oxide nanofibers:

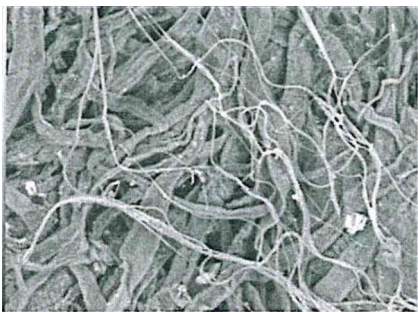


Figure 3: Sodium-Cobalt Oxide Nanofibers



Figure 4: Sodium-Cobalt Oxide Nanofiber Distribution

The hypothesis for the sodium cobalt oxide nanofibers was that the fibers would behave as a dielectric material does, meaning that there would minimal current running through it, with increasing voltage. The material would experience net polarization of permanent dielectric dipoles which are already in the material; in other words, no loosely bond, free electrons, are allowed to drift through the material. After the nanofibers were Electrospun, they were tested to verify the hypothesis through tests that measured the temperature of the material, as it was exposed to a 900Watt electromagnetic field over different time intervals. The following figure shows the temperature versus time of the sodium cobalt oxide nanofibers:

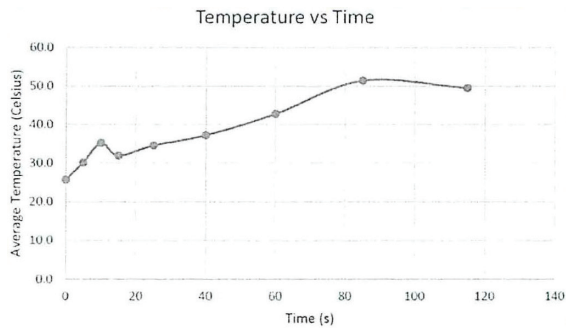


Figure 5: Average Temperature vs. Time

This figure proves that the nanofibers have the ability to absorb heat almost instantly when exposed to an external electromagnetic field. The temperature increases more than 5 degrees in Celsius scale, only after 5 seconds of exposure. In order to test the nanofibers for their dielectric properties, a linear sweep

voltammetry analysis was performed. Three trials were performed for this analysis. The following figures show the nanofiber's conductive response to an increasing applied voltage:

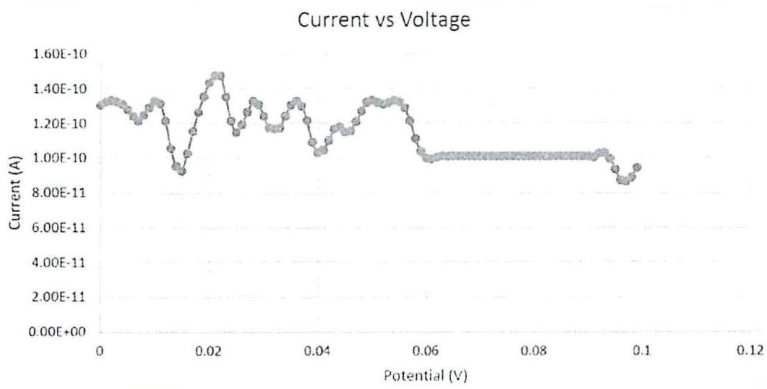


Figure 6: Current vs. Voltage Trial 1

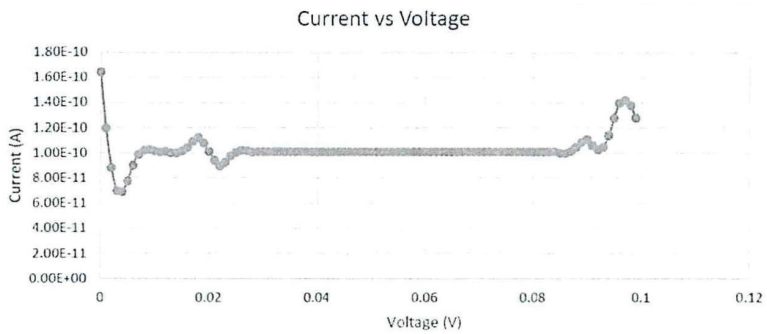


Figure 7: Current vs. Voltage Trial 2

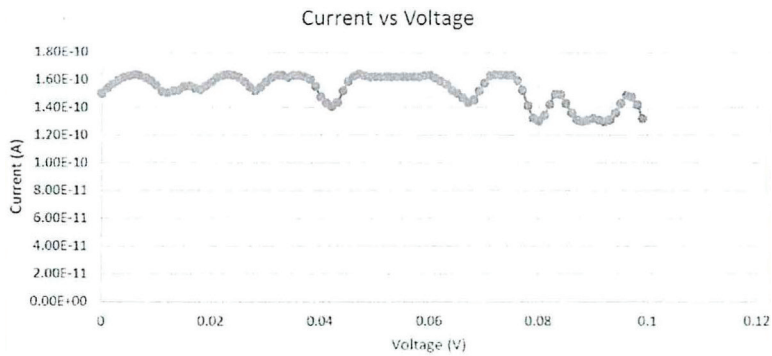


Figure 8: Current vs. Voltage Trial 3

The figures above show how the current in the nanofiber maintains relatively constant, as the voltage is increased across the material. Following Ohm's Law, as the voltage increased, the resistance increase, maintaining the current relatively constant. The voltage was increased from 0 to 0.1 volts, in 0.001 intervals. In research conducted by Maensiri et al, it was shown that the Co₂ component is responsible for the elec-

trical conduction of the nanofiber, and the Na provides a charge reservoir to stabilize the structure. Research performed by K. Parker, shows that the thermoelectric properties could be enhanced effectively if the Co₂ is partially substituted for Cu. The following images are some of the compounds used by Dr. Gan in his previous research:

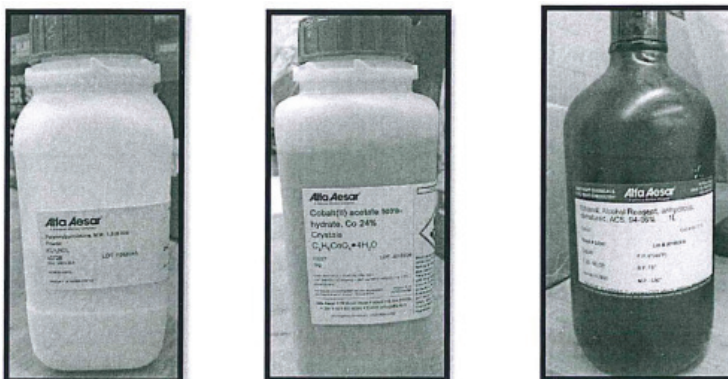


Figure 9: Several Compounds Used In Previous Research

In Dr. Gan's previous research, when making the conductive bismuth-telluride filled silicone nanofibers, the following steps were taken. First, 0.2 grams of bismuth telluride was mixed with 1.0 grams of grams of silicone rubber. Thereafter, the solution was thoroughly mixed at room temperature and 0.12 grams of the solution was transported to the syringe. The syringe was set up onto the electrospinning machine, just as it was set up for the ceramic nanofibers, using the syringe pump and collector plate. The syringe pump operated at a rate of 0.1 mL per minute. The DC voltage that was connected to the syringe tip, delivered up 30 kV of voltage. Due to the high-voltage electric field, the bismuth telluride and silicone rubber solution was stretched and extruded under electrostatic and surface tension.

In order to test the conductive bismuth-telluride filled silicone nanofibers, two separate sets of experiments

were performed to test for electrical resistivity and Seebeck coefficient. It was expected that the presence of the silicone rubber matrix would increase phonon scatters and hence reduce thermal conductivity. Although thermal conductivity of bismuth-telluride filled silicone nanofibers was not tested, the Wiedemann-Law can be used to relate the electrical conductivity to the electrical component of the thermal conductivity $\text{tlcrT} > \text{constant} > \text{Lorenz number}$, where t is electron thermal, and cr stands for electrical conductivity. Two composites of the bismuth-telluride filled silicone nanofibers were tested for resistivity and Seebeck coefficient. The following figures shows two trials for each of the two samples that were tested, as well as the Seebeck Coefficient varying with time, under two different temperatures:

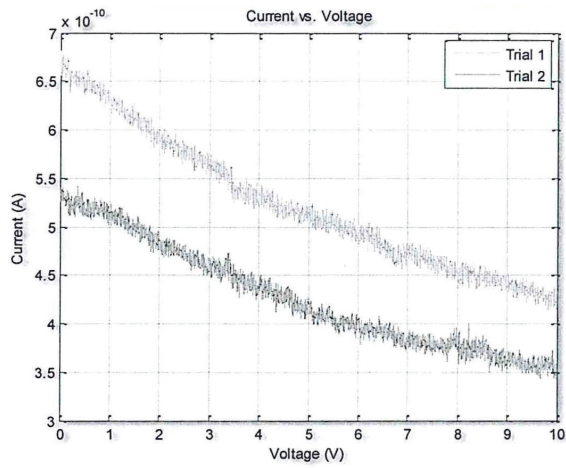


Figure 10: Voltage Vs Current Of Sample 1

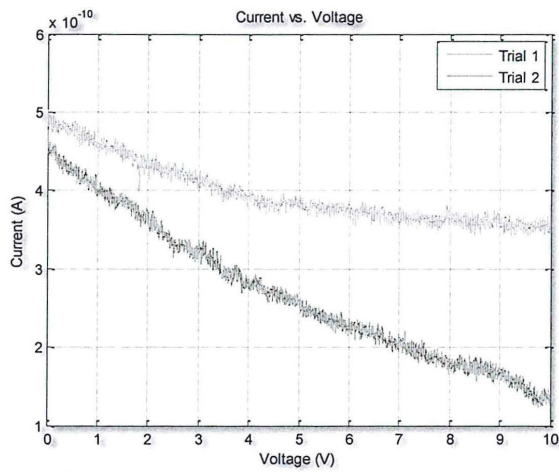


Figure 11: Voltage Vs Current Of Sample 2

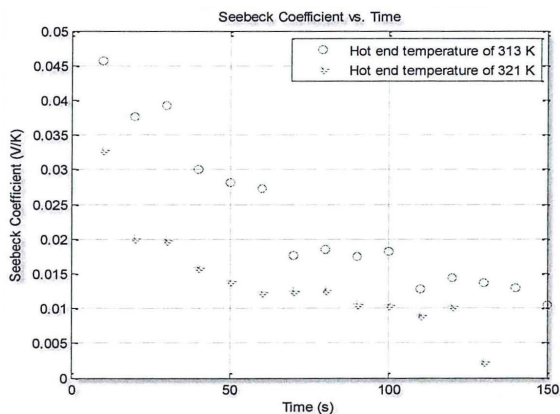


Figure 12: Seebeck Coefficient At Two Different Endtempera Tures

The test results showed no significant differences in the two consecutive experiment trials. The silicone rubber exhibits high electrical resistance in the nanofiber. By Ohm's Law, as the voltage increases and the current decreases, the resistance increases. Although electrical resistance is increased by using silicone rubber matrix, thermal conductivity is reduced as a result of an increase in phonon scatters. Therefore, there is a compromise between the electrical resistance and the thermal conductivity when choosing silicone rubber as the matrix. The figure above presented the Seebeck coefficient of the material with varying hot end temperatures. After reviewing the analysis, at 313 K, an average Seebeck Coefficient of 0.029 V /K is exhibited in the material. It is apparent that the presence of bismuth telluride in the silicone rubber matrix can effectively enhance the thermoelectric property. The

average Seebeck Coefficient in pure bismuth telluride is 250×10^{-6} V /K. This increases the Seebeck Coefficient by a factor of 116. As a result, the thermoelectric property of the composite material is increased significantly compared with the bulk reference material. In further improvement on the energy conversion efficiency, it is possible for making a flexible thermoelectric material for alternative energy applications. Generally, a good thermoelectric material should have a high Seebeck Coefficient. An excellent thermoelectric material should have a low thermal conductivity value.

Progress

Currently, we have tested the hyperthermia effect of non-infused Electrospun nanofibers, under normal conditions where the nanofiber has not been exposed to

any post-processes, as well as under a heat treatment post-process. We heat treated the nanofibers for 2 hours at 500 degrees Celsius and then tempered down to room temperature. We test both of these scenarios, prior to infusing the base with a nanoparticle, in order to see if the heat treatment of the base material will have an effect on the final product. Unfortunately, we have not been able to infuse our base materials with nanoparticles at the moment; however, that is the next step in our research.

In our current research, we have successfully Electrospun polyacrylonitrile (PAN) fibers, which were initially dissolved in N-Dimethylformamide solvent, resulting in a liquid nanofiber substance. First, we obtained 0.375

grams of the polyacrylonitrile (PAN) and dissolved in 15 ml of the N-Dimethylformamide solvent. This substance was then capped off from ambient air, or else the solvent will evaporate. The solution was later placed in the syringe pump and put through the Electrospinning process. The syringe pump operated at a rate of 0.05 ml per minute. We used 10 ml of the nanofiber solution. Our results were successful, the following temperature vs. time data and figures show the nanofiber's response to hyperthermia. The data tables show the different trials, average temperature, and natural log value for each time interval. The figures below, plot the relationship between the temperature and time. The natural log plot, shows the behavior of the data as an exponential function:

Polymer with Solvent								
Time (seconds)	Temperature (°C)							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Avg.	ln(Temp)
0	22.400	22.400	22.400	22.400	22.400	22.400	22.400	3.109
5	22.600	22.600	22.600	22.600	22.600	22.600	22.600	3.118
10	25.800	25.800	25.800	25.800	25.400	25.400	25.667	3.245
15	29.600	29.600	29.600	29.600	29.600	29.400	29.567	3.387
20	36.600	35.400	35.200	35.400	36.600	36.200	35.900	3.581
30	41.400	41.400	39.200	39.800	40.600	40.600	40.500	3.701

Table 1: Hyperthermia Temperature Data Polymer With Solvent

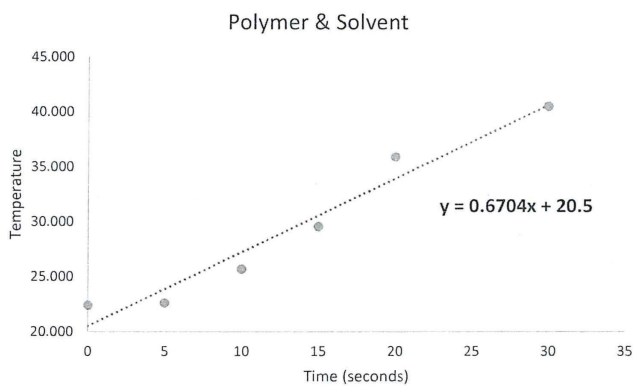


Figure 13: Temperature vs. Time

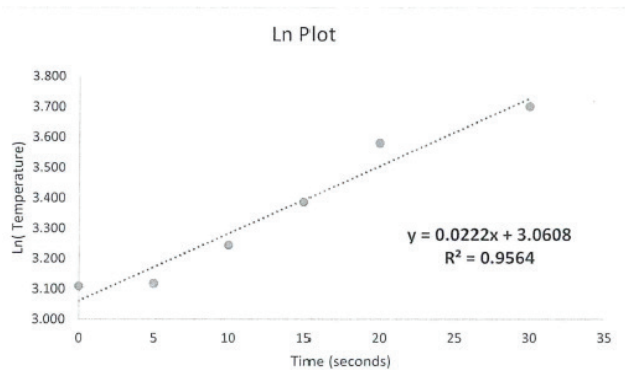


Figure 14: Ln (Temperature) vs. Time

Polymer with Solvent - Heat Treated									
Time (seconds)	Temperature (°C)							Avg.	ln(Temp)
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6			
0	21.400	21.200	21.600	21.200	21.200	21.200	21.300	3.059	
5	22.000	22.200	22.200	22.000	22.000	22.000	22.067	3.094	
10	25.200	25.200	25.200	25.000	25.000	25.000	25.100	3.223	
15	27.000	27.000	27.000	27.000	27.000	27.000	27.000	3.296	
20	33.600	33.400	33.400	33.400	33.400	33.600	33.467	3.511	
30	45.000	46.400	46.400	46.400	46.600	46.000	46.133	3.832	

Table 2: Hyperthermia Temperature Data After Heat Treatment

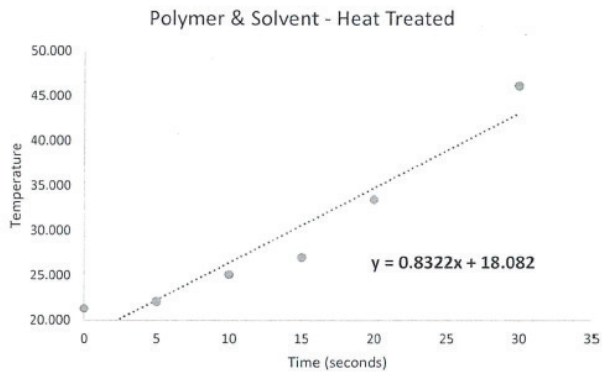


Figure 15: Temperature vs. Time After Heat Treatment

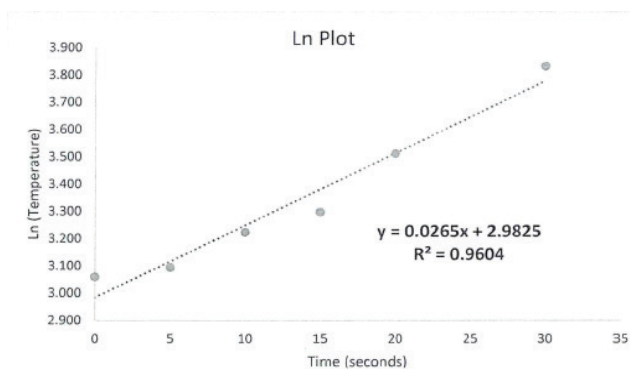


Figure 16: Ln (Temperature) vs. Time After Heat Treatment

Conclusion

After evaluating our produced nanofibers and reviewing our data, part of our hypothesis thus far proves to be correct. The heat treatment of the nanofibers has increased the heat generation of the material, when exposed to an external electromagnetic field. After testing both of the samples, heat-treated and non-heat-treated, it is clear that the heat-treated sample has a faster exponential increase in temperature. When looking at the temperature vs. time data plots above, when observing the natural log plots, the exponential curve of the heat treated nanofiber is greater, judging by the R^2 value of the plot. When plotting data as a natural log value we assume that the data is exponential and the accuracy of this assumption is dictated by the R^2 value of the data plot. The

nonheat-treated data yields an R^2 value of 0.9564, while the heat-treated data yields an R^2 value of 0.9604. An R^2 value equal to 1.0 would mean that the function is truly exponential. Although the R^2 values between the two data sets is not significantly different, it does show that the heat-treatment has an effect on the heat generation of the material. The heat-treated nanofiber has the potential to be used as the base of a ceramic nanofiber, which exhibits a dielectric behavior. Moreover, this nanofiber has the potential to be used as a form of energy storage in the biomedical engineering field. After heat treatment, this nanofiber would not be a wise choice as the base material of a conductive nanofiber, due to its high thermal conductivity. In a conductive nanofiber, we want a low thermal-conductivity and low electrical resistivity. The goal of a conductive nanofiber is to achieve a high

Seebeck Coefficient, and that is achieved by having a high temperature difference, meaning that we do not want the material to store any of the heat. On the other hand, the goal of a ceramic nanofiber is to have high electrical resistivity and high thermal conductivity in order not to generate a current in the material. We want all of the heat to be captured in the material and maintained stored.

The next steps in our research are to infuse the solution with nanoparticles to either produce a ceramic

nanofiber or a conductive nanofiber; depending on heat-treatment. We will also be using alternative solvents and polymer base materials. Our goal is to achieve a ceramic nanofiber that with higher dielectric and hyperthermia properties than the previously created NaCO₂Q4 nanofibers. We also aim to create a conductive nanofiber that has higher Seebeck Coefficient and lower electrical resistance than the previously created bismuth-telluride filled silicone nanofibers. The following figures are images of our current lab and research progress:

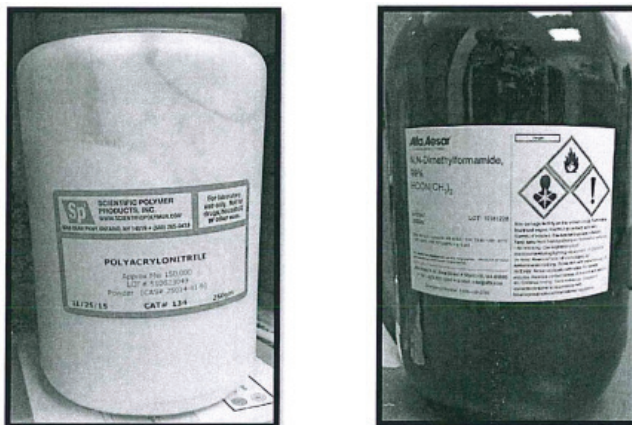


Figure 17: The Polymer Base Material & Solvent polyacrylonitrile (Pan) & N-Dimethylformamide Solvent

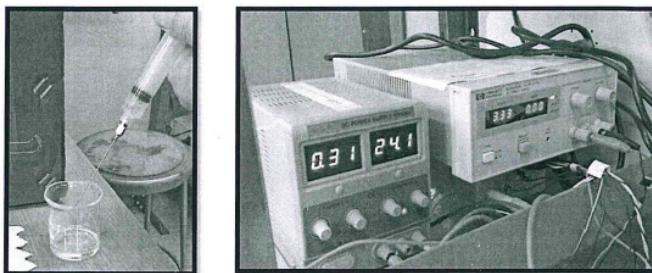


Figure 18: Nanofiber Solution & Electrospinning Power Supply

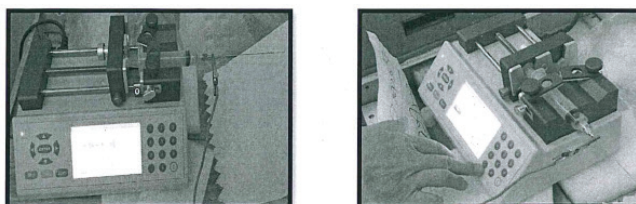


Figure 19: Syringe Pump Set-Up



Figure 20: Nanofiber Collector Plate & Nanoscale Microscope

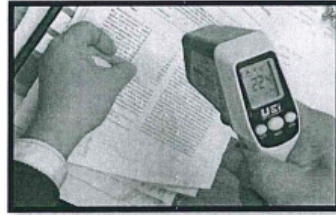


Figure 21: 900W Microwa Ve For Hypertermia Testing & Temperature Reading



Figure 22: Produced Nanofibers

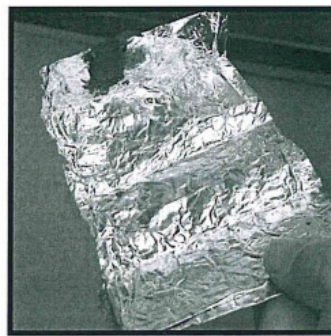
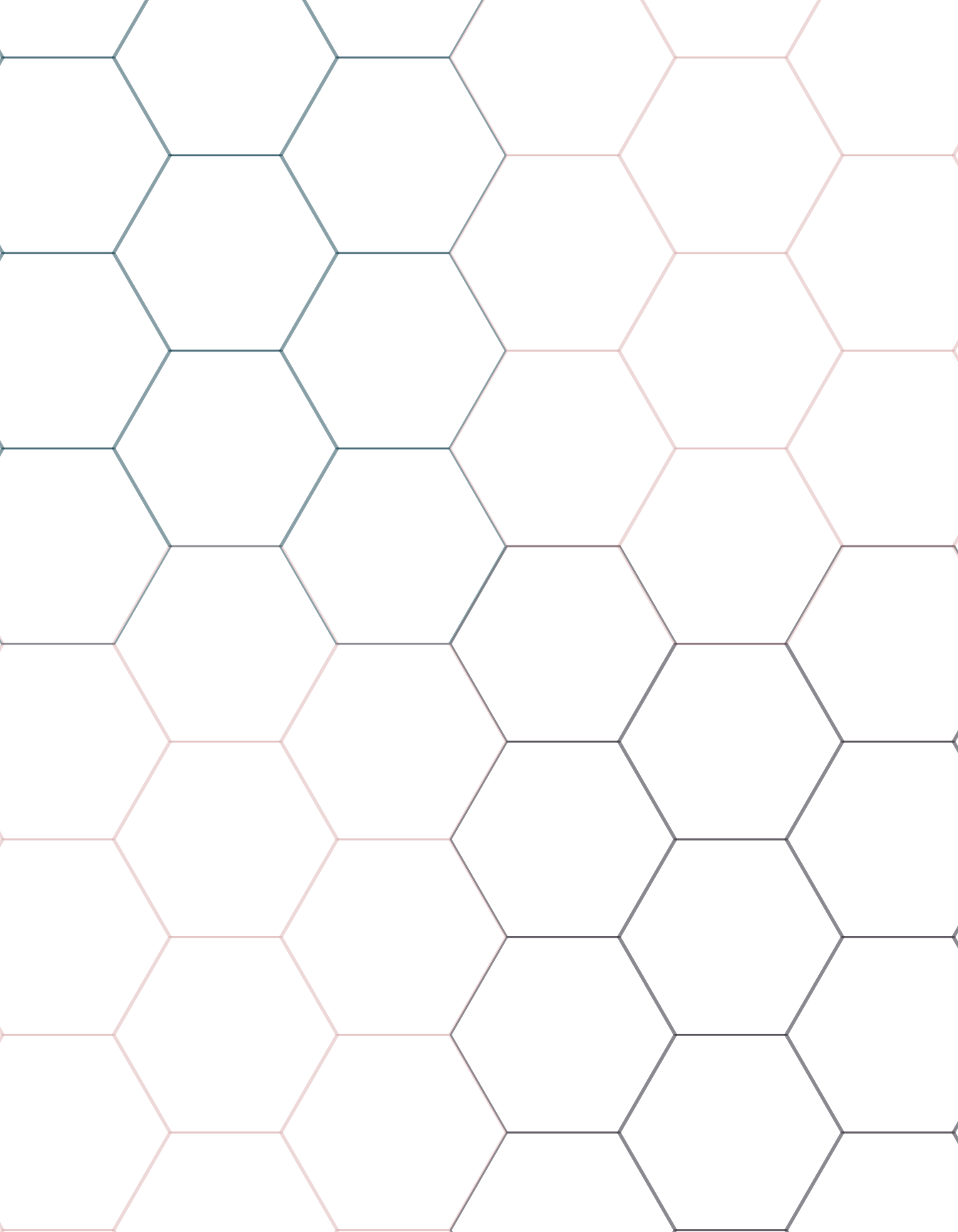


Figure 23: Heat Treating Furnace & Heat Treated Nanofiber

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Estephanie Munoz The Militarization of Latina/o Youth

Dr. J. Aguilar-Hernandez

*McNair Scholar

Abstract

As the fastest growing population in the United States, Latinas/as have become the most enticing group for the military to recruit. There is limited information regarding the experiences of Latina/a youth, specifically those who defer a post-secondary education to join the military. While the Latino population continues to increase rapidly, gains in the educational attainment do not follow the same pattern. Although educational attainment among US Latinas/as has improved in recent years, this group continues to hold the lowest educational attainment in comparison to other racial/ethnic groups. The experiences of four Latina/a youth who consider military service as the most viable option, centralizing on the following two questions: Why do Latina/a youth join the military? How does that decision impact their motivations for a higher education? This article highlights the importance of acknowledging the experiences of Latina/a youth in order to understand the factors that prompt them to enlist in military service. Further, to use these experiences to help improve the leaks within the educational pipeline to increase the educational attainment of Latinas/as.

Introduction

To what extent are Latina/o youth choosing to defer a post-secondary education and joining the armed forces? Relatively little research has examined the push factors that influence Latina/o students to find military service as the most viable option. Among working-class families in low-income communities, the pathway of serving in the military is common within the Latina/o youth population. The choice of deferring a college education and following other avenues, particularly

military service, is a recurrent course of action for Latina/o youth, but only a limited amount of research has documented the accounts of Latina/o youth who defer a college education to enlist in the armed forces. Documenting the experiences of Latina/o youth is of crucial importance in order to bring forward the push factors that influence their decision-making. In communities such as Baldwin Park, a low-income city located in the middle of the San Gabriel Valley region of Los Angeles County, California, the institution of the military is well received by its residents, especially by Latina/o youth. The experiences of Latina/o youth of Baldwin Park, California who have enlisted in the armed forces have not been previously explored. In this research study, I showcase the pathways of Latina/o youth of Baldwin Park, California who serve in the armed forces rather than pursue a college education.

The Frontline Population

The United States Census Bureau reports that the Latina/o population is one of the fastest growing minorities. Presently, it is reported that there are approximately 55 million Latinas/os. It is projected that by 2050 the population will increase to over 132 million. Due to the rapid recent increase in the Latino population, this group has become an object of attention for the Department of Defense (DOD).

As one of the fastest growing minorities, Latinas/os have become the most enticing group for military recruitment. According to the DOD, they have an annual agenda of recruiting over 200,000 people. Reaching the annual quota is difficult; therefore, the DOD prioritizes two main factors to ensure achieving the goal: competency and performance. In order to meet the annual quota, the DOD has revamped their

recruiting tactics and strategies with the purpose of attracting individuals. The Army provides its recruiters with a training handbook titled, “The School Recruiting Program Handbook,” on how to implement effective recruiting strategies. (USAREC Pamphlet p. 350-13). This handbook provides a number of suggestions, including advice about the importance of working with school faculty since they are an influential factor for students. The most crucial element a recruiter must complete is “establish rapport and credibility,” which includes assisting a physical activity classroom, handing out materials such as lanyards, pens, cups. etc. In like manner, recruiters must give the perception of caring about the best interest of the students with the purpose of “penetrating their school market...to obtain the maximum number of quality enlistments.” The school market is the largest source for military recruitment; for this reason, the handbook gives special prominence to recruiting in secondary institutions. The most alarming section in this handbook is that the primary goal is to achieve “school ownership” because it will guarantee a greater number of enlistments. The handbook emphasizes that it is pivotal that recruiters understand that “Once educators are convinced recruiters have their students’ best interest in mind the SRP [School Recruiting Program] can be effectively implemented.” The DOD ensures to implement different measures in order to meet the annual quota. The recruiting strategies are designed specifically for youth.

In terms of attracting Latina/o youth, the DOD released the advertisement campaign ‘Yo Soy El Army’ directed to the entire Latina/o community, especially to parents. It was produced in hopes of winning over concerned parents during a period of war. These ads use emotion in place of reason in order to manipulate the recipient’s emotions. As shown in Figure 1.,

an advertisement of two Latino parents embracing their son enhanced with a misleading caption on the top left: “When he was a boy we took care of him, and now he takes care of us.” This advertisement does not present factual evidence or a direct statement about joining the military, but rather appeals to the emotions of the recipient. In a sense, this advertisement makes note of the similarity between familial and military ‘values.’ This advertisement does not present logical reasoning; instead, its technique is logically fallacious. The DOD has revamped their recruiting strategies through the fallacy of appeal to emotion with the purpose of reaching the annual quota. A factor that demonstrates that their recruiting strategies have resulted successful is that data reports that Latinos made up 20% of the recruiting market in 2010 and by 2050 that percentage is projected to increase to 38%. Because the population continues to increase rapidly, the DOD focuses on designing strategies that attract the Latina/o community.

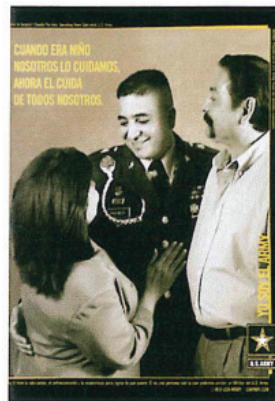


Figure 1. (Garza, 2015)

Baldwin Park, California

As of 2010, the United States Census Bureau reports that 80.1 % of residents living in Baldwin Park are Hispanic. The educational attainment level of this community is significantly low in comparison to other areas of Los Angeles County. Less than 10% of residents have a Growing up in a poor and violent neighborhood such as Baldwin Park, significantly increases the chances that a Latina/o child will choose the military rather than a college education.

Figure 2. showcases one of the several military advertisements scattered throughout Baldwin Park. This billboard, sponsored by the Marine Corps, is located between the 1-10 and Kaiser Permanente. The iconic backdrop photograph of the flag-raising on Iwo Jima and the three Marines gives a reassuring display of strength. It comes to represent not only heroism during the Battle of Iwo Jima, but depicts the core values of the Marines, and indeed all of the military branches. Even though, the billboard seems like an ordinary advertisement, it communicates a strong message to this low-income community about joining the military. These military billboards are non-existent in affluent communities in Southern California. These billboards are a part of this city's culture. It promotes a military going culture for the residents of this community.



Figure 2.

Student's decision to participate in the United States military, an institution that represents first-class citizenship for Latinas/as, are certainly shaped by the encouragement of parents, educational institutions, and communities. Parental guidance is a key determiner that influences students to join the military and defer a post-secondary education. The decision to defer a post-secondary education comes easy for numerous students at Sierra Vista High School (SVHS) in Baldwin Park, California. The military has become a viable option among numerous students, particularly Latina/a youth, who choose to enlist in the armed forces since the role of a post-secondary education plays of trivial importance.

The campus grounds of SVHS encourage students to participate in the military by allowing military recruiters to visit the campus on a weekly basis. Each week military recruiters walk around campus wearing battle dress uniforms to interact with students and host a variety of activities during lunch hour with the

purpose of informing students about the perks of signing up for the military. Not only do military recruiters interact with students, but they also give presentations in the classroom. Students eagerly gather beside the information booth and address their questions and concerns to recruiters while others participate in push-up or pull-up bar competitions. In doing this, students have become embraced by a military-going culture that solidifies the idea of deferring a college education to enlist in the armed forces.

It is important to take notice of the annual statewide summary report of SVHS. The report indicates that 88.9% of students attending this institution are Hispanic or Latino and 89.9% of students are socioeconomically disadvantaged. The most alarming part of these statistics is that 50% of Hispanic students are not proficient in English and 47% do not meet the proficiency mark in mathematics. This indicates that these students are not prepared for college-level math and reading. It is evident that the majority of Hispanic students attending SVHS are falling through the cracks of the educational pipeline. In this institution, a significant number of students take remedial courses, which places them in a disadvantage. This demonstrates that this institution is failing to a certain extent to provide adequate academic preparation for students to be pa Students in remedial courses are not exposed for college coursework. The test information indicates that these students are ill equipped to undertake college coursework because they are not academically prepared. Students must demonstrate proficiency in the English language as well as in mathematics to excel in the realm of academia. It is also indicative of the fact that these students have not been exposed to rigorous coursework.

In what follows, I draw on interview data to

discuss how Latina/o youth of Baldwin Park are submerged into an increasingly militarized community. As a former student of SVHS, I witnessed the heavy presence of military recruiters, which was generally supported, yet poorly regulated by faculty and staff. It was not long before I realized that my Latina/o classmates had no plans of attending college, but rather held deep enthusiasm to join the military. This peaked my interest to acknowledge and showcase the pathways of Latina/o youth of this community who deferred a college education because it brings forward the factors that prompted them to serve in the military. By focusing on the experiences of working-class Latina/o youth of Baldwin Park, I showcase how race and class as well as gender intersect to shape a military receptive mindset for these individuals. In particular, this article explains why Latina/o youth of SVHS consider military service as the most viable option in their pursuit of educational advancement. This article thus investigates whether Latina/o youth defer a college education based on socioeconomic and demographic factors. It also investigates if these individuals have unique attitudes about their community, specifically in regard to their educational trajectory. This status is based on the following research questions: Why do Latina/o youth join the military? How does this impact their motivations for a higher education? The hypothesis is:

HI: The Military Becomes a Viable Option When College is not a Viable Option

I will also examine how secondary institutions, particularly SVHS, provide the adequate preparation for students to undertake college coursework. Further, I examine if the heavy military presence on campus influences students to enlist. This is a primary

concern because there is no data available in regard to the experiences of Latina/o youth attending SVHS.

Latinas/os In The Educational Pipeline

Several studies indicate that there is an increasing *crisis* in Latino educational attainment. Different factors hinder their educational pathways such as attending schools that are under-resourced in which they experience the effects of inequity by not receiving adequate preparation. Tara Yosso argues that institutions tend to hold low educational expectations of underrepresented groups of students. Another factor comes in between are financial barriers. The Pew Hispanic Center reports that 4 out of 10 Latinos who graduate from high school defer college due to limited economic opportunities.

In terms of educational attainment, Latinas/cs remain at the bottom of the educational pipeline. The educational attainment of Latina/o youth has increased in the last decade. Although, the Latina/o group continues to fall through the cracks of the educational pipeline, efforts to increase the educational attainment of this group have resulted relatively successful. As of 2012, researchers report that for every 100 elementary Latina/o students approximately 63 students will graduate from high school. Followed by the post-secondary segment in which 13 students will receive a bachelor degree and only 4 students will obtain a graduate degree. Lastly, less than one will obtain a doctorate degree. In comparison to other racial/ethnic groups, Latinas/cs have remained at the bottom of the educational pipeline. In recent years, efforts to fix the cracks of the educational pipeline have increased the educational attainment of Latinas/os, but these numbers indicate that there is much room for im-

provement. It is important to consider the educational attainment of Latinas/os when examining the factors that influence them to defer a college education.

Latina/o Youth In The Military

Since the period of World War II, the U.S. remains in a status of permanent war today. Military values are deeply embedded in society, especially in public high schools in low-income communities. Gina Perez (2006) analyzes the complicated relationship between Latina/o youth and the United States' military. This article explores how Latina/o youth in Chicago high schools come to decisions regarding military service. The factors that inform Latina/o youth to join the military not only range from "limited economic opportunities," but also from parents who are "influenced by gendered understandings of autonomy, kinwork, honor, and respectability in turning to military programs while in high school" (Perez, 2006, p.53). Perez's article included scholarly research on "gender, communities, and military life" that served as a foundation to understand how family life and household economies impact Latina/o to choose the military over postsecondary education. The article shows interesting facts on how military recruiters are deeply infiltrated in Chicago high schools since Chicago is a "a global Latino city" that is deeply impoverished, with nearly twenty-four of Latina/o residents living in poverty (Perez, 2006, p. 56).

The gender, culture, and the militarization of Latina/o youth is examined thoroughly by Gina Perez (2010) who asserts that the U.S. military "symbolizes a vision of citizenship that rests on sacrifice, honor, and patriotism," but also is a "invaluable vehicle for economic mobility for many working class families" (p. 169). In particular, Perez (2010) gave significance to

the main symbol of the military: the military uniform. Those who wear the uniform obtain a sense of pride but for Latina/o youth, it gives them automatic acceptance into U.S. society. Perez (2010) concludes that Latina/o youth seek to join the military in order to attain respect and admiration for society since they are often disrespected and discriminated. The uniform serves as a shield against discrimination and prejudices. At the same time, Perez finds that in the U.S. Marine Corps, Latina/o youth recruits increased drastically since they are “more likely than recruits of other races and ethnicities to complete boot camp and the first term of service” (p. 173).

In a research article by Irene Garza (2015), advertising patriotism is addressed with the purpose of showing how the military targets the Latina/o community. Garza (2015) notes that the DOD spends millions of dollars to advertise the military in a virtuous fashion without presenting its actual dangers. This article examines the “Latino-directed” recruitment campaign of the U.S. Army called “Yo Soy El Army” (Garza, 2015, p. 245). Garza argues how ethnic marketing shapes and reveals significant “insights about citizenship, nationalism, and patriotism for Latina/o youth in the post 9/11 era” (p. 256). Garza (2015) incorporates research studies from Perez and also discusses about the sense of mandated nationalism due to the global war on terror. In this article, Garza (2015) notes that Latina/o youth are the fastest growing pool of military aged people.

Recruiting Latinas/Os Into The Military

Abundant research demonstrates the widespread acceptance of the U.S. military within American society. Even though, the ideals of the U.S. military are valued, a growing number of activists find multiple al-

ternatives to resist the militarization of youth in public high schools. Since the introduction of the NCLB, public secondary institutions across the nation are required to act in accordance with the policy by giving military recruiters backstage access to interact with high school students and acquire information on students. Under the federal statute, students also have rights that are frequently disregarded by military recruiters. In a research study conducted by the Rutgers School of Law-Newark (2008) finds that military recruiters in different high schools exert harsh influence over youth without parental consent. This is a serious issue since youth are vulnerable beings that are ill equipped to make informed decisions. The institution mentioned that students have the right to opt-out from military recruiting if and only parents sign the opt-out form, which in many cases is not given to students. The research study also notes that military recruiters purposefully use advertising techniques to lure young adults into enlisting. Through this study, the importance of informing youth of other postsecondary education options not including the military is highlighted multiple times. Although not explicitly stated, this study serves as counter-recruitment since it provided the current provisions that protect students as well as policy recommendations to protect the students from aggressive military recruiters.

Similarly like that the Rutgers School of Law-Newark, the American Civil Liberties Union (2008) provides a research study concerning the “abusive U.S. military recruitment and failure to protect child soldiers” (p. 1). This optional protocol provided minimum safeguards with the purpose of protecting youth. The study noted that military recruiters often violate the Optional Protocol, which is directed at protecting the rights of children under 18 from military soldiers. A

key point that addresses how military recruiters focus their attention on “high school campuses, in school lunchrooms, and in classes” (ACLU, 2008, p. 2). The information reported by the American Civil Liberties showcases a *persistent* issue that affects thousands of students, particularly of color, across the nation, but is of ten overlooked.

In a most recent study, Matthew C. Friesen’s (2014) indicates that counter-recruitment groups have mobilized across the nation “*resisting the armed forces recruiting efforts in public high schools*” (p.75). Friesen (2014) reveals five framing campaigns practiced by counter recruitment movements with the purpose of resisting the efforts of military recruiters to “dominate the symbolic discourse in public high schools (p. 75). Similar to previous studies, Scott Harding and Seth Kershner (2011) also mention the permanent state of war or the war on terror that continues to be a shared belief within different research fields. A significant factor that Friesen (2014) argues is while local schools resist against military recruiters, this causes military recruitment to penetrate more heavily in vulnerable communities. Despite an increasing awareness of militarization of U.S. public secondary institutions, Friesen (2014) asserts that additional “in-depth research with a broader cross section of activists is needed to reveal a more expansive view” of the counter recruitment movement” (p. 77).

These concurrent factors showcase the internal leaks in the educational pipeline that affect the educational outcomes of Latina/o students, but work in favor of military recruiters. The military continues to work diligently in developing successful recruiting tactics that entice the naive minds of Latina/o youth. Enlisting in the military is an irrevocable commitment and for this reason students must be informed with

meaningful and accurate facts concerning military enlistment. While these case studies approaches begin to showcase military recruitment tactics in low-income high schools, additional in depth analysis with Latina/o student experience is needed to reveal a more extensive perspective of military recruiting in vulnerable communities.

Theoretical Framework

The concept of critical race theory (CRT) is of crucial importance in order to examine and understand the critical connection between military recruitment and Latina/o students in the educational pipeline. The emergence of CRT came in response to the disparities within the United States legal system that disregarded the “lived experiences and histories of People of Color” (Yosso, 2006, p.5). The framework of CRT challenges the critical legal scholarship by disrupting the dominant ideology in giving voice to underrepresented groups of people.

Within the framework of CRT there are five tenets that are relevant to this study: (a) the *intercentricity* of race and racism; (b) the challenge to dominant ideology; (c) the commitment to social justice; (d) the centrality of experiential knowledge; (e) the interdisciplinary perspective. In the following section, I elaborate on each principle with the purpose of showing how military recruiters target Latina/o youth in low-income secondary institutions. This section also expands on demonstrating how the educational system affects the educational attainment of Latina/o CJ students by giving military recruiters unlimited backdoor access.

The first tenet, the intercentricity of race and racism, revolves around the idea that “race and racism are endemic and permanent in U.S. society” (Yosso,

2006, p.6). The concept of race is merely a social construct created by the dominant group that places racial/ethnic groups on different ladders of the racial hierarchy. In doing this, the power within the dominant group is preserved. This principle can be employed to military recruitment tactics and strategies that are practiced in public high schools across the nation, particularly Los Angeles County. Although military recruiters target youth of all backgrounds in every high school, they are more inclined to target students of color in working-class communities, such as Latinas/cs. Military recruiters realize that Latina/o students are more willing to join the military due to limited economic and educational opportunities. In recent years, the campaign Yo Soy El Army (YSEA) was generated by the U.S. Army to target the fastest growing minority in the U.S.: Latinas/os (Garza, 2006, p. 246). These factors determine that an examination of race must be considered to analyze the penetration of military recruiters in Latina/o working-class communities.

The second tenet, the challenge to dominant ideology, goes against the “traditional claims of race neutrality and objectivity” that serve as a disguise for the “self-interest, power, and privilege of dominant groups in U.S. society” (Yosso, 2006, p.6). Applying CRT to military recruiting challenges the idea of objectivity in military recruitment. By analyzing the high penetration of military recruiters in low-income public secondary institutions, it is evident that military recruitment does not offer objectivity and race neutrality. At the same time, CRT in education demonstrates the disparities within the educational system that tamper with the academic outcomes of Latina/o students. A particular disparity in low-income secondary institutions is the unlimited access that military recruiters have to interact with students and student information. High

schools in working-class communities firmly claim that every student receives equal academic opportunities to pursue postsecondary education, but the unlimited presence of military recruiters shows otherwise.

The third tenet, the commitment to social justice, takes the responsibility of “advancing a social justice agenda in schools and society” (Yosso, 2006, p.6). Although military recruiting in secondary institutions is permitted through the NCLB, there is also a provision that protects students to opt out from the military. However, students, parents, as well as educators are unaware of the opt-out form that exists to support students. By law, secondary institutions are required to release the opt-out form to its students. If high schools don’t provide the opt-out form to students, it is considered a violation of rights. Under the NCLB, secondary institutions also have the right to designate the number of times military recruiters are allowed on school grounds. Working-class communities are frequently unaware of these provisions that can assist Latina/o in opting out from the military. It is of crucial importance to advance a social justice agenda to protect student’s rights in low-income high schools with the purpose of reducing military recruiting.

The fourth tenet, the centrality of experiential knowledge, acknowledges that the experiential knowledge of People of Color is “critical to understanding, analyzing, and teaching about racial subordination” (Yosso, 2006, p.6). It is of crucial importance to value the voices of Latina/o students who consider military service instead of pursuing a postsecondary education in order to understand the factors that influenced them to make such a serious decision. In doing this, the experiences of Latina/o youth will impact how policy is drafted and implemented in education. The voices of Latina/o students in low-income communities are not

heard or listened to and this will allow them to freely express their experiential knowledge. The experiences of Latina/o students in low income high schools will serve as counter stories that will challenge the danger of the single story: majoritarian perspectives.

The fifth tenet, the interdisciplinary perspective, examines several factors from a historical and interdisciplinary perspective. These factors include: racism, classism, sexism, and homophobia (Yosso, 2006, p.6). Other fields of study such as Psychology, Ethnic Studies, and Sociology, will be incorporated and intersected into this research to provide a multidimensional perspective of how military recruitment in working-class communities impact the educational outcomes of Latina/o youth. These perspectives include pervasive issues such as racism and classism. Using concepts of other academic fields as well as CRT can uncover the forms in which military recruiters focus on Latina/o youth.

All in all, the five principles of CRT will assist me in foregrounding issues that have not been explored in the connection between military recruiting and Latina/o youth. Issues such as race and racism are pivotal for this examination. My intention is to demonstrate that military recruiting focus in working-class communities, such as Baldwin Park. At the same time, to show the unequal access to educational opportunities that Latina/o youth face in secondary institutions that have a heavy penetration of military recruiting.

Methods

The general framework of this research study adopted a qualitative approach. Because qualitative research data is a time consuming procedure, only a small sample was collected for this study. Samples of

four Latina/o youth participate in individual semi-structured interviews. This study involves research in performing a solid semi-structured interview. The use of semistructured interviews Eligibility to participate in this study was determined based on the following criteria: Latina/o youth between the adolescent ages of 18-24 considering military service or who are current active members of any military branch. Upon qualification, the participants received a consent form and a guide of the interview questions in order to prepare for the interview.

For the purposes of this study, the recruitment technique of snowball sampling was used to find research participants to assist in the research study. In 'snowball sampling,' the practice requires for the researcher to ask respondents to refer other possible respondents. The focus of this study is to obtain the experiences of former students of SVHS. It is important to note that the four participants recruited are former students of SVHS; this study was not conducted at the actual institution. A total of three males and one female were recruited and interviewed for this study. In order to conceal the participant's identity, I used pseudonyms in place of their actual name. The participants Andres and Luis are active members of the United States Air Force, while Edgar and Martha are active members of the United States Army. Each participant was informed that participation for this research study was completely voluntary and if they decided to discontinue participation, they were able to do so without penalty. At the same time, participants were informed that the interview was going to be audio recorded.

The study was not conducted nor was the data collected at SVHS, but rather through via Skype sessions and/or phone calls. Because the interviews were not made in person, I faced some issues that

delayed the process of data collection. The most common inconvenience that surfaced in the process of the data collection was finding a time frame that would accommodate the participant and me to schedule an interview. Since the four participants are active members of the armed forces, they are stationed in different locations around the world; thus, the tremendous time gaps became an issue. For this reason, collecting my data took longer than I had anticipated because the participants were not readily available. While conducting the interview, I experienced several technical difficulties, particularly poor connection. The main medium of communication that offered satisfactory connection was Facebook Messenger's phone. It was through this application that I was able to sustain a plentiful interview without interruptions of technical difficulties.

In order to develop a keen understanding of the research topic, I designed relevant semistructured questions to provide the opportunity of obtaining multiple perspectives of perceiving and understanding the topic at hand. The ten questions on the guide range from educational experience to familial background and military experience fit questions. These semi-structured interviews capture the experiences of Latina/a youth of this community who chose military service instead of a college education. Semi-structured interviews will also allow me to develop follow up questions to ask the participants. The questions were designed in a flexible form to allow the respondent to express her/himself at length. The interviews were tape-recorded and transcribed for evaluation.

Sample

The data for this project has been collected from four different individuals. Three males and

one female participated in this study and they are all currently enlisted in the military. The participants are: Andres, Edgar, Luis, and Martha. They are all former students of SVHS.

The first participant is a twenty-three year old male, Andres, born and raised in the city of Baldwin Park, California. The participant attended and graduated from Sierra Vista High School and joined the military shortly after graduating. He currently serves in the U.S. Air Force. A single mother who immigrated to the United States from Mexico raised him.

The second participant is a twenty-one year old male named Luis born in Duarte, California and raised in the city of Baldwin Park, California since the age of five. The participant attended and graduated from Sierra Vista high School and joined the military after he graduated. He joined the United States Air Force primarily because he witnessed his older brother join the military.

The third participant is a twenty-four year old female, Martha born and raised in the city of Baldwin Park, California. Presently, she is a member of the United States Army. The participant attended and graduated from Sierra Vista High School and joined the military a short time after graduation.

The fourth participant is a twenty-four year old male named Edgar born in East Los Angeles and raised in the city of Baldwin Park, California. He is currently a member of the United States Army and is married and has a seven-month old daughter. Edgar joined the military four years ago with the purpose of starting a successful future.

Findings

The following three themes are indicators of

why the participants chose to join the military rather than a college education: 1) Escaping Baldwin Park, 2) Casualties of a Broken Education System, 3) Military as the 'Better' Choice and 4) First-Generation Soldiers. The first theme, Escaping Baldwin Park, is defined as the desire to escape neighborhood violence or permanent uncertainty. Casualties of a Broken Education System describes Latina/o youth who have experienced the effects of inequity within the education system since this group continues to have the lowest educational attainment. The third theme, Military as a 'Better' Choice, explores the way in which Latina/o youth of this community consider the military as a better choice.

Escaping Baldwin Park

The circumstances that cause an individual to seek to escape a community are critical. To defer a college education is influenced in several ways by the atmosphere of the community. In the case of Andres, he shares he sought to escape the violent conditions he faced within his community and home. From an early age, he witnessed his uncles who were former gang members arrive to his home covered in blood. If that was not enough for a seven-year-old child, he also witnessed atrocious scenes of people getting shot in his front lawn: "My uncles were former gang members. Shootings going down all the time where I lived. I knew what marijuana was before I actually knew what the word marijuana meant. I would see people show up to our house and they would be covered in blood. I was only like six or seven." It is evident that the opportunities to the residents. The lack of educational or employment opportunities influenced Martha to enlist since it offered her the opportunity to obtain a stable

job to secure a good future.

Casual Ties Of A Broken Education System: Shifting Student Insecurities Into Recruiting Opportunities

Prior to graduating from secondary school, Andres did not consider college as a viable option. The lack of motivation that Andres faced during his secondary education prompted him to a great extent to join the military. While attending SVHS, Andres shares that his educational experience was average, but not challenging enough to undertake a college education. Andres describes a particular event that shifter his entire educational trajectory: "I never really got over the hump of math... Mr. Reynoso, pretty much looked at us as the delinquent children. So he didn't really teach so again I suffered more. He thought we didn't care about our education at all so he just passed out a worksheet and sat in the back of the classroom for the entire hour..." As a student, Andres recognized mathematics as his weakness since he had trouble understanding the subject. However, it is clear that Mr. Reynoso's failure to give instruction did not provide the foundation for math literacy, which suggests that he is a less-experienced teacher. Low-income institutions, such as SVHS, tend to place "the least experienced teachers" in the most low-income schools. (Yosso, 2006, p. 21). Indeed, allowing teachers like Mr. Reynoso who fail to properly instruct a classroom only hinders Latina/o youth access to the "ensuing levels of the educational pipeline" (Yosso, 2006, p. 21). It is evident that if Andres had received the adequate preparation to become literate in mathematics, college would have been a viable option. Andres became a casualty of the broken education system that pushed him out to consider military service as a potential educational or employment option. Stu-

dents like Andres and Edgar experienced the effects of inequity, which impacted their educational trajectory.

Another casualty of the broken educational system is Edgar because he lacked access to a quality education. Throughout the four years of his secondary education, Edgar never took honor courses or advanced placement courses until his senior year. AP psychology was the only college preparatory course Edgar took throughout his educational trajectory. While taking this course Edgar describes that, "AP psychology was a culture shock for me because I had never taken any advanced placement courses." Because Edgar had not been previously exposed to rigorous coursework, it is clear that this course became a pivotal turning point for his educational trajectory. For this reason, Edgar felt that he "was not competent" to pursue a post-secondary education due to the lack of academic preparation. Yosso notes that advanced placement courses "develop student's academic talents so they can continue to advance" (p.88). As a 'regular' student, Edgar never participated in enrichment activities to advance his talents because he was not identified as a gifted student by the institution. From an early age, Edgar was placed in a noncollege bound track, which hindered his potential from excelling academically and pursuing a post-secondary education. Navigating through the educational pipeline can be overwhelming for a first-generation, low-income student. The resources or information are not readily available for students of poor socioeconomic backgrounds and for this reason Edgar is considered a casualty of a broken educational system. In the realm of education there is a 'tracking' system, similar to a caste system according to Yosso, in which students receive different levels of preparation (Yosso, 2006, p. 87). This suggests that the broken educational system fails to serve underrepresented groups of students. It is

certain that Edgar could have followed a college education if had received the adequate preparation by SVHS, an institution that puts emphasis on military instead of college.

Similar to Edgar, Luis was not exposed to rigorous coursework throughout his educational trajectory until his senior year when he was placed in AP psychology. For the most part, Luis shares that education at SVHS was "too standardized" since "it didn't allow for creativity or self-expression ... it felt too robotic." Luis quickly lost interest in furthering his education because it did not challenge him to seek more knowledge. In a standardized based education, the pressure of excelling academically is placed on students rather than on educators. Teachers are not held accountable for the failures of the system and "they don't consider schooling conditions, lack of trained teachers" to be responsible for student's poor educational performance. Institutions give students an inadequate education and "blame them for not performing well (Yosso, 2006, p. 87). Luis describes that AP psychology shifted his expectations of education: The most challenging part of schooling was probably my AP psychology teacher which it was my only AP class I ever took and I never had that type of experience before. The whole AP experience was the most challenging for me. Again, Luis was placed in a non-college going track and denied access from rigorous coursework that could have potentially increased the chances of Luis pursuing a post-secondary education. This indicates that SVHS fails to challenge students to go above their potential, but rather promotes a military-going culture for students.

Martha's educational experience was average in her terms. In regard to her educational trajectory, she shares that SVHS treated students unequally

based on their academic potential. Martha was among those students who were not “college bound,” so for that reason teachers did not take interest in addressing her concerns. For this reason, Martha did not develop an interest to excel in her studies, but rather focused in pursuing other avenues. Martha shares that SVHS had a lot of “favoritism for the smart students” and disregarded those who appeared to have a lower potential. Martha recounts that her parents asked her to pursue a post-secondary education, but soon she realized that her experience at community college was not compatible with her desired ambitions. Pursuing a post-secondary education was not Martha’s plan because she knew college was not for her. This indicates that SVHS did not foster a college-going culture for Martha and other students. Students who shared a ‘low academic potential’ were disregarded and forgotten in the shadows. Martha was one of many students that were left alone in the shadows and feared pursuing a college-education. Instead of fostering of college-going culture, Martha became submerged in a military-going culture, which played a significant role in her choice to pursue military service.

In terms of nurturing a college-going culture, SVHS fosters a military-going culture for students. Edgar shares about the heavy presence of military recruiters: “military recruiters at our campus were there I wanna say once or twice a week.” It is more common to see a military recruiter on campus than a college recruiter. The presence of military recruiters in low-income communities is highly common and it is poorly regulated by school districts. Military recruiters find a student’s vulnerability as a positive factor for military recruitment. Student’s fall into a vulnerable state, especially if they feel incompetent for college, and military recruiters take notice of those indicators

and use them as an advantage to shift a student’s insecurities into opportunities.

Military As The ‘Better ‘ Choice

The military represents a symbol of hope for numerous Latina/o youth, particularly Andres. At one point, he shares that he lacked direction and became overwhelmed since he could not find employment or enroll in college. The overwhelming situation caused Andres to seek guidance from God with the purpose of receiving a sign to his future pathway:

I had no real plan than an attempt to go to college and just grab a job and help my family because of the whole economic recession and then after about a year with no luck I decided to take a trip to Colorado and go walk through the mountains and then somehow in my desperation I pretty much prayed to God that I just wanted to take care of my family...! didn’t know this at the time but I was actually really close to the Air Force Academy and I saw an aircraft fly over me through the mountains and then I just said, I gotta do this. And so I enlisted in the air force and my life has been all uphill...I’ve never regretted since.

It was in this moment that Andres understood that the military was a better option for him. The aircraft that flew over him caused him to experience an epiphany and realized that his prayers had been answered. The military gave Andres a second chance in building a future for himself based on his viewpoint. Because none of his other plans had followed through as he had anticipated, he knew that the military was a matter of now or never. Even though, Andres perceives that his

decision is the better choice, it is important to note that it was his last resort. In Andres' mind, there was no other opportunity that could give him everything the military offers.

The military is a symbol of honor and admiration within Luis's family, mainly because his eldest sibling served in the military and served two tours in Iraq. Edgar's brother set the expectation bar far too high and his ultimate desire was to follow his brother's footsteps: "What really prompted me to join was just how much of a man I saw of my brother became afterwards and I wanted that kind of recognition. I wanted to fall in his footsteps and kinda make him and my dad proud." This indicates that Luis' desire to join the military was due to familial support of the military. Luis's concern is bring honor within his family unit and be praised as much as his older brother. Because his brother served two tours in Iraq, there is a deep level of support for the military. Gina Perez (2015) asserts that "having an uncle, aunt, father, or cousin who is a veteran or currently in the military increased the appeal" of the military" (p. 42). It is evident that Luis views military service as the better option because his older brother served and became a contributing member of society. In Edgar's term, the best way to become a contributing member of society is to join the military. This suggests that Luis chose the military with the purpose of demonstrating his appreciation for his brother's service and to receive the same level of respect as his brother.

Discussion

The objective of this study is to bring social awareness in regard to Latina/o who defer a college education and join the military. The decision of defer-

ring a college education is determined mainly upon the lack of academic resources or socioeconomic barriers. To that end, the military becomes a viable option when college is a viable option.

The analysis yields interesting results. On first glance it appears that poor academic guidance and support did not impact an individual's decision to join the armed forces. Latina/o youth appear to be more willing to enlist in the military if a family member has previously served. However, demographic factors influence Latina/o youth to pursue the military as an educational or employment avenue, rather than to pursue a post-secondary education. The population of Latina/o youth differs; with the most ill equipped for college tend to be more inclined to serve in the military. Also, Latina/o youth who receive a rigorous academic preparation are less likely to enlist in the military and more likely to excel academically in postsecondary studies.

This analysis determines that the experiences of Latina/o youth are pivotal in order to gain a deeper understanding of the push factors that have an influence on pursuing a post-secondary education. Documenting experiences of minority groups, particularly Latino/a can help insulate the leaks within the educational pipeline with the purpose of increasing the educational attainment. While additional research is required to determine why Latinas/cs choose to defer a post-secondary education, the implications of these results are valuable.

In terms of theory, these results call forward the need to rethink the relationship between Latina/o youth and the military. As indicated by the results and previous literature on the topic, there are multiple circumstances that indicate the military is a source of upward mobility for working-class families. The perception of the military within the Latina/o youth

community demonstrates a sense of moving toward acculturation. The participants do not perceive that serving in the military contains a knapsack of privileges that a college education does not provide. For these participants, it is more rewarding to wear the uniform because it ensures admiration and respect from the community; they seek acceptance. The results, therefore, suggest that by joining the military, members of working-class families gain access to escalate the social ladder.

Evidently, these findings also indicate that receiving an education is not a viable option for these participants. The results reject the idea that Latina/o join the military voluntarily. Instead, the results indicate that Latina/o youth of working-class communities join the military because they become confined by neighborhood violence, a state of uncertainty, and lack of an adequate academic preparation. For this reason, the participants consider the military as the best option because it has placed them on path of guaranteed success. In other words, the participants do not envision their life without serving in the military. In the participant's perspective, the military has offered the opportunities, each of varying degrees, that are non-existent in a civilian society.

What do these findings imply about Latina/o youth who defer a post-secondary education to join the military? Most fundamentally, there are a number of contributing factors that lead an individual to pursue the military. The experiences of working-class people result useful in examining the factors that influence the motivations of Latina/o youth to pursue a college education. The low educational attainment of Latina/o youth indicate that the education system does not properly serve underrepresented groups of students. Numerous individuals have become casualties of the

education system and is crucial to implement intensified demands against educational inequity with the purpose of increasing the educational attainment of every racial/ethnic group, especially Latina/o youth who remain at the bottom of the educational pipeline. This would definitely challenge the existing structure of education that is founded on principles of inequity. It is important to always note that the military is an institution that focuses primarily on individuals of poor socioeconomic backgrounds who are uncertain. Pursuing a postsecondary education should be the primary course of action for Latina/o youth and it must be perceived as a source of upward mobility. Showcasing the experiences of disenfranchised groups of people brings light to the issues that permeate within society. In doing this, it will reduce the number of casualties within the education system and improve the educational attainment of Latina/o youth.

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California State Polytechnic University, Pomona Informed Consent Form for Research Involving Human Subjects

You are being invited to participate in a research study, which the Cal Poly Pomona Institutional Review Board (IRB) has reviewed and approved for conduct by the investigators named here. This form is designed to provide you -as a human subject -with information about this study. The Investigator or his/her representative will describe this study to you and answer any of your questions. If you have any questions or complaints about the informed consent process of this research study or your rights as a subject, please contact the Compliance Office within Cal Poly Pomona's Office of Research and Graduate Studies at (909) 869-4215.

Project Title: The Militarization of Latina/a Youth IRB# 15-0315

Principal Investigator: Estephanie Munoz (Tel:

This study involves research in performing a solid semi-structured interview. You will first be asked a set of primary questions and based on your responses there will be space for follow-up questions. You will then be given a series of follow up questions that will add experiential knowledge to your response. In other words, you have the flexibility of sharing answers based on your general experience. There will be 10 questions in this interview. You may answer the questions at your own pace. The interview will take approximately 1 hour to complete. These semi-structured interviews are simply a form of sharing your experience, and we do not anticipate you experiencing any discomfort or

other negative feelings when responding to items in this study.

Your participation in this study is completely voluntary. Should you decide to discontinue participation, you may do so without penalty. You may also skip any item you do not wish to complete. Your participation in this study may help you understand the leaks in the educational pipeline and the factors that prompt students to join the military. We are not asking you to place your name anywhere, so your participation is confidential. None of your answers can be directly traced back to you. After you complete the interview, you may request a copy of the conversation.

Should you have any further questions, please feel free to contact the study's principal investigator, Estephanie Munoz, a student at Cal Poly Pomona. My number is _____, and my e-mail address is _____.

CONSENT STATEMENT:

I, _____, hereby give my consent to participate in the research study entitled "The Militarization of Latina/a Youth." I have read the above information and am aware of the potential risks and complications. I fully understand that I may withdraw from this research project at any time or choose not to answer any specific item or items without penalty. I also understand that I am free to ask questions about techniques or procedures that will be undertaken. I am aware that there is no compensation for my participation. Finally, I understand that information obtained about me during the course of the study will be kept confidential .

Participant's signature (18+ years of age)

Date

I hereby certify that I have given an explanation to the above individual of the contemplated study and its risks and potential complications.

Principal investigator/Date

Witness/Date

Interview Questions

1. Tell me about yourself. Please state your age and name. Where were you born and raised?
2. Describe your parents and family background.
3. Describe the community you grew up in. What high school do you go to? Describe your neighborhood.
4. Describe your educational experience. Tell me more about your schooling. Was it generally positive or challenging?
5. What were your most and least favorite subjects in high school? Did you have any memorable teachers?
6. What were your plans when you finished high school? What are your long term plans?

7. What prompted you to join the military? What do your parents think about your plan to join (or if you're already enlisted) the military? Do you have family members in the military? Or family members that have served in the military?

8. How of ten did military recruiters visit your high school campus? How of ten did college recruiters visit your high school campus?

9. How informed were you about military service prior to enlisting? Have you heard about the opt-out form in your high school campus? Prior to enlisting did you express your concerns and questions to a military recruiter?

10. What does the military uniform mean to you as a Latina/o? What does it mean to you?

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