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Spectrum

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LETTER FROM THE EDITOR

Welcome to the 2019 edition of *The Undergraduate Spectrum*, a journal showcasing the rich diversity of artistic and rhetorical practice at Saint Mary's College of California. Published here are winners of the 29th annual Newman Awards for writing in Collegiate Seminar and the 31st annual Spectrum Awards for writing in the disciplines.

Each year, the difficult task of narrowing the field of submissions requires much serious deliberation by our diverse panel of judges, consisting of both professors from across the curriculum and student Writing Advisers in the Center for Writing Across the Curriculum (CWAC). Accordingly, we extend our deepest appreciation to all the professors who nominated their students' writing in 2018, to all the students who submitted their own writing, and to all the judges who gave of their time and wisdom during the selection process.

Following the first round of selection, a staged editing process, mirroring that which occurs when writers work with professional publications, brings finalists to CWAC to work with a Writing Adviser as they revise their work through three drafts. Working with Advisers, finalists review both idea- and sentence-level issues and refine and resubmit their pieces for final consideration. Winning texts are then selected from among these finalists.

This year marks the sixth in which students from the practicum course COMM 190 applied principles of copy-editing and design learned in the classroom to the publication of this journal. COMM 190 fosters a creative environment for Saint Mary's students to produce this publication, and we are grateful for the collaboration and support of the Communication Department, particularly Chair Aaron Sachowitz, in helping us shape this course.

We are also grateful for the contributions of the student artists whose visual works grace these pages and to Art and Art History Department, particularly Chair Costanza Gislon Dopfel, for their commitment to this journal. Please see page 87 for submission guidelines.

Joe Zeccardi

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Necessary Matriarchs: The Switching of Gender Roles in *The Bottom*

Lindsey Calvin

In her 1973 novel *Sula*, Toni Morrison presents *The Bottom* as a community controlled by matriarchs. Mothers like Eva and Helene are provocative and dignified, stubborn and strong. They lead their households independently. Compared to the overwhelming presence of the mothers, the fathers fade into “incomprehensible” minor characters (Morrison 52). Even the childless men of *Sula* slip into the background; they are reduced to sex objects, labeled by their “creamy haunches spread wide with welcome” (51). *Sula* explores a switching of gender roles, as the mothers provide for the family while the men of the town “sat tasting their teeth and waiting for something to distract them” (49). Dysfunctional fathers are made up for by sacrificial mothers. The turnover of control to the matriarchs of *Sula* is a reversal of gender conventions, but is widely accepted by the community as the men are incapable of fulfilling what is expected of them. Mothers in this text are forced into the role of caretaker and provider, and their experience provides a new understanding of “motherly love.”

Eva, *Sula*'s strongest matriarch, contrasts sharply against her inept ex-husband BoyBoy. His very name is a signifier of his lack of maturity, of his inability to fulfill the husband role: “He did whatever he could that he liked, and he liked womanizing best, drinking second, and abusing Eva third” (32). BoyBoy does not attempt to work. He spent most of his time not at home but in other women's beds, abandoning his responsibilities as a father. To BoyBoy, Eva is not a partner or a supporter in times of unemployment but rather someone to be dominated. BoyBoy's troubles could very well have started with a lack of job opportunities and a subsequent loss of purpose. Perhaps he believed that this inadequacy could be remedied by proving his masculinity in other realms – hence the “womanizing” – but all that is

proved is his own BoyBoyish nature. So little is seen of him in the novel, yet his immaturity catalyzes Eva's sacrifice: the removal and sale of her left leg. She had run out of provisions and her three young children wallowed in hunger. Instead of abandoning them in their starvation, Eva sells part of herself to ensure that food can be put on the table. Juxtaposed against Eva's devotion, BoyBoy is portrayed as selfish and incompetent. The “defeat in the stalk of his neck and the curious tight way he held his shoulders” when he visits Eva is a manifestation of a painful realization: despite his “new money and idleness”, Eva fills the provider role better than he ever could (36).

While BoyBoy's absence and descent into dysfunction seems to be of his own choosing, the plight of Jude offers an alternate portrayal. Nel's husband Jude makes a sincere attempt to be a conventional husband and father. He knows what is expected from a man and wants to meet those expectations: “Jude himself longed more than anybody else to be taken. Not just for the good money, more for the work itself” (81). His desire to work on the road shows an understanding of his responsibilities – he wants to earn money because his job “wasn't nearly enough to support a wife” (81). He also wants to “do real work” (81). Perhaps this desire to “do real work” can be read as a desire to do manly work, to prove his masculinity in a world where the “white man [is] running it” (102). But because young black men such as Jude are excluded from the road work, he is prevented from completely fulfilling those expectations. Men like Jude are left feeling powerless and inadequate. The tinges of dominance and fulfillment that Jude most likely experienced in his affair with Nel's best friend Sula attempt to fill the masculinity void created by his unemployment. As Jude searches for something or someone to make him feel functional again, Nel takes the head of the household out of necessity,

just as her own mother Helene did during the long absences of Nel's seaman father.

Matriarchs such as Eva are accepted because they come as a result of a chain of events, events that are often out of the hands of community members. Men are perpetually left out of meaningful work, perpetually without purpose or an ability to meet responsibilities, perpetually looking for fulfillment and a chance to feel adequate. This is evident to the entire community, especially those who walk past the men lounging in front of the pool hall, past the "inchworm smiles, the squatting haunches, the track-rail legs straddling broken chairs[, t]he cream-colored trousers marking with a mere seam the place where the mystery curled" (50). Everyone in *The Bottom* is aware that "a Negro man had a hard row to hoe in this world" (102). Therefore, the acceptance of motherly power in *The Bottom* is not so much a conscious rewriting of social norms but rather an allowance made because the men are unwilling (BoyBoy's case) or unable to use their fatherly power.

As the mothers of *The Bottom* have taken over the responsibilities of both parents, "motherly love" has been redefined. Sentimentality is stripped away from motherhood, as seen with Eva and her aforementioned sacrifice. Her daughter Hannah asks if Eva loved them: "I know you fed us and all. I was talkin' 'bout something else. Like. Like. Playin' with us. Did you ever, you know, play with us?" (68) Hannah's conception of motherhood is one that includes playing and laughter and love shared through gentle caresses. But just as *Sula* portrays fathers who break gender norms because they don't support their families, the novel portrays mothers breaking the norms and becoming both mother and father. "They wasn't no time", Eva says, to be playing when she had "three beets to my name" and children with mouth sores and constipation (69). To Nel and Sula, this brand of motherhood feels "distant" (52). That feeling comes from a lack of expected warmth, as seen when Hannah

admits that "...I love Sula. I just don't like her" (57). There is an implied argument that liking a child means playing with them, while loving them is about keeping them alive even when there is no food and no money to get it (68).

Motherhood is deconstructed into something unfamiliar and almost harsh, but this is a necessary deconstruction. And as Eva says, "Don't that count? Ain't that love?" (69) Through its portrayal of matriarchs, this novel offers a defense for mothers like Eva who are condemned for not loving their children. When the fathers are not being fathers, motherhood looks different. *Sula* therefore portrays men and women in perhaps the most basic binary: men looking to dominate and women trying to keep the children alive.

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Author's Note

This essay began as most do: with an observation and a slew of questions. *Sula* is a novel about strong women, and I couldn't help but notice the generational quality of their strength, strength that seemed to be passed down from mothers to their daughters. I set out to explore the mothers and the absent fathers provided a sort of framework, a contrast to build from. Where did the fathers go? Why do the mothers read as harsh and proud?

Why did Hannah feel the need to ask her mother if she loved her and her siblings? In writing "Necessary Matriarchs" I had to come to terms with the quiet heartbreak of single motherhood: you could literally sacrifice your body for your children, yet they still question your love because it looks different than typical motherly love. That emotional aspect added a strange new element: I felt as if I had to explain their meanness, to defend them even though they don't need my defense. I therefore had to come to terms with the continuum of motherhood. A soft-spoken woman who never has to worry about whether her children are going

Men like Jude are left
feeling powerless and
inadequate.

hungry is not a better mother than someone like Eva or Helene; different does not mean better or worse. These tangents regarding motherhood combined to form the soil from which my essay could grow.

While I am indebted to many (my parents, the CWAC staff, my classmates and friends), “Necessary Matriarchs” is dedicated to someone who, with kindness and a touch of sass, nurtured her students as a mother would: Professor Sandra Grayson. Professor Grayson, from my first day of class as an English major, you have made me feel at home in the department. You have held my respect and admiration for so long with your wit, your patience, and your incredibly extensive movie knowledge. You have a Dumbledore-like presence and have always viewed inexperience as an opportunity rather than a setback. Thank you for all that you gave to me and to the entire Saint Mary’s English department. You are a legend. And thank you for pushing me to submit this essay to *The Undergraduate Spectrum*. In returning to it and revising I am reminded of how this world needs strong, fierce women – women much like yourself.

In Defense of Counterintuitivity

William Roush

“Definition Five of Euclid’s *Elements* is problematic. Confusing prose and a counterintuitive approach to ratios engender a frustrating definition which is, at first glance, impenetrable. It reads, ‘Magnitudes are said to be *in the same ratio*, the first to the second and the third to the fourth, when, if any equimultiples whatever be taken of the first and third, and any equimultiples whatever of the second and fourth, the former equimultiples alike exceed, are alike equal to, or alike fall short of, the latter equimultiples respectively taken in corresponding order’ (99; Book V). Only Euclid could find a way to make such simple ideas complicated. This definition merely complicates ideas that everyone knows intuitively.”¹ These might be the statements of an uncharitable, sophomoric reader in response to Definition Five. However, such a reader has a point. Both a mouthful to say and a difficult idea to digest, Definition Five is frustrating. Yet, it is also the essence of Book V. The definition carries within it the idiosyncrasies of the book which can be called into question.² To examine the underlying structure of the definitions in Book V is to examine many of the important questions within the book as a whole. Namely, Definitions Three, Four and Five’s intriguing use of the word “same” all serve as ways to better understand this supposedly impenetrable text.

Definition Three states, “A *ratio* is a sort of relation in respect of size between two magnitudes of the same kind” (99; Book V). This definition assumes that it is known intuitively what a magnitude is. Although the term is clear when looking at the magnitudes illustrated in Book V, it is not clear what qualifies as a magnitude without such examples. Further, it is even less apparent

what should be considered a thing which is of the same kind as another thing. The reader is left with many questions and no answers, at least until Definition Four.

Definition Four declares, “Magnitudes are said to *have* a ratio to one another, which are capable, when multiplied of exceeding one another” (99; Book V). This is where the definitions may appear to go awry. Why is it that things of the same kind must be multiplied in order to have a ratio? Is it not the case that magnitudes of the same kind inherently have a ratio, that is, a relationship with respect of size? The answer to this question answers both the curious ambiguity in Definition Three and substantiates the need for the line “which are capable, when multiplied of exceeding one another” (99; Book V). A thing is known to be of the same kind as another thing when it is capable of being multiplied to exceed that thing. There is no capability to say that things inherently have a ratio until they are known to be of the same kind, and things are known to be of the same kind when they can be multiplied to exceed each other. For example, the length of a book cannot be compared to the volume of a speaker. This is because, at least in Euclid’s view, no multiplication of the length of the book could ever exceed something measured in decibels. The two magnitudes are simply incomparable. Having identified the potential problems in Definitions Three and Four, now remains the intriguing use of the word “same” in Definition Five.

The word “same” in Definition Five is a bold word. Its boldness lies in the fact that things can be said to be different but equal, but things cannot be said to be the same but unequal. In other words, all things which are the same are equal but not all things which are equal are the same. For example, Proposition 11 states, “Ratios which are the same with the same with the same ratio are also the same with one another” (109; Book V). To say that the ratios are the same is also to say that they are equal,

1) The quotes here indicate the words of a hypothetical contrarian.

2) The definitions in the books can only be questioned from a perspective of consistency. The truth of their claims is given, much like the givens within the Propositions.

and even further, that they are identical. Another particularity of Proposition 11 is its potentially circuitous route of explaining itself. For if using the word “same” is to also include the word “equal”, then it is possible to apply Common Notion 1 to the proposition and call it complete. However, this simplistic and intuitive route is unlikely to be taken by anyone who saw it necessary to prove that two sides of a triangle added together are greater than the remaining side.

Book V can appear needlessly confusing due to its use of what appears to be counterintuitive ideas applied to an intuitive concept such as ratio. However, a full examination of the definitions reveals that Euclid is choosing to *refine* the intuitive idea and make it more specific in order to avoid ambiguity and confusion. One reason Euclid might not define the term “magnitude” is because he, as a geometer, has no interest in exploring what it means for something to be a magnitude. Instead he narrows his aim, allowing him to operate in his constructions and utilize a precise form of the idea of ratio. So, the frustrated reader who claims that Book V is counterintuitive is partially correct. What such a reader misses is that it *should* be. A book of any kind which challenges the intuitions and assumptions of the reader is exactly what should be sought after if the reader wishes to learn anything new.

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Euclid. *Elements*. Translated by Thomas L. Heath.
Edited by Dana Densmore. Green Lion
Press, 2017. Print.

Author’s Note

The writing of this essay began the first day my Freshman Mathematics cohort opened our copies of Euclid’s *Elements* to Book V. It is from my various class discussions that the ideas driving this paper come from. In fact, the reader I refer to is an exaggerated version of myself. I was the one who so quickly took issue with Euclid and was so bewildered by Book V. Perhaps that is why I was so comfortable calling him “sophomoric.” However, my numerous struggles with the text

made it difficult to complete my assignments. I found, given my many problems with the text, demonstrating the propositions to my class required a sort of doublethink I am incapable of. Wanting to complete my homework and knowing that it is uncommon to be right when disagreeing with Euclid, I investigated my questions from the perspective that I was missing something. The fruit of that study was a firmer understanding of Book V and a greater lesson learned, a lesson which inspired the title and conclusion of my essay.

I would like to thank the following: my cohort for so kindly putting up with my endless questions, Tutor Ted Tsukahara for granting me the freedom to explore my curiosity and guiding it when necessary, Tutor Steve Cortright for additional guidance with my questions, my friends and family, and my kind editor Rachel Telljohn.



An Analysis of “Danny Boy”

Isaac Choi

Socrates described the human soul as a form of musical harmony, meticulously arranged by a maker god. Though purely parabolic in nature, the myth highlights the undeniably intimate connection between humankind and music. Like a mystical incantation, music can move the deepest parts of the soul with mysterious power, drawing out emotions and experiences too great or too subtle for speech. Perhaps no music does this quite like folk music, for such songs come from the very heart of a people. They are shaped by the voices of the everyman: the coarse call of the patchwork farmer, the homely melody of the country wife. Folk songs can be sung and understood by all, conveying common struggles and desires from the ground level. “Danny Boy” is one such song. The iconic lyrics to the piece were originally penned in 1910 by an Englishman, Frederic Weatherly. However, “Danny Boy” as it is known today, truly took shape in 1913, when adapted to the tune of a traditional Northern Irish folk song called “Londonderry Air”. Combining a masterful melody with honest words, “Danny Boy” speaks to the dual nature of humanity, both the frailty of human life and the undying devotion that makes people whole. It brings both these themes together, knitting them into a single, beautiful tapestry of mature resignation and resolute hope in the face of change and uncertainty.

From the beginning, “Danny Boy” weaves elements of duality into its melody. The version of the song discussed herein, arranged by Bernard Dewagtere, is in the key of C major, a decidedly high tonal range. Accordingly, all the notes in the melody play out in a middle to upper range along the musical spectrum, the lowest note being an A4 and the highest note being an E5 (Dewagtere 1-4). Such lighter tonal arrangements would usually accompany sunnier melodies, communicating feelings of happiness to the listener. But “Danny Boy” does something different. Here, the major

mode generates a far more solemn atmosphere. This is due to the particular notes utilized in the melody and the way in which those notes progress. The song begins below the staff on a low B4, stepping up to middle C, then up again to D4, breaking into the staff at E4, before returning to D4 (Dewagtere 1-2). The music continues in like manner before coming to a rest on middle C, closing out the first period (Dewagtere 2-4). Though the notes fall into a comparatively higher range when viewed in light of the larger musical spectrum, in the context of their given key, they are strikingly low. Most of them lie on or below the staff, never straying too far from that quintessential middle C. In short, though the key is higher, the individual notes are lower. This juxtaposition of tone affords the song a sense of nostalgic gravity, even irony, like a memory of distant warmth or sunshine at a funeral.

Further, these deeper notes progress in a remarkably even pattern, gently ascending and descending in a steady series of successive steps. Though there are small jumps between notes, such moves are minor and quite uncommon, an occasional skip up from E to A for instance, or from A up to C. In the first and third periods which follow this arrangement, there are no great leaps or deep drops; each subtle step follows its natural path through the staff. The even temperament of the music matches well with the sentimental quality of the words. Every lyric is laden with longing, a feeling made especially apparent in the first segment of the song. “O Danny Boy,” it begins, “the pipes the pipes are calling / from glen to glen and down the mountain side / The summer’s gone and all the flowers dying / ‘tis you, ‘tis you must go and I must bide” (Weatherly 1). Here, the words and melody work in conjunction to express sentiments of change and parting. As the lyrics go, “O Danny Boy,” the E4 note on “Boy” is held for an extra half beat, as though the singer is reaching

out with hand and voice to Danny. At “’tis you, ’tis you must go and I must bide,” the E4 on the second “you” is likewise syncopated (Weatherly 1). The middle C on “bide” is emphasized by virtue of its position as the last note of the period; it hangs in the air for as long as the performer chooses to hold it and rings out in the subsequent silence. In every case, each elongated word potently reflects the poignant themes of separation and longing.

In the midst of this incompleteness, there is also a feeling of profound resignation. The level intonation of the music leans not toward lamentation but to a more even-tempered mourning. Once more, the lyrics augment the tone of the music with its particular word choices. Rather than linger on memories of the past, the singer instead focuses entirely on the present, “the pipes are calling... the flowers are dying” (Weatherly 1). This present-tense focus leaves no room for bemoaning the former days. Rather, the circumstances, sad though they may be, are approached with a mature acceptance not often found in the face of tragedy. This attitude is emphasized further in the third verse, “And when you come and all the flowers are dying, / if I am dead, as dead I well may be; / You’ll come and find the place where I am lying and kneel / and say an “Ave” there for me” (Weatherly 2). Just as the singer is resigned to the reality of separation, so too is this person resigned to the possibility that Danny will return too late, that the two will be divided again by the gulf of death. Here, we see the transient nature of human life made manifest. In this world, nothing lasts forever. The singer’s evocation of natural change highlights this. Just as flowers fall and summer fades away, so too must death and parting be.

Thus, the period concludes on middle C, mirroring the key of C that the song started in; musically, everything has come full circle. The song could very well end here, but instead it begins anew, bolder than ever, for there is more to this story than longing and resignation. All things must pass, that

is true, but there is one thing that remains steady, one sure thing that survives death and outreaches distance: love. It is love that lifts mortal humanity above the dust, love that causes them to hope. While life is transient, love is transcendent. Accordingly, this portion of the song that sings of love swells in a grand crescendo, rising to unprecedented heights. This grand elevation happens suddenly, springing four whole notes from C4 up to G4, a leap unforeseen in all the melody thus far. From thence, the music makes a steady ascent up the staff to A5, then B5, then C5, before gradually descending to G4. Then from G4, the music leaps all the way up to E5, the highest note in the whole

melody, continuing thus gallantly until the song comes to a close. This segment, containing the second and fourth periods, is the most dramatic of the entire piece. It is the answer to which the previous verses

Here, we see the transient nature of human life made manifest.

allude, an idea brightly reflected in the lyrics. Whereas the first verse spoke of separation and change, the second sings of constancy amid that change: “But come you back when summer’s in the meadow, / or when the valley’s hushed and white with snow, / ’tis I’ll be here in sunshine or in shadow, / O Danny Boy, Oh Danny Boy, I love you so” (Weatherly 3-4).

The last note on “so” is a C4, mirroring the end of the previous period while simultaneously shining new light on it. Amid all the impermanence of life, the singer smiles; for though the seasons shift, this love shall not. That unwavering assurance empowers the singer to be content in hopeful resignation. Even as early as the third verse, this hope is foreshadowed: “You’ll come and find the place where I am lying / and kneel and say an “Ave” there for me” (Weatherly 3). Though death should come between them, the singer is fully confident of Danny’s return, for their love defies death. The effects of this bond are powerfully displayed in verse four: “And I shall hear though

soft you tread above me, / and all my grave will warmer, sweeter be, / for you will bend and tell me that you love me / and I shall sleep in peace until you come to me” (Weatherly 4).

Still, the sense of longing persists. The promises spoken throughout the song remain unfulfilled. The singer must still wait for Danny. The song ends with the line, “I shall sleep in peace until you come to me” (Weatherly 4). This line may be interpreted in an immediate sense or in a more abstract one. In the former case, the singer shall wait for Danny to return home and say his love-laden “Ave”. Meanwhile, in the latter case, the singer will wait for a full reunion with Danny in the next world. Both possibilities require nigh on eternal patience, which the music conveys in its final note. Unlike the first and third periods, this last period does not end on a C to match the overall key, but rather, on the highest note, E4. Musically speaking, such a note would usually indicate a transition point, not an ending. The music climbs up and up, but rather than return to level ground as one would expect, it stops on a veritable cliffhanger, lingering at the tonal peak. This move is quite unorthodox, to say the least. But for “Danny Boy”, such a conclusion is more than fitting. In accordance with the overall theme, we are left not with a fulfillment but with an open ended promise, a promise that the music, like the singer’s steadfast devotion, will persist even after the song ends.

Thus, “Danny Boy” portrays the duality of human nature, the brevity of life and the immortality of love, uniting musical and conceptual opposites throughout the piece. The higher key, juxtaposed with lower notes in the opening periods, sets a tone of solemn yearning. The near linear progression of those notes combined with the simple, present-focused lyrics conveys a sense of resignation amid sadness. Yet within this resignation lives an indomitable spirit of hope founded on love, which comes to bear in full force in the finale. There, the notes soar to unprecedented heights, dramatically leaping along the staff as the singer exults in the thought of reunion with Danny. These events have yet to be fulfilled, but until that day, the singer will

wait, patient in longing and steadfast in love. Far from abstract concepts, these are powerful realities unique to humankind. As such, they must be experienced from a distinctly human perspective, with two feet on the ground. Folk songs like “Danny Boy” remind us of these realities. They demand no great knowledge from singers or listeners, but invite all to partake, for all will recognize the sentiments therein. They are the songs of the everyman, the songs of the heart, harmoniously flowing from the depths of the soul.

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Author’s Note

Initially, this essay was written as an assignment for my first-ever music class, a simple paper to show what I’d learned about music theory and style up to that point in the course. I chose to write about “Danny Boy” in particular out of a nostalgic attachment to the song I’d developed during the previous year. Over the process of developing the paper, I had a series of discussions with my music professor about the content of the song, how the different aspects worked together to form a harmonized whole. Of note, I learned that the melody had no single, identifiable composer, unlike the lyrics, which could be credited to a single source. Furthermore, there were multiple versions of the melody in circulation, requiring me to focus on a single version of the piece to discuss. Though I was new to the world of music theory, overall, I found the process of writing the analysis quite enjoyable, and I turned in the assignment satisfied, hoping for approving marks. Imagine my surprise when, a few months later, I received a congratulatory message from the CWAC office, that my professor had submitted my essay to a panel of judges for possible publication!

I am currently a sophomore at Saint Mary's College of California, majoring in the Integral Liberal Arts Program. At the time of writing this note, I am in Rome, studying ancient philosophy and literature. So far, the experience has been challenging, but also highly satisfying. In preparation for publication, I have been aided and encouraged by many. First and foremost, I thank my mother, for a great deal of moral support and an ever-available second opinion. I must also thank my music professor, Tutor Julie Park, for acknowledging my writing and bringing me this opportunity. Much thanks are owed to Joana Rowlands at CWAC, for all her advice in editing my essay. I never walked away uninspired! Last but certainly not least, I owe thanks to the judges for their gracious complements and wise critiques. I truly appreciate every single one!

Origins and Evolution of Arbuscular Mycorrhizal Fungi

Ashlynn Yap-Chiongco

One of the central tenets of biology is that everything is connected. Consequently, living systems, far from being simple, are full of complex interactions which shape the world in which live. Illustrative of this concept is the rich microbial community that inhabits the soil surrounding plant roots, called the rhizosphere. The interactions that take place in this region impact every aspect of plant life from seedling establishment to growth rates and are crucial components to the cultivation of crops on which humans rely for food and goods. Arbuscular mycorrhizal fungi (AMF) are among the most important microorganisms which inhabit the rhizosphere. AMF form mutualistic symbioses with over 80% of vascular land plants as well as many basal non-vascular plant lineages such as hornworts and liverworts (Bonfante & Genre 2008). These symbioses are formed when biochemical signaling, primarily via strigolactone root exudates, attracts fungal partners to plant hosts (Delwiche & Cooper 2015). The fungi penetrates the cortical tissue of the host plant and extensively colonizes its root system (Bonfante & Genre 2008). During colonization, AMF form specialized structures called arbuscules which allow the fungi to exchange valuable nutrients such as nitrogen and phosphorous for carbohydrates from its plant host. This exchange increases the fitness of both partners, resulting in increased growth and productivity. In spite of the benefits of this symbiosis, the origins and evolutionary processes by which AMF-plant mutualism formed are not well understood. However, in the last decade much progress has been made in understanding three key components of this relationship: when the symbiosis between land plants and AMF arose, the context in which the symbiosis arose, and what taxa formed these relationships over time.

A 2008 review by Bonfante and Genre presents a broad overview of the current knowledge

regarding AMF-plant mutualism. It was widely assumed that the pervasiveness of this symbiotic relationship was due to millions of years of co-evolution. To verify this assumption, the authors synthesized evidence from the fossil record and paleobotanic data to establish a possible timeline for the origin of the AMF-plant relationship. Vascular plant fossils from the early Devonian Period with endophyte colonies morphologically identical to AMF were discovered in 1975. This implied that the mutualism is at least 400 million years old (Bonfante & Genre 2008). In 2000, fossils of isolated Glomeromycota-like fungi from the Ordovician Period led researchers to hypothesize an even earlier origin, approximately 460 million years ago (Bonfante & Genre 2008). However, these fossils provided only indirect evidence for this timeline as the fungi discovered was not associated with a plant host (Bonfante & Genre 2008). In the greater context of plant evolution, an origin during the Ordovician Period has interesting implications. Plants have a unique life cycle called alternation of generations which involves shifting between two distinct forms, the haploid gametophyte and the diploid sporophyte. The earliest land-colonizers arose during the Ordovician Period, 470 to 500 million years ago. These were small, non-vascular plants with a dominant haploid gametophyte stage and simple root-like structures called rhizomes. Around 430 million years ago, vascular plants with a sporophyte-dominant life cycle arose, and approximately 395 million years ago they evolved true root systems (Bonfante & Genre 2008; Delwiche & Cooper 2015). The dramatically increased efficiency of water and mineral uptake by true root systems led to the rapid diversification and eventual dominance of vascular plants. If the AMF-plant symbiosis was indeed established 460 million years ago, then AMF would have been present during both of these important

transitions in plant evolution: from gametophyte to sporophyte dominance and from rhizomes to true root systems.

Bonfante and Genre discuss researchers attempts to support this potential origin by examining the colonization mechanism of the plant host. Studies of early non-vascular and vascular plant lineages indicated that both groups share two key mechanisms (Bonfante & Genre 2008). The first shared mechanism is the construction of the prepenetration apparatus (PPA) in the plant. The PPA is an assembly of organelles, cytoplasm, and cytoskeletal elements that establishes the trajectory of penetrating hypha in the plant tissue prior to colonization (Bonfante & Genre 2008). In both haploid rhizoid and diploid root tissue the process of cell wall formation is co-opted to build the PPA (Bonfante & Genre 2008). The second mechanism shared by gametophyte- and sporophyte-dominant plants is the formation of the perifungal membrane, which is constructed by the PPA in both groups. This membrane is a novel apoplastic compartment which envelopes the fungal hypha once it has colonized the plant tissue (Bonfante & Genre 2008). In addition to these shared mechanisms, the lack of any aquatic plants that form AMF symbioses implies that the mutualism was established after the transition of plants to land (Bonfante & Genre 2008; Delwiche & Cooper 2015). These findings provide strong evidence for the existence of a relationship between AMF and land plants prior to the two transitions in plant evolution. Further, they allow Bonfante and Genre to argue that AMF was likely an important factor in the original establishment of plants in harsh terrestrial ecosystems.

A subsequent study performed in 2010 by Wang et al. examined Bonfante and Genre's 2008 review in more detail. Wang et al. discuss the "mycorrhizae landing" hypothesis that AMF-plant relationships originated 460 million years

ago when non-vascular plants were dominant and were an important factor in the colonization of terrestrial ecosystems. Wang et al. argue that this hypothesis must be examined more rigorously for two reasons. First, the fossils from the Ordovician only provide indirect support because they do not contain AMF-like fungus actually colonizing plant tissue; they only show isolated fungi. Second, the homologous mechanisms of PPA and perifungal membrane formation in haploid rhizoid and diploid root tissue do not directly prove that AMF persisted through the shift from gametophyte- to

sporophyte-dominance (Wang et al. 2010). Wang et al. propose the "host-shifting" hypothesis as an alternative evolutionary timeline. This hypothesis proposes that AMF formed their first relationships with early vascular plants 430 to 440 million years ago (Wang et al. 2010). In this scenario, extant non-vascular plants that form

The dramatically increased efficiency of water and mineral uptake by true root systems led to the rapid diversification and eventual dominance of vascular plants.

AMF mutualisms do so because of a host switching event from a vascular to a non-vascular plant in a more recent time period (Wang et al. 2010).

One of the limitations of Bonfante and Genre's 2008 study was a lack of understanding of the underlying genetic networks controlling the response to fungal colonization in plants (Bonfante & Genre 2008). However, by 2010 three plant genes had been identified as being required for the establishment of mycorrhizae symbioses: DMI1, DMI3, and IDP3 (Wang et al. 2010). These genes encode for proteins involved in a complicated signal transduction cascade leading to the formation of the PPA and allowing AMF to colonize the plant (Wang et al. 2010). In order to distinguish between their hypotheses, the researchers performed phylogenetic and molecular analyses based on these genes in all extant plant lineages. Their analysis included bryophytes, lycophytes, monilophytes, gymnosperms, and angiosperms

(Wang et al., 2010). If the mycorrhizae landing hypothesis was correct, the researchers would have expected to see evidence of vertical gene transfer. Vertical gene transfer is the processes by which genes are passed down from parents to offspring. In terms of AMF-plant symbioses, this would mean that DMI1, DMI3, and IDP3 would have originated in ancestral non-vascular plants and, due to vertical gene transfer, would be conserved in all extant plant lineages. Alternatively, if the host-shifting hypothesis were true, no evidence of the genes would be conserved in ancestral non-vascular plant lineages. Instead, the genes would have evolved in vascular plants and arisen later in only some non-vascular plants as response to an AMF host switch.

Genetic analyses yielded a phylogeny identical to the accepted land plant phylogeny with all nodes strongly supported (Wang et al. 2010). This demonstrated that all three genes were vertically inherited by all extant plant lineages and supported the mycorrhizae landing hypothesis (Wang et al. 2010). To bolster these findings, Wang et al. also carried out mutant rescue experiments. In these experiments, bacteria were used to transfer DMI3 genes into recessive mutants that could not form symbioses (Wang et al. 2010). The researchers found that genes from any taxa, save for some moss species, could “rescue” the mutant and restore their ability to form AMF mutualisms (Wang et al. 2010). This finding showed that in addition to the simple inheritance of symbiosis-forming genes, the function of those genes was conserved over time. Taking these findings together, Wang et al. confirmed that the most likely evolutionary scenario was that AMF established mutualisms with the earliest land plants approximately 460 to 480 million years ago (Wang et al. 2010). Further, AMF-plant symbioses have been maintained in the majority of extant plant groups via vertical gene transfer (Bonfante & Genre 2008; Wang et al. 2010).

In a 2015 study, Rimington, Pressela, Ducketta, and Bidartondo challenged a previously unexamined assumption implicit in both the Bonfante and Genre review and the Wang et al. paper. It was widely believed that only fungi

from the division Glomeromycota formed AMF-like relationships with plants. Rimington et al. provide evidence for a second division of fungi, Mucoromycotina, forming relationships with numerous basal vascular plants. The authors examined fungal symbioses among extant lineages of early vascular plants, with particular focus on lycopods and ferns. They collected samples from around the globe and used molecular and cytological analyses to identify the fungal symbionts colonizing the plants. Analysis showed that more ancestral lineages formed diverse relationships with multiple species of Mucoromycotina and Glomeromycota, while later diverged groups showed specificity for Glomeromycota (Rimington et al. 2015). Rimington et al. used these results to argue that in the distant past fungal-plant symbioses were flexible, dynamic interactions between ancestral plants and both Glomeromycota and Mucoromycotina species. The increasing specificity for Glomeromycota in more recently diverged plants suggests that complex competitive interactions likely occur between soil fungi and influence their success in forming symbioses. Over time, Glomeromycota species must have gained some advantage over Mucoromycotina species that allowed the group to dominate fungi-root mutualisms. An interesting consequence of this study is that a great morphological similarity between Glomeromycota and Mucoromycotina species was discovered. Species from both divisions form arbuscules and loops in the plant cortical tissue. This discovery calls into question the identity of fossilized fungi and other Glomeromycota identified on the basis of morphology alone. With their study, Rimington et al. achieved new insight into the context in which the AMF-plant relationship was formed and thus raised interesting new questions about alternate fungal-root symbioses.

Considered synergistically, the review and two research articles examined provide an interesting look into the questions of the origin, context, and extent of the AMF-plant symbiosis. In the past decade, a well-supported timeline placing the origin of AMF-plant symbioses at least 460 to 480 million years ago has been widely accepted, although researchers are still

seeking direct fossil evidence to support this claim (Strullu-Derrien, Selosse, Kenrick, & Martin 2018). It has also become widely accepted that basal vascular plants and early bryophyte lineages vertically inherited symbiosis-forming genes from the ancestors of terrestrial plants (Wang et al. 2010). One potential avenue for future studies is to illuminate the complex signaling pathways which are crucial in initiating the colonization of roots by AMF. Another particularly fascinating avenue for future work lies in the revelation that AMF were not the sole fungal symbionts present in ancient soil microbiomes (Rimington et al. 2015). This necessitates further exploration of the interspecific interactions between fungi of different divisions in historic and modern soils. In a greater context, understanding AMF-plant symbioses has important implications for our understanding of restoration requirements, agricultural uses of microbes, and community structure in terrestrial ecosystems. Currently, researchers are testing AMF applications with the potential for high impact in the agricultural industry including: as an inoculant to increase crop yields and stress tolerance, as a bioremediation agent for persistently contaminated soils, and as a potential biocontrol for harmful mycoparasites (Maiti 2010; Aggarwal et al. 2011; Lenoir, Lounes-Hadj Sahraoui, & Fontaine 2016).

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Author's Note

I first became interested in the relationships between plant life and the microbes inhabiting the rhizosphere during my ecology class in spring of 2018. Later, when the opportunity arose to select a topic for my final paper in Theory of Evolution, I jumped at the opportunity to delve more deeply into this fascinating hidden world through a critical examination of a review and two research articles discussing AMF-plant coevolution.

I'd like to thank Dr. Rebecca Jabbour for the opportunity to explore this topic and for submitting my paper to *The Undergraduate Spectrum*. I'd also like to thank Drs. Anthony Talo, Carla Bossard, and Michael Marchetti for introducing me to the fields of ecology and plant biology. Finally, I'd like to thank Joana Rowlands at CWAC for her invaluable help in editing this essay, and the judges of the Spectrum contest for giving me this wonderful opportunity.



Goldsworthy, Andy. *Drawn Stone*. 2005, *De Young Museum*, <https://i1.wp.com/drystonegarden.com/wpcontent/uploads/2009/07/goldsworthydeyoungfront.jpg?w=606>.

Fault Lines of Preservation

Sierra Nguyen

The original de Young Museum was constructed between the early-1920s and mid-60s, but suffered damage in 1989 due to an earthquake that rattled the San Francisco area. Deemed unsafe, the building was torn down in 2002 and rebuilt three years later, completely reconstructed with huge seismic shock absorbers in defiance of earthquakes. Installations, sculptures, and earthworks were commissioned for the unveiling of the new building. One of them was a work by British land art artist, Andy Goldsworthy.

Goldsworthy is known to many through the 2001 and 2017 documentaries *Rivers and Tides* and *Leaning into the Wind*. It was his work at the de Young that first cemented his relationship with San Francisco, earning him an ongoing project with the Presidio Trust, where he has created four site-specific earthworks in the park: *Spire* (2008), *Wood Line* (2011), *Tree Fall* (2013), and *Earth Wall* (2014). As captured in *Rivers and Tides*, his style suggests temporality that teeters on the edge of collapse. Over time, the natural materials used in his works decay and return to their natural state and serve as reminders of the history of the site on which they were planted, constructed, or cracked. *Drawn Stone* (2005) is no different.

Drawn Stone is embedded in the courtyard tile of the de Young Museum. Goldsworthy carefully composed a continuous zigzagging fissure that runs from the edge of the Music Concourse roadway in front of the museum, down its main walkway, into the exterior courtyard, and up to the museum's main entrance door. Along this path, the crack intersects, cleaves, and bisects eight large rough-hewn stone slabs found in the courtyard. These stones allow visitors a seat to view the building's copper skin. Chosen for its changeable quality due to oxidation, it assumes a rich patina over time that blends gracefully with the museum's surrounding natural environment. Aptly, the stones are Appleton Greenmore sandstone, quarried from Yorkshire, where Goldsworthy grew

up.¹ This is not simply a sentimental connection to the artist's hometown, however. Much like the building's copper exterior, the stones were selected for their oxidizing properties. The ocher-orange color of the stones is caused by oxidized iron in the soil.² The oxidizing properties of the building and its courtyard count their own growth and decay, pointing to the inevitable effects of time.

Drawn Stone provides a window, a glimpse, a crack into the museum: while the fissure doesn't lead guests to the entrance, its winding and curving across the courtyard almost mimics how one would wander in the museum, not necessarily following a set path or straight line. Its simple wall placard near the museum's second floor window identifies the work and the artist if one is lucky to stumble upon it. When seen from above, the fissure suggests a topographical map that curves across the pavement laid out by Goldsworthy and his team. Walking into the museum via the courtyard, one might not think the simple crack is art, but merely an unintended flaw in the building's grounds. But this impression adds to the work; the thin line running through the ground from the driveway to the entrance is often overlooked. It is merely a gentle indication of what has happened, what may happen, and what will happen given California's tectonic topography.

Much like the location of the de Young, the stones are a sculpture of the geological and topological history in which they are placed, a reminder of the museum's history and the fragility of its contents and structurings. In addition to exhibiting a wide survey of Californian art and history, the museum houses an eclectic collection

1) Fine Arts Museum of San Francisco. "Andy Goldsworthy: Drawn Stone, 2005." Accessed February 25, 2019. <https://deyoung.famsf.org/about/site-specific-art-commissioned-de-young/andy-goldsworthy-drawn-stone-2005>

2) Hamlin, Jesse. "Follow the Fissure to the New de Young - Andy Goldsworthy Will Lead the Way." SF Gate, April 28, 2005. www.sfgate.com/entertainment/article/Follow-the-fissure-to-the-new-de-Young-Andy-2637545.php

of oddities and curiosities from American art, international textile arts and costumes, and art of the ancient Americas, Oceania, and Asia. It is also deeply devoted to the conservation and preservation of objects, paintings, paper and textiles, opening its conservation department in the early 1970s as a brace for disaster preparedness. This department actively collaborates across the museum to address exhibition design, lighting, climate control, storage, and maintenance of the works.³ While the tiles were painfully hand-cracked by Goldsworthy and his team, *Drawn Stone* challenges the historical conservation the de Young prides itself on, being purposely faulted and allowed to remain faulted, a literal drawing in stone.

It seems as though the dimensions of *Drawn Stone* extend the entire courtyard, tethered to the institution, apart of it, and a reflection of it. Yet *Drawn Stone* is dialectically bound: while part of the seemingly permanent structure of the courtyard, the piece ages, oxidizes, and with time, will extend along its human-made fault, accentuating nature's power to undermine or destroy even the most monumental works constructed. In this way it foregrounds the literal fault lines that run beneath the institution: no amount of humidity control, restoration, or shock absorbers can defend what we preserve and protect from the repetition of the past; that is in part the fault lines of history and the fault lines of preservation.

Author's Note

Like many of the visitors at the de Young, I first overlooked the peculiar, single crack that zigzagged down the main atrium to the foot of the entrance. I finally discovered it when I noodled through a group of school children who—because they are closer to the ground—easily noticed the crack and followed it from their school bus to the front of the building. I began wondering about the implications this peculiar, single crack could have as a permanent feature of the museum, much less a commissioned one. It was easy for

3) Fine Arts Museum of San Francisco. "Conservation." Accessed February 25, 2019. <https://deyoung.famsf.org/legion/collections/conservation>

me to view museums as monolithic chapels of conservation and culture. At least, that is how I first approached them as a wide-eyed art student. Over my final semester at Saint Mary's I returned to this peculiar, single crack, wondering what the logical parameters necessary were to deviate from this idea. This curiosity snowballed into a critique that excavated the history, selection and poetic contradictions surrounding a peculiar, single crack in the ground.

Although I have graduated from Saint Mary's, I continue to revisit this critique. As I enter the field of curation, I continue to grapple with permanent collections in museums in terms of ethics and politics. Like *Drawn Stone*, my hope is that a simple 900-word critique will compel my readers to, over time, extend their own opinions on preservation and consider art through a deviant and dialectic lens. I would not have thought this way without four years of bristling intellectual and creative inspiration from my friend and mentor, Professor Peter Freund, who first encouraged me to think deviantly and dialectically during my sophomore year at Saint Mary's, and from then on, always questioned my stakes while showing me the beauty in learning through teaching. I would also like to extend my gratitude to Professor Andrew Mount, who changed the way I think about museums and encouraged me to critique institutions; to the entire Chemistry Department at Saint Mary's for giving me a place to kick off my shoes, take risks and think about art in different contexts; to my loyal friends and loving family who always came out to see my work in whatever its medium; to the judges who—to my surprise and delight—believed in my work, vouched for it and even thought it worthy enough to win an award; to CWAC and my kind editors whose insights and intelligence made this critique better; and finally, to the person who sat next to me through the many episodes of brainstorming, writer's blocks and quakes of inspiration, Nicholas Nguyen, who continues to listen to what I have to say. Thank you, thank you, thank you; I am humbled by the army behind my 900 words.



Goldsworthy, Andy. *Drawn Stone*. 2005, *De Young Museum*, <https://i0.wp.com/drystonegarden.com/wpcontent/uploads/2009/07/goldsworthydeyoung>.

Demystifying Zyklon B and the Nazi intent to kill all Jews

Melia Granath-Panelo

An underlying principle that general life scientists adhere to is that the cell is the most basic unit of life. To inhibit the function of cells is to inhibit life at its most fundamental point. Nazi chemists aspired to achieve this inhibition through the creation of the infamous blue-tinted gas that killed millions of Jewish people: Zyklon B. Although an incredibly important part of the world's history, Zyklon B is not often discussed in the classroom. As a scientist, I was naturally inquisitive about how and why the gas was so lethal, so I decided to further explore its molecular interactions with the human body. The purpose of researching Zyklon B is to face head-on the horror that occurred and provide an understanding of the meaning behind the phrase "sent to the gas chamber". A further study of the gas provides a holistic understanding of the malevolent Nazi psyche from an area that remains relatively unstudied in traditional Holocaust courses, and forces us to examine the worst sides of human nature. In fact, the motivation behind the creation of the gas goes further than a mixture of chemicals. The gas, which was also used as a commercial insecticide, even influenced propaganda depictions of Jews as vermin. Each ingredient and ratio was meticulously calculated to cause a painful death, staining the cold walls of the chamber it was released in as a memory of what was once progressive science suddenly turned malicious warfare.

Unknowingly pioneering the creation of Zyklon B was German-born Jewish Scientist Fritz Haber. When antisemitism began to flourish in Germany, Haber, though desperate to remain a patriotic German, began to be shunned by his colleagues. After the Nazis came to power, his life was destroyed, and his work was subsequently taken and manipulated by Nazi chemists. Known as Zyklon B, which translates to Cyclone B from German, this chemical was formulated into discs and small pebbles that vaporize after exposure to

the air. Once dispensed into the gas chambers, it killed victims within minutes.

The primary component of the gas is hydrogen cyanide (HCN), which is a colorless liquid primarily used in commercial fumigating, mining, and electroplating. In extreme cases, it is used in chemical warfare; in cases such as the Holocaust, it was used as a silent executioner. When inhaled, HCN impairs the human body's ability to metabolize oxygen, leading to multisystem organ failure as well as rapid and painful asphyxiation from the inside out. Another harmful ingredient used to create the gas is referred to as diatomaceous earth, which includes harmful chemicals such as silica, causing detrimental effects on the lungs. HCN is a linear molecule that ionizes, or separates, in water, forming individual hydrogen and cyanide ions in solution.¹ When the HCN vapor released from the pellets is inhaled, the water in our bodies causes HCN to separate in the tissue of the lungs. Normally, hydrogen isn't very harmful to the human body. However, the cyanide component is especially destructive.

Cyanide acts as a poison by instigating what is known as histotoxic hypoxia, or the inability of cells to take up oxygen.² As a result of histotoxic hypoxia specifically induced by cyanide poisoning, the enzyme cytochrome C oxidase is inhibited. Cytochrome C oxidase is the last enzyme involved in the electron transport chain, which takes place in the mitochondrial membrane of human cells.³ The electron transport chain is essential to sustaining human life, as it is the body's primary source for generating ATP (adenosine triphosphate), a tiny molecule of stored energy that is

1) McQuarrie, D; Rock, P; Gallogly, E. *General Chemistry, 4th Edition*. Sausalito, CA: University Science Books, 2010.

2) Pandey, A; Sharma, H: "Histotoxic hypoxia: New Perspectives of Central Nervous System Injury and Neuroprotection," *ScienceDirect*, Elsevier, 2012.

3) Watson, J; Baker, T; et al.: *Molecular Biology of the Gene, 7th Edition*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2014.

essential for the body's cellular processes. By inhibiting cytochrome C oxidase, the process that generates ATP is compromised. Recall that cytochrome C oxidase is the last enzyme to function in the electron transport chain, making its function especially crucial. Cytochrome C oxidase primarily functions to convert oxygen into water, which helps establish a stable environment for firing of action potentials, or signals from the brain.³ Cytochrome C oxidase's area of weakness is the iron (Fe) ion located within the structure. The cyanide ion binds with this iron ion, completely halting the electron transport chain reactions, preventing the mitochondria from producing more ATP. Once the cell cannot produce ATP, downstream reactions that require it are no longer possible, and the cell dies. Tissues that require high oxygen content, such as brain matter and the heart muscle, are quickly affected and begin dying faster than other tissues. In short, cyanide causes the inability of human cells to convert oxygen into ATP, which will lead to death within minutes.

The other chemical of high concentration inside of Zyklon B is called diatomaceous earth. This component is a naturally occurring substance containing silica and alumina that is subsequently ground into a fine white powder. Silica dust, once inhaled, causes the lungs to rapidly form scar tissue, inhibiting their ability to process oxygen.⁴ The silica crystalline structure further destroys the intricacies of the cell membrane, disrupting the membrane's natural ability to act as a filter. In destruction of this filter, toxins are allowed to enter the cell and water is allowed to leave — a detrimental ion exchange.

4) Labour Department, Republic of South Africa: Silica exposure and its effect on the physiology of workers. Chief Directorate of Communication, Department of Labour. Labour.gov.za.

Another harmful effect of diatomaceous earth is the formation of a free radical, which is an electron that is left unpaired from another electron and thus highly unstable and chemically reactive towards other substances. This free radical forms on an oxygen ion, leading to fatal damage of other intracellular structures due to its high propensity for reactivity.⁵ The

term “radical” in reference to the unpaired electron is to be taken literally as this electron is likely to react sporadically, often resulting in destruction. In some extreme cases, exposure to crystalline silica can result in the cell initiating apoptosis, or “cell suicide”. These symptoms — scar tissue formation, membrane filter destruction, and oxygen free radical formation — cause the cell to become susceptible to other physical and chemical disturbances. Thus, in combination with the cyanide, the silica within the diatomaceous earth renders the cell defenseless, allowing the

cyanide to have fully catastrophic effects on the cellular environment. The two chemicals work in tandem with each other; imagine diatomaceous earth as a blade that can easily break the surface of your skin. The cyanide then acts as if someone has put salt in the wound.

The hidden message behind using a cyanide-based gas, which was also used as a pesticide and insecticide, is that the Nazis thought of Jews as pests. Although there were many different forms of public antisemitism that the Nazis utilized to spread their message, the focus of this topic was the use of a comparison of Jews to rats, rodents,



Figure 2. Nazi propaganda poster distributed in Russia, reading “Jews are rats that will destroy your nation.” From Google Images.

5) Allison, A; Harington, J; Birbeck, M: “An examination of the cytotoxic effects of silica on macrophages” *Journal of Experimental Medicine*. 1996. 142:2, 141-154. DOI: 10.1084/jem.124.2.141.

and vermin.⁶ The portrayal of Jews as pests promoted dehumanization of the Jews, and made viewers begin to think of Jews in the same way, thereby creating an intense political divide between those who were Jewish and those who were not. Propaganda posters depicting Jews as rats and snakes were distributed throughout Europe as a desperate attempt to poison civilian minds and dehumanize Jews as much as possible. At the time, the popular German newspaper *Der Sturmer*, which translates to “The Attacker”, featured anti-Semitic caricatures depicting Jews with exaggerated and ugly features. Additionally, a pamphlet titled “The Jew as World Parasite” was published and released by the Nazis in 1943.⁷ The pamphlet calls Jews liars and says that the Jews were planning world takeover. Next, there are sections defining what is considered a parasite, as well as sections that outlined why Jews are parasites: “The Jew is the parasite of humanity. He can be a parasite for an individual person, a social parasite for whole peoples, and the world parasite of humanity.”⁸ The goal of comparing Jews to parasites was to get readers to adhere to the idea that Jews were resource-consuming enemies of the state, haters of the greater good, and responsible for all of the misfortunes that Germans endured.

By the time World War II had begun, Haber had long passed. However, just because his body was physically gone, that did not mean that the legacies of his mind had passed with him. Once a man of Jewish faith, he unintentionally pioneered the work that led to the murder of six million of his own kind, including some of his relatives. His work is still utilized today as the main industrial method of producing ammonia for pesticides. Since his work still remained

in the archives where he studied as the Nazis were rising to power, Nazi chemists referenced and then manipulated it, and used his agricultural pesticide and legacy as the “father of chemical warfare” to create the mother of all ironies. Among the scientists to manipulate Haber’s work were Richard Kuhn, Otto Wallach, and Richard Willstätter.⁹ Despite very public knowledge that Haber’s work led to the creation of Zyklon B, there is not much evidence of how exactly Haber’s work was manipulated, and who was responsible for unearthing his archives and tactics.

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The only evidence to suggest that Haber was the founding father of Zyklon B is through a comparison of methods and similarities in chemical composition between his cyanide pesticide and Zyklon

B. Additionally, Haber’s pesticide was named “Zyklon”, which prompted the Nazi chemists to title the gas “Zyklon B”, as to suggest a better, stronger version of the chemical.

As a scientist, unearthing the physiological effects of Zyklon B was truly frightening for me. The intricacies of the molecular and chemical design of the gas, the ratios, and the specific chemicals that were used to create the gas pinpointed the most essential functions of the human body at the cellular level. This leads me to believe that the Nazi’s not only wanted to eradicate the Jewish people, but they also intended to hurt them. The Nazis behind the administration of the death camps wanted Jewish deaths to be painful and excruciating. I took this deep dive into the specificities of the gas that killed the Jews in part due to my own personal interest, but also because the gas is an essential part of the Holocaust that is usually not studied as its own topic in Holocaust courses. There is a deep and rich history that is interconnected in the creation of the gas itself and the propaganda surrounding it, and it is important that those motivations are understood. In studying the Holocaust, it is imperative that particularly harsh topics are not glossed over in order

6) United States Holocaust Memorial Museum, Nazi Propaganda. Web. Accessed 31 Jan 2018.

7) Bytwerk, R. The Jew as World Parasite. German Propaganda Archive, Calvin College. 2008. Web. Accessed 31 January 2018

8) Everts, Sarah, Chemistry in Nazi Germany. *Chemical & Engineering News*. 91(37). 2013. Web. Accessed 29 Jan 2018.

to protect emotions or sensitivities. These events were horrific themselves; learning about them is bound to be provocative, jarring, and even uncomfortable at times. In reaching these limits, however, one begins to truly understand the event as not so much history, but more-so a holistic story of pushing the boundaries of psychology, brutality, and humanity.

Biologically speaking, it is a natural survival reflex that dates back to the origin of multicellular organisms that the primary purpose in life is to propagate the species. In common use, we refer to this principle of species propagation as the “replacement rate” but it is called “fitness” in formal scientific literature. Both terms serve to quantify the rate of successful reproduction in reference to species propagation. The blatant defiance of this principle as exhibited by the Nazis demonstrates their inhumanity and savagery. Not only did they have to face — and probably disregard — the moral challenges of mass genocide, but also somewhere in the depths of the neuronal network they had to find a place dark enough to allow them to defy billions of years of evolutionary success and survival instinct. In mammals, ignoring instinct such as that would be considered an incredibly complex psychological fallacy. However, the human species specifically has mentally and socially evolved to consider self propagation instead of species propagation as the highest priority. Reflex and instinct, in this situation, came to a junction with selfishness, petty concerns, and ignorance; the latter set of conditions took precedence, and I personally regard those who took part as a keen example of evolutionary failure. Human consciousness came to a pinnacle that took our capabilities of elevated and deep cognition for granted. My only hope for the future is that we have learned from our past, and realize the truly special gift that we have been given of cognition and intelligence, and use it as evolution has intended us to: for the greater good of our species, humankind.

Author’s Note

My name is Melia Granath-Panelo and I am a senior biochemistry major. On a whim, I decided to take Professor Joan Peterson’s Holocaust

remembrance course over January term 2018. I had never studied the Holocaust in depth, and thought it might be a change from the usual hustle of my science courses. One day in class, we were reading excerpts from *The World Must Know*, our main textbook for the course. We glossed over a section about the gas chambers and Zyklon B, and there was a photo included of the inside of a chamber whose walls were stained blue. The impact that seeing that photo had on me was inexplicable; I had to know more.

My background in science and my brief understanding of the event as a whole inspired me to run with this subject and discover its incredibly interesting and twisted history. Even though the class was primarily about the art and music inspired by the Holocaust, Professor Peterson was incredibly encouraging of me writing about Zyklon B. I started off by perusing Fritz Haber, and his early work before World War II, as well as researching the propaganda inspired by the gas. Then, I researched Zyklon B’s chemical composition, and used my textbooks from previous science courses to learn about how those chemicals affect cells. After browsing through more published experimental articles about each chemical in the cellular environment, I opened Microsoft Word and let it fly for about 4000 words. For the Spectrum submission however, I took a fine-tooth comb to the essay, and shared the necessary technical details of the gas, but tried to tell more of a story as well.

I wanted to tell the story of not only how horrific the gas itself actually was, but also tell the story about how propaganda was inspired by the chemical composition of the gas, and bring awareness to the ironic and cruel history behind its creation. In this class, the most important takeaway was that we should not shy away from talking about uncomfortable and dark topics in order to protect our own emotions. The only way to understand the event properly is to be provocative and not have boundaries in our learning. Thank you to Professor Joan Peterson for being incredibly encouraging in my discussion of this topic, and for taking on the challenge of teaching a course revolving around such a harsh topic. I hope this piece brings proper awareness of the horrors that occurred, and sheds light on an incredibly important area of the Holocaust that is not traditionally studied in depth.



Figure 1. Nazi propaganda poster depicting Jews as vermin. From Google Images.

Demonic Iago

Lindsey Gamache

Despite being one of the most verbose characters in Shakespeare's *Othello*, Iago never explains the reason for his villainy. Why is he always scheming? What grudge does he have against Othello? Reason itself seems to disappear in the midst of Iago's half-hearted excuses, which run the gamut from military career rivalry, to marital jealousy, to racial hatred. Ultimately, Shakespeare forces readers to search beyond their rational, mortal world to explain Iago's character: why he loves evil more than revenge, survives mortal injury, gives demonic identity statements, weaponizes envy, tempts Othello with a fruit-speckled handkerchief, and binds himself to Othello in a strange, ominous ceremony. With these subtle, religious hints, Shakespeare depicts Iago as a demon with the special purpose of instigating Othello's fall.

Lacking a clear motivation, Iago's villainy seems to stem mainly from a mere love of evil, rather than revenge. At the end of the play, Othello demands that Iago admit why he goes to such lengths to ruin Othello's life, warping his mind with determined persistence that should not be humanly possible. However, Iago simply replies, "Demand me nothing. What you know, you know: / From this time forth I never will speak a word," (V.ii.296-297). At this point in the play, officials have already apprehended Iago for his crimes. Continued secrecy will not protect Iago from judicial punishment, so there is nothing to keep him from bearing all. Yet instead of claiming racism, military rivalry, or marital disloyalty as his reasons for enacting revenge, as he has at other points in the play, Iago reveals nothing. This suggests that Iago at his heart is not motivated by revenge at all, but by a love of evil. He works vigorously to destroy Othello's mind and happiness because he wants to see suffering and villainy triumph. Why? Iago's vague reference to some prior knowledge that Othello has is notably mysterious. What does

Iago think Othello knows? Iago certainly has not explained his motivations to Othello before. The closest answer to this question comes before Iago's statement about knowledge, when Othello asks, "Will you, I pray, demand that demi-devil / Why he hath thus ensnared my soul and body?" (V.ii.294-295). Iago's reply subtly confirms that which Othello states outright: Iago is a demi-devil, and his goal in practicing evil all along has been to ensnare Othello's body and soul.

Shakespearian audiences surely had their own mythology concerning demons, and Shakespeare uses lore suggesting that demons cannot be killed to evince Iago's true nature. Othello presents the beliefs common among Shakespeare's Christian audiences, first stating, "I look down towards his [Iago's] feet, but that's a fable," a reference to the idea that demons have cloven hooves (V.ii.279). Yet Othello easily dismisses this "fable," marking it through word choice and tone as a fairy tale, rather than a fact. But then Othello says directly to Iago, "If that thou beest a devil, I cannot kill thee" – right before attempting murder (V.ii.280). Othello's tone shifts from light to deathly serious from one line to the next, making a distinction between the validity of the two claims. While both of these statements seem purely fantastical and metaphorical to modern audiences, Othello's phrasing of the second implies that the majority of Shakespearian audiences truly believed in the existence of demons. When Othello stabs Iago, Shakespeare emphasizes the gravity of Othello's conviction that demons cannot be killed. Significantly, Iago does not die, saying calmly after being stabbed, "I bleed, sir, but not killed," (V.ii.279-281). In spite of sustaining a serious injury, Iago appears unfazed, as if his life is not in danger and his body is not in pain. In this moment, Iago barely seems mortal; his human mask slips. Further, he outlives the other major characters, Desdemona and Othello, making his unlikely survival all the more prominent. In preserving Iago from death,

Shakespeare supports the possibility that he is not a human being in the mind of the audience.

Through demonic statements of identity, Iago distinguishes himself as a creature opposite to God and capable of possessing Othello. First, Iago professes himself as a being at odds with God immediately before his first act as the villain. Before waking Brabantio and making him aware of the secret marriage between Othello and Desdemona, Iago tells Roderigo, "I am not what I am" (I.i.63). This backwards statement of identity stems from the Bible. The footnote connected to the line states that, "the language reverses God's 'I am what I am' (Exodus 3:14)," (Greenblatt 2006). This is God's reply when Moses asks for His name, designating God as an almighty being, omnipresent, existent beyond the limits of time. These words, "I am what I am," were believed too holy to be spoken by human mouths, and were abbreviated YHWEH, a sound more like a breath than an actual, spoken word. By reversing God's divine statement of identity, Iago commits an act that is borderline blasphemous, and at the same time, indicates that his existence is a reversal of God and the divine. Those creatures opposite to God are called devils. In these same words, Iago hints that he operates under false pretenses: he is not what he seems to be. On one level, this points to his role as a false friend to Othello and Roderigo. But on another level, this statement of false identity indicates that Iago is not human at all, but rather, a demon pretending to be human.

Furthermore, Iago employs a second reversed statement of identity when Othello demonstrates that he has fallen prey to Iago's manipulations. After Othello strikes Desdemona, Lodovico asks Iago if that man is truly the same Othello, who has such an honorable reputation, or if he has gone insane. Iago replies, "He's that he is: I may not breathe my censure. / What he might be – if what he might, he is not – / I would to heaven he were," (IV.i.257-259). Iago's words are markedly mysterious, not quite answering Lodovico's question, suggesting that Iago is being purposefully evasive. Iago cannot reveal Othello's true nature because in doing so, he would reveal

himself, both as a villain and as a demon. This is why he cannot speak a word on the subject. Shakespeare's use of the word "breathe" points to the inability of unworthy creatures to speak God's holy name. Through this same lens, the word "heaven" ironically highlights Iago's opposition to it, and the absurdity of a demon asking heaven for help in damning souls. In truth, Iago does not need any help. By hitting Desdemona, Othello proves that Iago has successfully clawed his way into Othello's mind – an image that mirrors a demonic possession. Backwards statements of identity once only applied to Iago, but now, this statement can apply to Othello too. They are conjoined in their unholy identity. By describing Othello in such a way, Iago demonstrates the success of his possession of Othello, and in turn, identifies himself as the demon within him. In these two backwards statements of identity, Iago establishes himself as a creature antithetical to the divine.

According to Christian religious canon, there are seven deadly sins to which one can fall prey; Iago admits to choosing envy as his weapon against Othello. During his psychological manipulations, Iago describes the power of envy, saying, "Oh, beware, my lord, of jealousy! / It is the green-eyed monster which doth mock / the meat it feeds on" (III.iii.163-165). Shakespeare uses vivid language to personify jealousy, reflecting the speaker's demonic nature. Indeed, "monster" is simply another word for demon. Moreover, Shakespeare's depiction of jealousy as "feeding" on meat calls to mind the image of a demon feeding upon an immortal soul like a parasite prior to damnation. The word "mock" establishes Iago's place behind his words, as a master manipulator mocking his victim. Iago's technique builds up the power of jealousy in Othello's mind. Yet it also demonstrates a deep understanding of envy on Iago's part, not necessarily because Iago feels envy himself. Relating distant rumors that Othello has slept with Emilia, Iago rationalizes, "I know not if't be true, / But I, for mere suspicion in that kind, / Will do as if for surety" (I.iii.366-368). These are the words of a man who understands the cause and effect of jealousy from a distance, but does not

feel the passionate rage that jealousy incites in men like Othello. The sin is merely a tool of the trade for Iago. He understands envy not because he feels subject to it himself, but because he knows how to use it to torture Othello.

The handkerchief is another weapon in Iago's arsenal, working the same way the forbidden fruit works for Satan in Genesis. Like the fruit, the handkerchief is an object that serves to incite man's obsession with sin and his fall from grace. By associating sin with a physical object, Iago makes Desdemona's marital disloyalty tangible for Othello, fulfilling the need for "ocular proof," upon which Othello places "the worth of mine eternal soul" (III.iii.357, 358). By providing this proof, Iago gains Othello's soul. When Othello first gives Desdemona the handkerchief, he trusts that she will take care of it out of loyalty and love for him. In the same way, in Genesis 2:17, God places the tree of good and evil in the Garden of Eden as a symbol for the man's obedience and trust in Him: "but of the tree of the knowledge of good and evil you shall not eat, for in the day that you eat of it you shall die". By following God, man would never need to know for himself the difference between right and wrong. When Desdemona loses the handkerchief, she breaks the trust that Othello places in her to keep it safe, proving, in turn, that she has broken his trust sexually as well. In the same way, the eaten fruit proves Adam and Eve's disloyalty to God. By drawing a comparison to the handkerchief and the Genesis fruit, Iago ensures that Othello will internalize these biblical associations. Iago asks Othello, "Have you not sometimes seen a handkerchief / Spotted with strawberries in your wife's hand?" (III.iii.430-431). While usually thought of as an apple, the fruit of the tree of good and evil is never directly described in Genesis, although it is traditionally

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a red fruit, since red is a color symbolic of passion and temptation. The strawberries on the handkerchief fulfill this visual requirement, since, like apples, they are temptingly sweet, juicy, and vivid red. Additionally, since Eve eats the fruit first in Genesis, the fruit is imagined in the collective, Christian consciousness as being held in the hand of a woman. By noting that the handkerchief is seen specifically in Desdemona's hand, Iago parallels the image of Eve's hand, thereby associating Desdemona with Eve in Othello's mind as a sinful woman. In this comparison, Iago can be seen as a figure for Satan, as he is the deceiver who, through a significant object, brings about the fall of man. Iago's manipulation by use of the handkerchief eventually sends Othello into a fit, crying, "Handkerchief? Oh, devil! [He] falls in a trance" (IV.i.40). Othello's fit here indicates that he is the victim of a demon, and his last two words before the fit, "handkerchief" and "devil" name the two causes of his possession. By associating the handkerchief with the fruit in Genesis, Shakespeare characterizes Iago as a devil-figure that brings about a fall.

Eventually, Othello pledges his soul to Iago, making a deal with the devil that ultimately ensures his damnation. Othello forges this contract verbally when he disavows heaven and gains Iago's service in return. This agreement is made in a ceremonial way: Othello begins by kneeling with the words, "Arise, black vengeance, from the hollow hell," (III.iii.442). Othello recognizes vengeance as an unholy power. By drawing upon it, Othello spurns heaven and his own salvation. His language calls to mind the conjuring of a demon. Ironically, that demon is already present. Iago then kneels, and closes the ceremony with the words, "I am your own forever" (III.iii.473). To Othello, Iago's pledge of loyalty appears comforting. Shakespeare's use of dramatic irony gives the statement an ominous tone. Iago

has absolutely no intention of helping Othello with anything other than ruination. The use of the word “forever” is especially significant, as it ends the sentence and the scene; one can imagine it echoing through the theater. Instead of vowing to remain by Othello’s side until their vengeance is complete, Iago vows to stay with Othello “forever.” Forever does not end with Othello’s life, meaning that Iago plans to serve Othello in the afterlife as well. Instead of being Othello’s own servant, Iago means that he will be Othello’s own personal demon, dedicated to tormenting Othello throughout eternity. This grand pledging ceremony binds Othello’s fate to Iago’s, creating an unholy contract between them.

There is a reason that Iago stands out among all of Shakespeare’s antagonists: his villainy surpasses the realm of humanity. The minds of modern readers are hardly open to such supernatural interpretations of the text. However, Shakespearian audiences lived in a different time, in which demons were a constant, surreptitious threat to humanity, not limited to the supernatural. By characterizing Iago as a demon in the literal sense, Shakespeare emphasizes the gravity of the darkness that lives within Iago’s heart, and the unseen power of evil in the mortal world. Othello is a man who has risen far above all expectations. Yet even he crumbles when Iago becomes his personal demon. Iago reveals that the best men still have demons, and that the worst evil often defies detection.

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Author’s Note

Growing up, I always thought of demons the same way I think about ghosts – spooky, but

nonexistent outside of horror movies and scary stories. Raised Catholic, I had been taught to believe in angels, but not in their evil counterparts. As far as I knew, no one else believed in demons, either. It wasn’t until high school that I met someone – my religion teacher – who felt that demons were part of an ever-present reality. When she told the class, with the utmost sincerity, that she keeps Holy Oil by her bed to protect herself from demons at 3:00AM, she might as well have said that she thinks the boogiemer lives in her closet. I couldn’t fathom how such an intelligent woman – a teacher at a respected private high school with a classroom full of honors students – could be so superstitious. Soon, I learned that all of my religion teachers, as well as several other adult Catholics in my area, believe in demons.

Now a junior in college, majoring in English with an emphasis in creative writing, I am still fascinated by this aspect of the Catholic faith. Belief in demons is perhaps unfashionable in modern times, and yet, it persists. Experiencing this in my own life has given me a sense of just how deeply ingrained belief in the demonic might have been among past Christians. It is an unseen but powerfully present reality. This is how the demonic appears in Shakespeare’s *Othello* – as an invisible driving force behind the villain Iago. Tracing religious elements in the text, I explain Iago’s obsessive pursuit of Othello. At first, I considered writing a paper that also studied Othello as a fallen man and Desdemona as an angel figure. However, I quickly realized that I would need to dive more deeply into the demonic symbolism surrounding Iago’s character if I truly wanted to argue that Iago is more than human.

I am thankful for Professor Hilda Ma, who encouraged me to write this wild essay, instead of asking me to find a more conventional topic. I could not have written this paper without the editing and advising help of Mia Maramba at CWAC. I would also like to thank all of my high school religion teachers, and all who have been willing to talk with me openly about faith, allowing me to learn outside of my own experiences.



Hegemonic Masculinity, Misogyny, & Men: The Three Toxic Ms

Kerry-Anne Loughman

Masculinity can be defined as a grouping of characteristics, behaviors, and practices that are used in performing the male gender. Men around the world and across cultures feel the need to rigidly adhere to its contents for fear of being ostracized or vilified, which not only proves its inherent toxicity, but also its hegemony – or overarching supremacy. Hegemonic masculinity is a “configuration of gender practice which embodies the currently accepted answer to the problem of the legitimacy of patriarchy, which guarantees (or is taken to guarantee) the dominant position of men and the subordination of women” (Raewyn Connell 293). In other words, hegemonic masculinity ensures the existence of patriarchy through the overwhelming societal supremacy of men, who are given this power through their practice of masculinity. The intertwining of male identity and masculinity ensures the subordination of women by forcing men to believe there is only one way to identify as male: by rejecting all feminine characteristics. This internalized misogyny is displayed through upholding the belief that masculinity and male identity are synonymous, particularly through the masculine behaviors of dominance, adherence to the gender binary, and violent reactions to threatened masculinity.

One of the ways masculinity perpetuates misogyny is that it favors dominance over subservience – a dynamic often seen in stereotypical heterosexual relationships. In order to be masculine, one must also be dominant – particularly in sexual situations – and to be feminine is to be weaker, and subservient to the masculine man. In “Chicano Men: A Cartography of Homosexual Identity and Behavior”, Tomas Almaguer examines the importance of dominance in American/European and Mexican/Latin American gay culture, specifically in regards to the “giver/receiver” dynamic. In American/European culture, there

is little importance placed on sexual roles; the stigma is attached to the fact that both men are participating in homosexual relations. However, in Mexican/Latin American culture, more stigma is placed on the man who holds the “receiver” position. Almaguer connects the role of the receiver to female subservience when he states: “Although stigma accompanies homosexual practices in Latin culture, it does not equally adhere to both partners. It is primarily the anal-passive individual (*the cochon or pasivo*) who is stigmatized for playing the subservient, female role” (257). This assignment of the male/female roles to dominant/subserving roles shows how ingrained heteronormativity, or the normalization of heterosexuality in everyday culture, is in our world. Even in homosexual relationships we still gender the roles as masculine and feminine, as well as place the heaviest stigma on men performing the feminine roles. Connell speaks to this intersection of misogyny and homophobia when she states that “gayness, in patriarchal ideology, is the repository of whatever is symbolically expelled from hegemonic masculinity... hence, from the point of view of hegemonic masculinity, gayness is easily assimilated to femininity” (294). In American/European culture, there is less specificity when it comes to stigmatizing homosexuality; however, gay men are more likely to be harassed and societally robbed of their male identities the more they embody traditionally feminine characteristics.

Hegemonic masculinity is also misogynistic in the way that masculinity is born from what femininity is not, and both men and women are punished when they cross gender lines. Connell states, “in [masculinity’s] modern usage the term assumes that one’s behaviour results from the type of person one is. That is to say, an unmasculine person would behave differently: being peaceable rather than violent, conciliatory rather than dominating, hardly able to kick a football, uninterested in sexual

conquest, and so forth” (288), which speaks to how society observes and defines masculinity in terms of a person’s characteristics, as well as how they act and react to stimuli. We assign these characteristics associated with dominance, violence, and action to men because of the connotations of power they carry. When men reject these characteristics in favor of more feminine ones, whether intentionally or not, they are seen as being without power – and yet, when women adopt these masculine characteristics, they are seen as neither male nor female and are ostracized for it. This polarization between men and women is also seen when Connell states, “Masculinity does not exist except in contrast with ‘femininity.’ A culture which does not treat women and men as bearers of polarized character types, at least in principle, does not have a concept of masculinity in the sense of modern European/American culture” (288), meaning that without the rigid gender binary of men and women, we would have no concept of masculinity or femininity. To be one is to not be the other, and to be neither is to be nothing.

Misogyny is also seen through the way men react when their masculinity is threatened, or when it is proposed as toxic. These reactions are often offense and anger. In “Do We Need to Redefine Masculinity – or Get Rid of It?”, Collier Meyerson recounts her personal experience in calling out masculinity: “when I describe their unsavory qualities as rooted in what bell hooks calls the ‘disease’ that is masculinity – punching walls, talking over women, screaming at a sporting event in a tone that should only be reserved for encounters with killers – they’ve looked at me quizzically, angrily”. All of these masculine traits Meyerson lists threaten women in some way, and show how closely misogyny is weaved into masculine acts. Men who are so quick to jump to violence, whether through punching walls or screaming at sporting events, don’t usually think about their surroundings or how the women in the room might be threatened by their behavior. This

disrespect of comfort and space is indirect misogyny, while a more direct form of misogyny can be seen through men talking over women. This is a blatant form of disrespect that shows disbelief in the fact that women have equally smart or relevant things to say. The reactions men have when these behaviors are criticized, particularly those of indignation and refusal to change, show an unwillingness to alter their behavior to exclude the misogyny embedded within it. This refusal to change is also an example of how deeply embedded masculinity is within the male identity.

Meyerson proposes getting rid of masculinity altogether, referencing Gail Bederman, who states that “Manhood – or ‘masculinity’, as it is commonly termed today – is a continual, dynamic process” (qtd. in Meyerson). The first thing we need to do, according to Bederman, is stop arguing masculinity has traits that are inherent. “Gender”, she writes, “is dynamic and always changing” (qtd. in

The first thing we need to do, according to Bederman, is stop arguing masculinity has traits that are inherent.

Meyerson). Through “getting rid of masculinity”, we can allow for a more fluid determination of gender, which would soften the sharp dichotomization that exists within the gender binary (qtd. in Meyerson). Thus, the best way to rectify the misogyny perpetuated by hegemonic masculinity would be to liberate the performance of the male gender from the practices of masculinity altogether. Some good first steps in this direction would be to remember that there is more than one way to perform maleness, to eradicate the idea that there are inherently male and female traits, and to stop synonymizing femininity with weakness and passivity. Through these acts we can eliminate the misogyny perpetuated through hegemonic masculinity.

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Author's Note

As a senior English – creative writing major and women's and gender studies minor, I've always found the practice of masculinity to be a particularly intriguing theme in the works I've studied. So, naturally I was very excited for the opportunity to write a critical analysis of masculinity in American culture. This paper originated from the critical analysis assignment in WGS 177: Feminist and Gender Theories. The list of prompts to choose included themes of gender, race, and sexuality, but something my professor, Dr. Denise Witzig, said during a class discussion inspired my choice to write about masculinity: "What if all masculinity is toxic?". Until then, I had always considered the pitfalls of toxic masculinity to exist alongside regular, nontoxic masculinity, but the thought of approaching masculinity as inherently toxic was intriguing simply because of how radical it was. The more I thought about masculinity, especially in regards to its treatment of women and promotion of misogyny, the more sense it made. I was hooked, and this paper was born.

I would like to thank Dr. Witzig for so many things, but especially for teaching WGS 177, the most challenging and rewarding course of my undergraduate career, and for being a general beacon of light throughout my time in the minor. I am so grateful for the opportunity to have been her student. I would also like to thank my writing adviser/editor at CWAC, Joana Rowlands, for being patient with me as I typed and rambled my way through our editing sessions. This paper would not be what it is without her superb editing skills.



“God Intended It For Good”: Examining Satan’s Role in Luke’s Salvation Narrative

Katie Hill

Besides Jesus himself, Satan is one of the most recognizable figures in the Christian tradition. He appears at least briefly in all four Gospels, and several other books of the New Testament mention him by name. Of the Gospels, Luke seems to feature him more than others—he mentions the name “Satan” five times, uses “devil” seven times, and refers to “Beelzebul” three times. Additionally, he includes twenty-three references to “demons” which fall under Satan’s power. Despite the numerous references, Luke provides few specifics about the character of Satan. He does not include a detailed description of Satan’s physical attributes, and he limits Satan’s speech to the temptation scene in chapter 4. However, ambiguity should not be mistaken for unimportance. In many ways, Satan and his evil realm are constantly present in the Gospel; Jesus not only meets Satan face to face, but he also confronts demons and exorcises possessed people throughout his earthly ministry. All the same, the character of Satan is difficult to interpret based on his brief appearances. Examining broader themes within the narrative and the biblical tradition as a whole helps to illuminate the significance of Satan’s role in the Gospel of Luke. In particular, thematic parallels between the Old Testament story of Joseph and his brothers and Luke’s portrayal of the tension between Jesus and Satan reveal the ironic role of evil forces in the narrative of salvation.

Luke clearly associates Jesus with salvation from the very beginning of his Gospel. The angel of the Lord announces the birth of Jesus to the shepherds with the words “to you is born this day in the city of David a Savior” (2:11). During the presentation in the temple, the faithful Simeon holds Jesus in his arms and proclaims “Master, now you are dismissing your servant in peace, according to your word; for my eyes have seen your salvation” (Lk 2:29-30). A chapter later, John the

Baptist refers to Jesus with similar language when he quotes Isaiah 40: “all flesh shall see the salvation of God” (3:6). All of these prophetic declarations depict Jesus as the long-awaited Messiah, revealing his purpose as the Savior of the world. As the one who brings God’s salvation to the world, Jesus has a specific mission. He tells his disciples that “the Son of Man must undergo great suffering, and be rejected by the elders, chief priests, and scribes, and be killed, and on the third day be raised” (9:22). In other words, Jesus must die and rise again to fulfill his Messianic purpose. The Passion narrative of chapters 20-23, where Jesus enters Jerusalem, suffers, and eventually dies on the cross, is therefore a pivotal moment in the divine mission of salvation.

Out of the Synoptic Gospels, Luke alone shows the influence of Satan in the Passion narrative.¹ Since the Passion is necessary for the completion of Jesus’s mission of salvation, and Satan appears in the Passion in Luke’s Gospel, Luke implies that Satan has a role in the narrative of salvation. Understanding the nature of that role proves a delicate task, as the theological implications of the answer must be taken into account. Two troubling possibilities can be immediately eliminated based on textual evidence. Luke does not see Satan as the cause or source of salvation; Satan’s express purpose is to *prevent* salvation, as shown in the explanation of the parable of the sower (8:12). Nor is Satan merely a pawn of God acting in a deterministic worldview, as the power of God and the power of Satan are shown to be separate and opposed to one another in Jesus’s discussion of the kingdom divided (11:14-23). Satan’s place in Luke’s story of salvation then falls somewhere in between these two extremes. He acts autonomously and with true bad intent;

1) Victor P. Hamilton, “Satan,” *The Anchor Bible Dictionary*, 3rd ed. (New York: Doubleday, 1992).

however, the consequences of his actions ironically align with God's will for salvation — in light of the resurrection, Jesus's death on the cross is a victory rather than a defeat.

The story of Joseph in Genesis 37-50, with its examination of the roles of God and evil in salvation, sheds light on what Luke tries to accomplish by including Satan in his depiction of the Passion events. The book of Genesis describes Joseph as a young shepherd boy with 11 brothers. Joseph's father, Jacob, loves him the most out of all of his siblings. Because of Joseph's favored status, his brothers are filled with hatred for him (Gen 37:3-4). Additionally, Joseph's prophetic dreams irritate his brothers, as they imply an inversion of the status quo by placing the second-youngest son in a position of power over his family (vv. 5-11). Driven by jealousy, Joseph's brothers sell him into slavery (v. 27). Despite the brothers' efforts, Joseph's dreams come true—he eventually becomes a prominent power in the pharaoh's house and saves the Egyptians from a devastating famine (41:37-57). When Joseph's brothers come to Egypt in search of food during the famine, they are shocked to find Joseph in charge. Their short-sightedness prevents them from understanding the irony of the situation, and so they are overcome with guilt and fear over their betrayal.² Joseph assures them, “do not be distressed, or angry with yourselves, because you sold me here; for God sent me before you to preserve life” (45:5). Joseph understands that his brothers' betrayal made his current situation possible. He echoes this sentiment after the death of his father, when his brothers still express their distress: “Even though you intended to do harm to me, God intended it for good, in order to preserve a numerous people, as he is doing today” (50:20). In both of these interactions, Joseph distinguishes between human intent and divine intent while implying that the two are somehow connected. While his brothers have their own, ill-intentioned motives for selling Joseph into slavery, God guides the outcome of their actions to yield positive results. Their attempt to stifle their brother's privileged

2) Sol Schimmel, “Joseph and his Brothers: A Paradigm for Repentance,” *Judaism* 37, no. 1 (1988): 64-65.

position within the family structure ironically gives him power with a much grander purpose. That purpose, facilitated by God's influence in human events, is salvific — Joseph's divine deliverance from those who meant to harm him results in the salvation of those who are under his power. He recognizes the larger significance of his own salvation and must reassure his brothers twice that God's work overshadows their guilt. Whether his brothers achieve full repentance is not explicitly stated,³ but more important is the fact that Joseph has accomplished the divine purpose revealed to him in his earliest dreams.

The theme of God's saving activity in relation to human events found in the Joseph story also appears in the Gospel of Luke; this shared theme makes the Joseph story a helpful tool for considering the problem of Satan's place in the divine will of God. A reading of Satan's main character arc in Luke with the Joseph story as a framework reveals a possible understanding of his contributions to the narrative as a whole, especially the Passion. Starting from his first appearance, the parallels between the two texts can be traced through Satan's major scenes in the Gospel.

Luke first mentions Satan in the temptation scene in the wilderness (4:1-13).⁴ In this passage, Luke establishes Jesus's role as the Son of God and sets Satan in clear opposition to him. Satan begins his first and third temptations with the phrase, “if you are the Son of God” (vv. 3, 9). This phrasing indicates that Satan wants a sign of Jesus's divine power. His intention is not to doubt, but rather to lure Jesus into using his power for his own personal gain.⁵ Self-preservation lies at the heart of all of Satan's temptations. First, he attacks Jesus's hunger and asks him to “command this stone to become a loaf of bread” (v. 3). Then, he entices Jesus to worship him in exchange for authority over “all the kingdoms of the world” (v. 5), though scholars doubt that Satan had any authority to give them

3) Schimmel, “Joseph and his Brothers,” 65.

4) Luke uses the phrase “the devil” instead of “Satan,” but both titles appear to refer to the same entity and will be used interchangeably.

5) John Nolland, *World Biblical Commentary: Luke 1-9:20* (Dallas: Word Books, 1989), 179.

over in the first place.⁶ Lastly, Satan takes Jesus to the pinnacle of the temple in Jerusalem. Satan urges Jesus to “throw yourself down from here” (v. 9). Thus, Satan’s attempt to defeat Jesus in Jerusalem during the temptations demonstrates his grander mission to “thwart [Jesus’s] role in salvation-history.”⁷ All three temptations, especially the third, show Satan’s complete misunderstanding of salvation. Satan encourages Jesus to give in to selfish desires; Jesus, as the Son of God, instead emphasizes the importance of spiritual preservation over the physical, of eternal salvation over the temporary. Like Joseph,

Jesus correctly interprets the will of God. Jesus’s trust in God and successful resistance of Satan preserve him until his next time of trial, just as God carried Joseph through his hardships and temptations in Egypt. Luke ends the temptation narrative on an ominous note: “When the devil had finished every test, he departed from him until an opportune time” (4:13). This language alerts the reader that this will not be the last they see of Satan. Jesus may have defeated him three times, but Satan’s purpose in the narrative is not yet fulfilled. He is still looking for a way to defeat the promise of salvation that Jesus brings.

Satan mostly disappears from the narrative between 4:13 and 22:3, though his influence continues in episodes of demonic possession throughout Jesus’s ministry.⁸ He returns in chapter 22, an early stage in the Passion narrative. The thematic connections between Luke and the Joseph story are more obvious in the Passion than in the temptation, as Satan’s ill intent factors more directly into the events of the Gospel. Satan finally finds his “opportune time” (4:13) upon Jesus’s entrance into Jerusalem. He enters into Judas Iscariot and incites him to betray Jesus (22:3),

6) I. Howard Marshall, *The Gospel of Luke: A Commentary on the Greek Text* (Grand Rapids: Eerdmans, 1978), 172.

7) Joseph A. Fitzmyer, *The Gospel According to Luke I-IX* (New Haven: Yale University Press, 1970), 517.

8) Darrell L. Bock, *Luke* (Downers Grove: InterVarsity Press, 1994), 85.

a curious element that Luke shares with John but none of the other Synoptic Gospels.⁹ Luke emphasizes Judas’s position as “one of the twelve” (v. 3), reminding the reader that the betrayal comes from one of Jesus’s closest friends.¹⁰ As in the Joseph story, those whom the betrayed should be able to trust most intimately (in Joseph’s case, brothers; in Jesus’s case, a friend) are the ones who hand them over. The writer of Genesis indicates that Joseph’s brothers betrayed him because they hated him out of jealousy (Gen 37:4; 37:11), but Luke does not explicitly state Judas’s personal motivation for

betraying Jesus beyond a brief mention of money offered by the chief priests.¹¹ No matter the motivation, both accounts show an intent to harm the betrayed person. In Judas’s case,

the intent springs from the influence of Satan, which shows Satan’s participation in the events of the Passion from the beginning. The conspiracy of Judas is only the first step towards Satan’s goal of preventing salvation.

Jesus’s speech during the Last Supper in 22:21-34 reveals his awareness of Satan’s influence on the Passion events. After distributing the bread and wine to his disciples, Jesus informs them of his upcoming betrayal: “But see, the one who betrays me is with me, and his hand is on the table. For the Son of Man is going as it has been determined, but woe to that one by whom he is betrayed!” (vv. 21-22). As in verse 3, Luke emphasizes Judas’s place at the table, “a place of intimate and trusted fellowship in Judaism,” to highlight the true tragedy of the betrayal.¹² While Jesus’s statement indicates his awareness of Judas’s (and, implicitly, Satan’s) intention to betray him, he also understands the role

9) Luke Timothy Johnson, *The Gospel of Luke* (Collegeville: The Liturgical Press, 1991), 332.

10) John T. Carroll, *Luke: A Commentary* (Louisville: John Knox Press, 2012), 427.

11) Robert C. Tannehill, *Luke* (Nashville, Abingdon Press, 1996), 310.

12) James R. Edwards, *The Gospel According to Luke* (Grand Rapids: Eerdmans, 2015), 631.

Self-preservation lies at the heart of all of Satan’s temptations.

the betrayal must play in the accomplishment of his salvation mission. His mention of the determined death of the Son of Man (see 9:22) clarifies that his death, though brought about by “the evil enemy of God’s purposes,” is “the expression of the divine will”.¹³ In one sense, Judas’s betrayal helps Jesus complete his mission, but this fact alone does not fully justify his actions. The disciples worry about who would betray Jesus, but their focus shifts abruptly to a conversation about who among them is the greatest. In response, Jesus reminds them of their journey’s greater purpose: “I confer on you, just as my Father has

conferred on me, a kingdom” (v. 29). True power defies expectations and earthly obstacles; recall the way Joseph’s brothers

initially feared his power but ended up being saved through it. Next, Jesus delivers a stern warning to Peter: “Simon, Simon, listen! Satan has demanded to sift all of you like wheat” (v. 31). Satan’s influence on Jesus threatens to spread to others, and in fact it has already infected the community through Judas.¹⁴ However, all hope is not lost. Jesus tells Peter, “I have prayed for you that your own faith may not fail” (v. 32). While Satan’s demand for control over the disciples poses a real threat, God’s protection will ensure the fulfillment of divine purpose. The salvation of the people is yet to come, even as the evil events which threaten it are in full force.

The conflict between Satan and Jesus comes to a head in the crucifixion story. The crucifixion is part of a larger “dishonoring process” that Luke builds into his narrative from 22:63 onward.¹⁵ The process is a natural one, i.e., since Jesus has already been rejected by the crowds throughout his ministry, his humiliating and devastating death on the cross *must* occur, and it follows that he will

13) Carroll, *Luke*, 437.

14) Joseph A. Fitzmyer, *The Gospel According to Luke X-XXIV* (New Haven: Yale University Press, 1985), 1424; Johnson, *The Gospel of Luke*, 346.

15) Tannehill, *Luke*, 340.

eventually rise again (see 9:22). For the time being, though, Luke sets up a depressing execution scene. The crowd’s language throughout the crucifixion relates back to the temptations from chapter 4, suggesting a connection between the crowds and the influence of Satan.¹⁶ Just as Satan did earlier, the crowd mocks Jesus and tempts him to exercise his power as the Son of God (“let him save himself” (v. 35); “save yourself” (v. 37)). Luke adds a unique third salvation demand, this time from one of the criminals crucified alongside Jesus: “Save yourself and us!” (v. 39). This trio of taunts

“highlights the salvific significance of Jesus’s crucifixion”¹⁷ with great irony, as Jesus actually *has* the power to save himself but chooses to forfeit his own self-preservation for the salvation of many. Only Jesus and the second criminal crucified with him recognize and understand

this important reversal. Jesus even prays for the ignorant crowd: “Father, forgive them; for they do not know what they are doing” (v. 34). While some manuscripts lack verse 34, it fits thematically within Luke’s vision of Jesus as a scorned prophet and should be at least briefly considered in this analysis.¹⁸ The content of the prayer mirrors the relationship between Joseph and his brothers in Genesis, as the brothers were unaware of the true impacts of their actions and needed forgiveness (Gen 45:5-8). After a lengthy period of humiliation, Jesus finally dies on the cross (Lk 23:46). Satan’s mission of killing the Messiah is complete, though the outcome is significantly different than expected. After Jesus’s death, a centurion proclaims that “certainly this man was innocent” (v. 47), and the crowds go home sorrowfully “beating their breasts” (v. 48). Nobody rejoices at the death of the Savior. Jesus’s death on the cross, which should have been a victory for those who meant to harm him, instead turns out to be a victory for Jesus with the resurrection in chapter 24. This ironic reversal recalls Joseph’s two statements of forgiveness (Gen 45:5; 50:20) and

16) Edwards, *The Gospel According to Luke*, 688.

17) Fitzmyer, *Luke X-XXIV*, 1501.

18) Johnson, *The Gospel of Luke*, 376.

True power defies expectations and earthly obstacles...

reestablishes that God's influence in human affairs ultimately leads to widespread salvation. Though Satan meant to harm Jesus, God has bigger plans that are still yet to be completely fulfilled.

While it is impossible to say for sure whether or not Luke took direct inspiration from the Joseph story, the thematic similarities between the two stories are strong. Both narratives involve favored sons with prophetic qualities who overcome great trials so that a wide amount of people may be saved. Additionally, the writers of both texts show God's power over human events in the face of ill will. After careful consideration of this theme in both texts, we can see that Luke's Satan has a role in salvation that is neither fully passive nor fully active. Instead, Jesus uses Satan's evil intentions to strengthen himself in preparation for the crucifixion, just as God intends for him. However, Jesus's resurrection does not mean that Satan disappears for good. As Jesus states in 22:31, and as later New Testament writers attest, Satan's power is still a real threat to the community. But Satan's ironic role in the salvation narrative of Luke's Gospel reminds readers that there is no need to fear evil. If they follow the example of Jesus and resist Satan's temptations, they can hope to understand the cosmic workings of God.

Author's Note

Hello there! My name is Katie Hill. I am currently a first-year graduate student at the Boston College School of Theology and Ministry. But when I wrote this paper, I was a senior English major with a theology and religious studies minor. I was enrolled in TRS 191, Intensive Inquiry on the Gospel of Luke, my second scripture study course at SMC. I wanted to push myself a little bit in my exegesis to prepare for the challenging work of graduate school, and I knew that I wanted to be creative with my final paper for the course. Because of my background in English, I am very interested in narrative theory. So, when I was first brainstorming what to write for this paper, I was looking at narrative elements such as plot, characters, themes, etc. In Luke's Gospel, one character kept jumping out at me — Satan.

Now, I know how weird that sounds, but it's true. He only appears twice in the whole gospel, but something about the way Luke constructed his character fascinated me. I started thinking about how Luke might have used Satan as a literary device to illustrate a broader concept of evil. Satan's direct impact on Jesus' Passion, through his possession of Judas, likewise caught my attention. I honestly struggled to understand the relationship between Satan's influence and the eventual salvation brought by Jesus' death and resurrection. Then, I recalled the story of Joseph from the Old Testament book of Genesis, and its famous line "you meant to harm me, but God intended it for good". From there, everything clicked. I was able to tackle a subject with enormous theological implications through narrative parallels. As I look back on this work now, I can see how much I've grown in my understanding of exegesis; however, I'm still proud of the work I did and I'm grateful for the experience it gave me.

There are so many people to thank when it comes to this paper. First of all, I want to say thank you to all of my friends who listened to me rant about Satan and didn't write me off as a heretic. Thank you also to Mia Maramba, my fearless Writing Adviser (and former coworker) who helped me edit this paper. And, additionally, I'd like to thank all the hardworking people at CWAC, especially those who put the Undergraduate Spectrum together every year. Most of all, I want to thank Professor Michael Barram, who always encouraged me to be bold in my studies and make my own claims. It is mostly because of his Intensive Inquiry scripture classes that I decided to take a leap of faith (so to speak) and apply for graduate school in theology. The confidence that Michael instilled in me, as I know he instills in every student, has carried me far.



Picture-Hanging Problem

Chris Gloudeman

1 Introduction

Imagine that a picture is hung with a piece of string around two nails in the traditional fashion. If one nail is removed, then the picture will still hang on the other nail. But what if we wanted the picture to hang on both nails and fall when either one of them was removed? This is the picture-hanging problem we will be examining in this paper, and a hanging satisfying this criteria can be seen in Figure 1. We see a solution to the two nail problem, where removing either one of the nails will cause the picture to fall. If we have more nails, similar hangings can be constructed that still satisfy this criteria. When generalized to n nails this is referred to as a 1-out-of- n puzzle, where the picture is hung on n nails and the removal of any single nail causes it to fall. We will use two different methods to construct solutions to these puzzles with free group theory and analyze the efficiency of each.

Figure 1: Solution to the two nail problem.[2]



Section 2 will introduce some basic knot theory concepts that will help us better contextualize the picture-hanging puzzle and its place in mathematics. We then examine how to represent solutions to this 1-out-of- n picture-

hanging problem using free groups in Sections 3 and 4. Then we will create solutions to the puzzle using two different methods in Section 5 and examine their efficiency in Section 6.

2 Brunnian Links

2.1 Knot Theory Background

In this section we will briefly introduce some knot theory concepts and discuss how they relate to our picture-hanging puzzle. Knot theory is a branch of topology that studies mathematical knots and their properties. To start, imagine a piece of string. Then tangle this string up and glue the ends together. You now have a knot! To make this knot more mathematical, let this string exist in a three-dimensional space and have a thickness of one point. In other words, our knot is a continuous curve with a cross section of just one point.

We can also have multiple knotted loops instead of just one. A **link** is a set of knotted loops that may be tangled together. Similar to a subset of a set, a **sublink** is a subcollection of loops contained in a larger link. Links can also be moved in space without changing. Any deformation of a link that does not cause any loop to intersect another is referred to as an **equivalent link**. Equivalent links are topology preserving transformations. [6]

The most basic example of a link is the trivial link of two components, which can be seen in Figure 2a and Figure 2b. A link is said to be **trivial** if its components can be separated by a plane. The link in Figure 2a can be separated since the loops lie on top of one another. On the other hand, **nontrivial** loops are tangled together and cannot be separated. A nontrivial link of two components can be seen in Figure 3. These loops cannot be separated without breaking one of the loops or allowing them to intersect and cross over each other. This brings us to a special type of link: Brunnian links.

Figure 2: Trivial and nontrivial links of two components.[1]

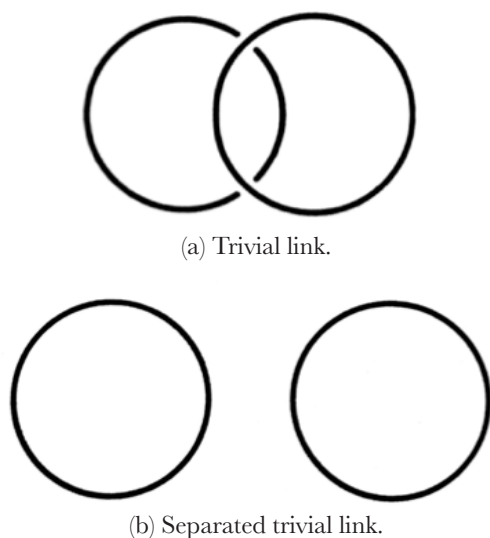
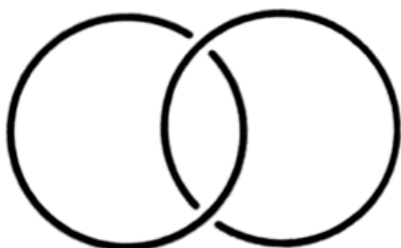


Figure 3: A nontrivial link.



Definition: If a link is nontrivial, yet every proper sublink is trivial, then it is a **Brunnian link**.

In other words, a link is called Brunnian if the link itself is nontrivial, but the removal of any single component leaves a set of trivial unlinked loops. The link in Figure 3 is Brunnian since the overall link itself is nontrivial, but removing either loop will leave one loop which is clearly trivial. The term Brunnian is used in honor of knot theorist Hermann Brunn, who included examples of such links in his 1892 paper *Über Verkettung* (On Linking).[6]

One popular example of a Brunnian link is the Borromean Rings shown in Figure 4. Each of the three rings lies entirely on top of one ring and entirely beneath the other, so no pair of rings are nontrivially linked. However, the whole link itself cannot be separated without breaking one of the rings. This makes the Borromean Rings a Brunnian link.

Figure 4: The Borromean Rings.

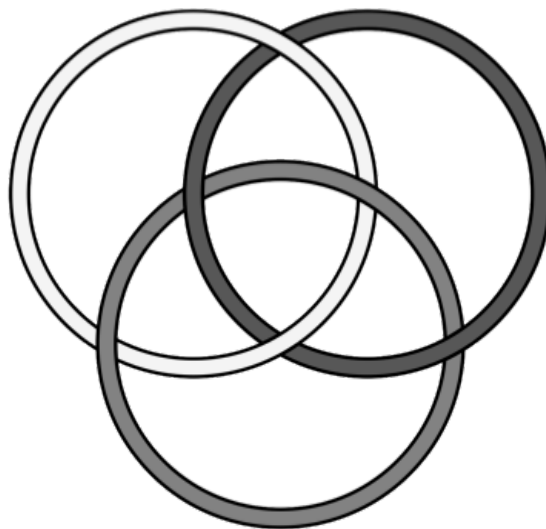
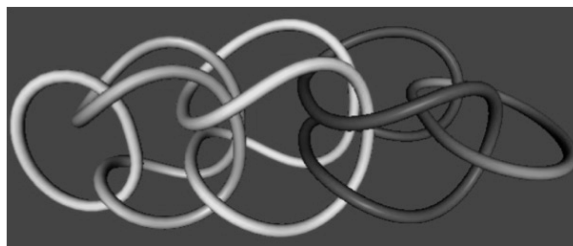


Figure 5 shows a Brunnian link consisting of five components. Repeating the same trend seen in the center three links can allow you to make Brunnian links of $n \geq 3$ components. [5]

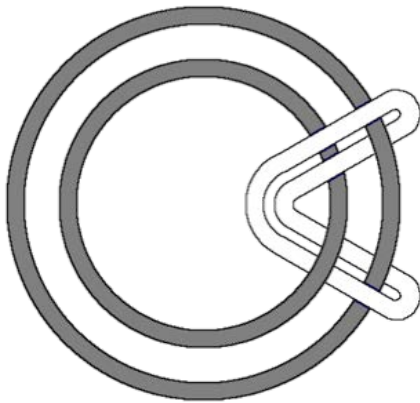
Figure 5: Brunnian link of five components.[8]



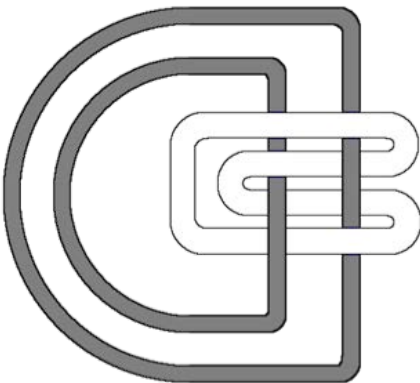
2.2 Brunnian Links in the Picture-Hanging Problem

We will now demonstrate how Brunnian links are analogous to the 1-out-of- n nail problem. You can probably already see the resemblance; removing one link from a Brunnian link leaves a set of unlinked loops, while removing one nail from a picture-hanging causes the picture to fall. To show the connection between Brunnian links and the nail problem, we will transform a Brunnian link into a nail problem and show that they can be equivalent links. Figure 6 shows a pair of equivalent Brunnian links.

Figure 6: Equivalent Brunnian links of three components. [7]



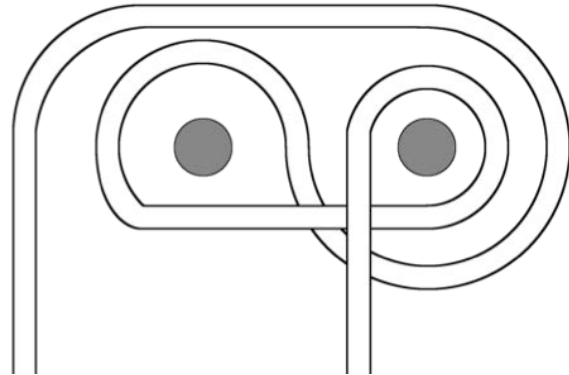
(a)



(b)

The deformation from Figure 6a to 6b is quite clear, but now we must rotate it to resemble string and nails. Since the loops overlap, they exist in three dimensional space. We will rotate the Brunnian link in Figure 6b by 90° along a fixed horizontal axis. The two straight sections of the outer loops will become the nails, and the white loop will become the string. The top of the gray loops are where the nails enter the wall and the bottom of those loops will be the heads of the nails. The last change that needs to be applied to Figure 6b is that each of the links is cut. Only the straight section of the gray links remain, and the white string is cut so that a picture can be attached on the ends of the string. The final deformation can be seen in Figure 7.

Figure 7: Solution to the 1-out-of-2 nail problem. [7]



3 Free Groups

A useful way of describing the solutions to picture hanging puzzles is through free group theory. Before we define a free group, we must define some preliminary terms. We will start by defining the **alphabet** A from which we will construct our solutions. An alphabet is the list of all elements (or letters) in our system. For example, the set $A = \{a, b\}$ is an alphabet. Combinations of elements of A are called **words**. For free groups we want to focus on the **reduced words**, which are sequences of symbols such that no elementary manipulations of integer exponents are possible. The exponent manipulations in this context are simply adding or subtracting exponents when adjacent terms have the same base. For example, the word $a^1 a^3 b^5 b^2 a^3$ can be rewritten in its reduced form as $a^4 b^7 a^3$. We are now ready to define a free group.

Definition: A group F_A is called a **free group** if there exists a generating set A of F_A such that every non-empty reduced word in A defines a non-trivial element of F_A . Concatenation is the group operation with the multiplication rule $a^n a^m = a^{n+m}$. [4]

The free group F_A will be the collection of all reduced words made up of elements from the alphabet A . For example, $a^2 b a^{-1} b^{-3}$ is an element of the free group F_A since each of the symbols is in A and it is written in lowest terms. It is also important to note that our free group is **non-abelian**, meaning that it is not commutative. Our words can be reduced only when two adjacent terms have

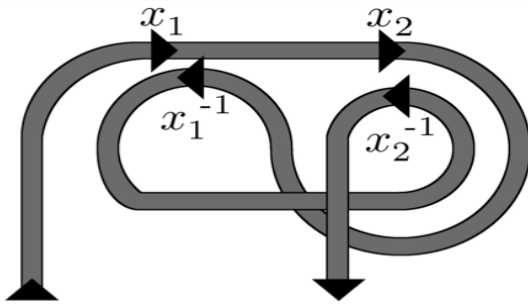
the same base. For example, the reduced word aba^{-1} is not the same as baa^{-1} . The word baa^{-1} can be reduced to b , but aba^{-1} is in lowest terms and cannot be reduced.

4 The Puzzle as a Free Group

In our case, we will set our alphabet $A = \{x_1, x_1^{-1}, x_2, x_2^{-1}, \dots, x_n, x_n^{-1}\}$, where each x_i corresponds to a clockwise turn around the i th nail and x_i^{-1} corresponds to a counterclockwise turn around the i th nail. Solutions to the 1-out-of- n puzzles will be reduced words consisting of combinations of these terms to describe how the string wraps around each of the nails. Note that we are restricting the possible configurations to only wrap around the nails, meaning that the string cannot wrap around itself.

Reducing words in our picture-hanging problems will only deal with exponents of ± 1 . For example, the reduced form for $x_1x_1^{-1}x_2$ would be x_2 . This is to be interpreted as a clockwise turn around nail 1, followed by a counterclockwise turn around nail 1, then a clockwise turn around nail 2. A clockwise turn immediately followed by a counterclockwise turn around the same nail will cancel each other out since they are undoing each other. So the reduced word x_2 makes sense in the context of our problem. Our group is also non-abelian. In context, $x_1x_2x_1^{-1}$ is not the same as x_2 since a clockwise turn around nail 1, followed by a clockwise turn around nail 2, and a counterclockwise turn around nail 1 will not act the same as one clockwise turn around nail 2.

Figure 8: Solution to the 1-out-of-2 nail problem with each turn labeled. [7]



We can visually examine the hanging for the 1-out-of-2 nail problem shown in Figure 1 and write a reduced word corresponding to it. We will call this reduced word a **solution** to the nail problem. The string first makes a clockwise turn around nail 1, then nail 2, followed by a counterclockwise turn around nail 1, and another counterclockwise turn around nail 2. Therefore, the word $x_1x_2x_1^{-1}x_2^{-1}$ is a solution to the 1-out-of-2 puzzle. Figure 8 shows a solution for the two nail problem with each of the turns appropriately labeled according to their free group element. The sequence begins at the bottom left arrow and follows the other arrows until it reaches the bottom right. Each of the other arrows describes either a clockwise or counterclockwise turn around a nail.

5 Generating Solutions

In this section we will construct solutions to the 1-out-of- n picture hanging puzzle. In Section 5.1 we will use the commutator to find solutions for up to 3 nails, and then generalize it to apply to any number of nails. Then, in Section 5.2 we will use a similar approach to create simpler solutions.

5.1 Recursive Method

We will first find solutions to the 1-out-of- n puzzle using the recursive method. We will construct solutions recursively by adding one nail and incorporating it into the previous solution. This is a simple approach that proves to be less efficient for a large number of nails. If the picture is hanging on only one nail, then the solution is trivial: one x_1 clockwise turn (or one x_1^{-1} counterclockwise turn) will result in the picture falling when nail 1 is removed. We will call the solution to the $n = 1$ nail problem P_1 , where $P_1 = x_1$.

Definition: The **commutator** of two elements x_1 and x_2 of a group F_A is the word $[x_1, x_2] = x_1x_2x_1^{-1}x_2^{-1}$.

For the $n = 2$ nail problem, we can construct a solution by finding the commutator of P_1 with x_2 . In other words,

$$\begin{aligned}
 P_2 &= [P_1, x_2] \\
 &= P_1 x_2 P_1^{-1} x_2^{-1} \\
 &= x_1 x_2 x_1^{-1} x_2^{-1}. \tag{1}
 \end{aligned}$$

Solutions to a picture-hanging puzzle can be verified algebraically when written in this form. Removing the i th nail is equivalent to removing all of the x_i and x_i^{-1} terms from the solution. If the remaining terms cancel each other out after removing the x_i and x_i^{-1} terms, then the picture will fall. For example, if the first nail is removed then we are left with $x_2 x_2^{-1} = 1$ where 1 is the fallen state of the picture. If the second nail is removed then we have $x_1 x_1^{-1} = 1$.

In terms of how this corresponds to the hanging picture, removing the i th nail will unravel any turns around that nail. This allows us to drop each of the x_i and x_i^{-1} terms in the solution P_2 since the nail that was holding up each of these turns is no longer there. Then we are left with a clockwise turn around a nail immediately followed by a counterclockwise turn around the same nail. These turns will undo each other causing the terms to cancel.

Now from the solution P_2 on two nails, we can construct a new solution P_3 for the 3 nail system. This can be done by taking the commutator of P_2 with the third nail x_3 :

$$\begin{aligned}
 P_3 &= [P_2, x_3] \\
 &= P_2 x_3 P_2^{-1} x_3^{-1} \\
 &= (x_1 x_2 x_1^{-1} x_2^{-1}) x_3 (x_1 x_2 x_1^{-1} x_2^{-1})^{-1} x_3^{-1} \\
 &= x_1 x_2 x_1^{-1} x_2^{-1} x_3 x_2 x_1 x_2^{-1} x_1^{-1} x_3^{-1}. \tag{2}
 \end{aligned}$$

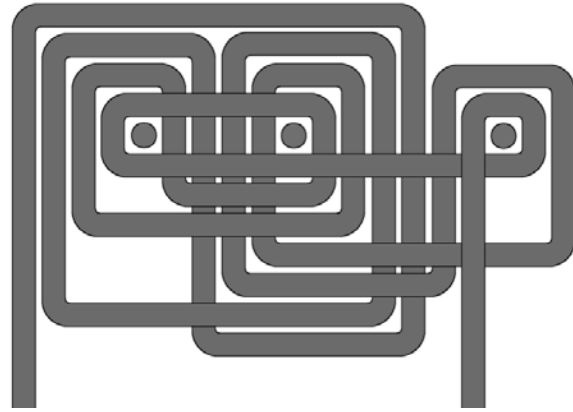
For this simplification, we use $(ab)^{-1} = b^{-1}a^{-1}$. A visual representation of solution P_3 can be seen in Figure 9. The nails are numbered one through three from left to right. For the last two terms in P_3 , we have $x_1^{-1}x_3^{-1}$. Notice in the figure that when we skip past nail two, the rope simply passes underneath it.

This solution can be verified with the same method as P_2 . Removing all of the x_i and x_i^{-1} terms for $i = 1, 2$, or 3 will cause the remaining terms to cancel out and the picture to fall. For example, removing the second nail would leave us with the following:

$$\begin{aligned}
 P'_3 &= x_1 x_1^{-1} x_3 x_1 x_1^{-1} x_3^{-1} \\
 &= (x_1 x_1^{-1}) x_3 (x_1 x_1^{-1}) x_3^{-1} \\
 &= (1) x_3 (1) x_3^{-1} \\
 &= x_3 x_3^{-1} \\
 &= 1
 \end{aligned}$$

Since all of the terms cancel, the rope is no longer wrapped around any nails. This causes the picture to fall. Removing nails 1 and 3 would also cause the remaining terms to cancel. This will be left as an exercise for the reader. By continuing this pattern with the commutator, we can find a solution for any number of nails. A formal proof of this statement follows in Theorem 2.

Figure 9: Solution to the 1-out-of-3 nail problem. [7]



Lemma 1. *If P_k is a solution to the 1-out-of- k picture hanging puzzle, then so is P_k^{-1} .*

The inverse of a solution can be thought of as equivalent to viewing the picture-hanging reflected through a mirror. Then it is obvious that if a picture hanging near a mirror falls when any single nail is removed, its reflection will also fall.

Lemma 1 is true due to the symmetric similarities between P_k and P_k^{-1} . When finding the inverse P_k^{-1} , we simply reverse the order of terms in P_k and switch the exponents from +1 to -1 and vice versa. We have assumed that P_k is a solution, so removing all of the x_i and x_i^{-1} causes the picture to fall for every integer $1 \leq i \leq k$. In other words, when any pair of x_i and x_i^{-1} are removed, the remaining terms cancel each other out. Then for the inverse P_k^{-1} , removing each x_i and x_i^{-1} will also cause each

term to wind up next to its inverse since the only differences between P_k and P_k^{-1} do not affect the rules for the cancellation of terms. Thus if P_k is a solution to the 1-out-of- k puzzle, then so is P_k^{-1} . We will use this in the following proof.

Theorem 2. *For a picture hanging with $n \geq 2$ nails, a solution to the 1-out-of- n problem can be found using the recursive method. [2]*

Proof. We will prove this by induction. For the base case when $n = 2$, $P_2 = [x_1, x_2] = x_1 x_2 x_1^{-1} x_2^{-1}$. This was shown in Section 5.1 to be a valid solution. Thus a solution to the case when $n = 2$ exists.

Now suppose P_k is a solution to the 1-out-of- k puzzle for some $k \geq 2$. This means P_k is some combination of x_i and x_i^{-1} terms where $i \in \{1, 2, \dots, k\}$ such that removing all of the x_j and x_j^{-1} terms for any one value of $j \in \{1, 2, \dots, k\}$ will cause the remaining terms to cancel out. In other words, if $x_i = x_i^{-1} = 1$ for some $i \in \{1, 2, \dots, k\}$ then $P_k = 1$. We can then examine the solution for $k + 1$ nails, which can be written as

$$\begin{aligned} P_{k+1} &= [P_k, x_{k+1}] \\ &= P_k x_{k+1} P_k^{-1} x_{k+1}^{-1} \end{aligned}$$

If we remove any nail numbered 1 through k , then what remains of P_k after removing the appropriate terms will reduce to 1 by definition of it being a solution. And by Lemma 1, what remains of P_k^{-1} will also reduce to 1. This leaves us with $x_{k+1} x_{k+1}^{-1} = 1$. Since all of the terms cancel, the picture falls. If the $k+1$ nail is removed then we are left with $P_{k+1} = P_k P_k^{-1} = 1$ so the picture falls. Therefore, by the principle of mathematical induction, a solution to the 1-out-of- n picture hanging problem exists for all integer values $n \geq 2$.

5.2 Interval Method

In Section 5.1, we built solutions by adding one nail to the previous solution. However, it can be seen in Figure 9 that the solutions are already getting quite complicated. For higher numbers of nails it becomes more efficient to build separate solutions for each half and combine them. This new method gives a shorter construction than the

recursive method. We will examine the efficiency of each method in greater depth in Section 6. Although this method also has recursive characteristics, we will refer to it as the interval method to differentiate it from the recursive method in Section 5.1.

We can rewrite some of our previous solutions from Section 5.1 in interval notation. For the one nail problem, we can rewrite P_1 as $P(1:1)$, meaning that the solution is for nail 1 only. The solution P_2 for an interval of two nails can be written as $P(1:2)$, meaning that the solution is for the interval from nail 1 to 2. As we know from Section 5.1, a solution for one nail is $P(1:1) = x_1$, and a solution for two nails is $P(1:2) = [x_1, x_2]$.

These patterns can be generalized to arbitrary intervals and intervals larger than two nails. We will define the simplest component of our solutions as

$$P(i:i) = x_i.$$

The interval $(i:i)$ can be interpreted as being a solution for nail i . This is similar to the solution for the one nail problem P_1 , the difference here being that $P(i:i)$ can be applied to any single nail i as a component of a larger solution. Using this new notation we can describe the solution for two arbitrary nails neighboring each other as

$$P(i:i+1) = [x_i, x_{i+1}]. \quad (3)$$

These types of solutions will be the building blocks for larger solutions. For an interval from $(i:j)$ we can now split the interval in half and take the commutator of the solutions for each half. If the half solutions are larger than two nails, then they will need to be split further down. If there is an odd number of nails, then we cannot cut the problem perfectly in half. Therefore we will need to utilize the floor function, which takes a real number x and gives as output the greatest integer less than or equal to x and is denoted $\lfloor x \rfloor$. In simpler terms, we “round down” when we take the floor of x .

Definition: A solution for the 1-out-of- n puzzle for the interval $(i:j)$ can be written as

$$P(i:j) = [P(i:\lfloor \frac{i+j}{2} \rfloor), P(\lfloor \frac{i+j}{2} \rfloor + 1:j)]. \quad (4)$$

To illustrate this method in practice, we will find a solution $P(1:4)$ for four nails. We start with the whole interval from nails 1 to 4, so in Equation 4 we set $i = 1$ and $j = 4$.

$$\begin{aligned}
P(1:4) &= \left[P\left(1:\left[\frac{1+4}{2}\right]\right), P\left(\left[\frac{1+4}{2}\right]+1:4\right) \right] \\
&= [P(1:2), P(3:4)] \\
&= [[x_1, x_2], [x_3, x_4]] \\
&= [x_1 x_2 x_1^{-1} x_2^{-1}, x_3 x_4 x_3^{-1} x_4^{-1}] \\
&= (x_1 x_2 x_1^{-1} x_2^{-1})(x_3 x_4 x_3^{-1} x_4^{-1})(x_1 x_2 x_1^{-1} x_2^{-1})(x_3 x_4 x_3^{-1} x_4^{-1})^{-1} \\
&= (x_1 x_2 x_1^{-1} x_2^{-1})(x_3 x_4 x_3^{-1} x_4^{-1})(x_2 x_1 x_2^{-1} x_1^{-1})(x_4 x_3 x_4^{-1} x_3^{-1}) \\
&= x_1 x_2 x_1^{-1} x_2^{-1} x_3 x_4 x_3^{-1} x_4^{-1} x_2 x_1 x_2^{-1} x_1^{-1} x_4 x_3 x_4^{-1} x_3^{-1}
\end{aligned}$$

In this example, $P(1:2)$ is a solution for the interval from nail 1 to nail 2, and $P(3:4)$ is a solution for nail 3 to nail 4. When plugged into Equation 4, both of these interval solutions reduce to an interval of length two. This allows us to write it as a simple commutator of two nails as shown in Equation 3. If we were to find the solution for a wider interval, we would continue to split the intervals in half until the largest interval length was two nails.

This solution has fewer terms than the solution we would find using the recursive method described in Section 5.1. For this reason, we would say that the interval method is more efficient. The proof stating that Equation 4 gives a solution to the 1-out-of- n nail problem is nearly identical to the proof of Theorem 2, so it has been omitted. In the next section, we will more thoroughly examine the efficiency of these two methods. Figure 11 also shows this solution $P(1:4)$.

6 Efficiency of Solutions

Due to their different natures, the recursive and interval methods find solutions with differing numbers of terms. We will define the length of a solution to be the number of terms in the solution. For example, the two nail solution $P_2 = x_1 x_2 x_1^{-1} x_2^{-1}$ has length 4 since it is composed of four terms. In Figure 10, we can see that the interval method is much shorter in length when dealing with a large number of nails. See Appendix

A1-A2 for simple code detailing how the terms in table 10 were found. A more rigorous examination of the lengths of solutions for these methods follows.

Figure 10: Table showing the length of solutions found using each method described in Section 5.

Nails	Terms in Recursive Method	Terms in Interval Method
1	1	1
2	4	4
3	10	10
4	22	16
5	46	28
6	94	40
7	190	54
8	382	64
16	98,302	256
32	$6.4 \cdot 10^9$	1,024

6.1 Recursive Method Length

When finding a solution to the 1-out-of- n nail problem using the recursive method, we took the previous solution and added one additional nail through the evaluation of its commutator. In other words, $P_n = [P_{n-1}, x_n] = P_{n-1} x_n P_{n-1}^{-1} x_n^{-1}$. This new solution involves repeating the sequence of turns in the previous solution, followed by one clockwise turn around the new nail, then the inverse of the previous solution, and finally a counterclockwise turn around the n th nail.

Each of the P_{n-1} and P_{n-1}^{-1} terms have the same length, and each of the x_n and x_n^{-1} have length 1. If we call the length of the previous solution L_{n-1} , then we can express the length of the current solution as a function of the previous length. The equation

$$L_n = 2L_{n-1} + 2 \quad (5)$$

gives the length for any integer value of $n \geq 2$ nails. Since the solutions using the recursive method depend on the length of the previous solution, the length increases exponentially. This is not very efficient. As shown in Figure 10, the number of terms gets out of hand relatively quickly.

We can also find an equation for finding the length of a solution with n nails without finding each of the previous solutions. The length of a

solution for the 1-out-of- n nail problem is given by the equation

$$L_n = 2^n + 2^{n-1} - 2$$

for $n \geq 2$ nails. We can verify this equation with a proof by induction.

Proof. For the base case when $n = 2$, we see that $L_2 = 2^2 + 2^{2-1} - 2 = 4 + 2 - 2 = 4$. Examining Equation 1 can confirm that the length of P_2 is 4, so the base case holds. Now suppose that the length for the solution to the 1-out-of- $(k-1)$ picture hanging problem is given by $L_{k-1} = 2^{k-1} + 2^{k-2} - 2$. Then for the 1-out-of- k nail problem, we can apply the recursive equation shown in Equation 5 to give us

$$\begin{aligned} L_k &= 2(L_{k-1}) + 2 \\ &= 2(2^{k-1} + 2^{k-2} - 2) + 2 \\ &= 2 \cdot 2^{k-1} + 2 \cdot 2^{k-2} - 4 + 2 \\ L_k &= 2^k + 2^{k-1} - 2. \end{aligned}$$

Therefore, by the principle of mathematical induction, solutions found using the recursive method for the 1-out-of- n nail problem have length $L_n = 2^n + 2^{n-1} - 2$ for $n \geq 2$ nails.

In the next section, we will see the increased efficiency of the interval method.

6.2 Interval Method Length

In Section 5.2 we defined the floor function. For finding the length of solutions using the interval method, we will need the similar ceiling function. The **ceiling function** takes a real number input x and gives as output the lowest integer greater than or equal to x and is denoted $\lceil x \rceil$. In other words, we “round up” when we take the ceiling of x .

For the interval method, we split the nails in half and combine the partial solutions for each side. This method produces different solutions from the recursive method once we have more than three nails, which can be seen in the table in Figure 10. If there is an odd number of nails, then one of the “halves” will have one more term than the other. Therefore, we can say one of the terms in the commutator from Equation 4 will be for the floor of half the nails, while the other term is for the ceiling of half the nails. The commutator includes each term and their inverses, so the length of a solution found from the interval

method is given by the equation $L_n = 2L_{\lfloor n/2 \rfloor} + 2L_{\lceil n/2 \rceil}$ for any integer $n \geq 3$ nails.

The length of solutions to the 1-out-of- n nail problem using the interval method can be easily calculated when n is a power of two. As seen in Figure 10, the length of the solution is

$$L_n = n^2 \quad (6)$$

if n is a power of two. The table shows that this is true for the first six powers of two, but with a proof by induction we can show that this equation for length will hold for all powers of two.

Proof. The base case for $n = 2$ nails gives $L_2 = 2^2 = 4$. This was shown to be true in Equation 1 since the interval method and recursive method produce the same solutions until $n \geq 4$.

Now assume that for some $n = 2^a$ number of nails, the length of the solution is $L_n = n^2 = (2^a)^2$ where a is a positive integer. Then let L_m be the length for a solution where $m = 2^{a+1}$ is the next power of two. Because m is $2 \cdot n$, we can split the solution for m nails in half to get two partial solutions for n nails. This means that using the interval method formula from Equation 4, the solution for m nails is given by $P(1:m) = [P(1:n), P(n+1:m)]$. Both of these half solutions have length L_n , and from the definition of the commutator, we know that both of these solutions will appear twice in the solution for $P(1:m)$. Thus, the length L_m is given by:

$$\begin{aligned} L_m &= 2 \cdot L_n + 2 \cdot L_n \\ &= 4 \cdot L_n \\ &= 2^2(2^a)^2 \\ &= (2^{a+1})^2 \\ &= m^2. \end{aligned}$$

Thus, if n is a power of two, then the solution found using the interval method has length $L_n = n^2$.

If the number of nails is not a power of two, then the length depends on how much greater the number of nails is compared to the previous power of two. For a 1-out-of- n nail problem, if n is b larger than the previous power of two given by 2^a , then the length is $L_n = (2^a)^2 + b(2^{a+2} - 2^a)$. A formal proof for this equation can be found in the *Journal of Automata, Languages and Combinatorics* [3].

Figures 11 and 12 show solutions to the 1-out-of-4 nail problem found using each method. It is quite

clear that even though the interval method produces a solution that looks quite complicated, it is much simpler than the solution from the commutator method. As the number of nails increases, we see an even greater difference in complexity between the two solution types. These images also provide visual comparisons for characteristics of each solution type. The interval method tends to spend time turning around nails 1 and 2, then moves over to nails 3 and 4, and then repeats this cycle. The commutator method tends to spend the majority of its turns around the first two nails and only sparingly wraps around nails 3 and 4. This can be seen in Figures 11 and 12, but is perhaps even more apparent in the algebraically written solutions.

Figure 11: Solution to the 1-out-of-4 nail problem using the interval method given by $P(1:4)=x_1x_2x_1^{-1}x_2^{-1}x_3x_4x_3^{-1}x_4^{-1}x_2x_1x_2^{-1}x_1^{-1}x_4x_3x_4^{-1}x_3^{-1}$. [7]

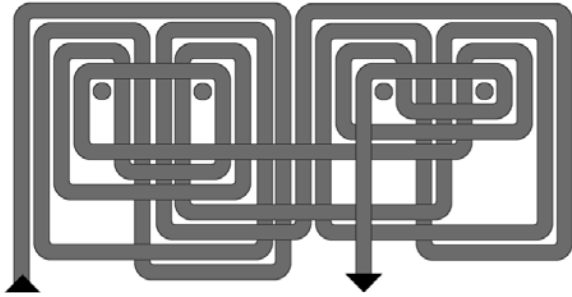
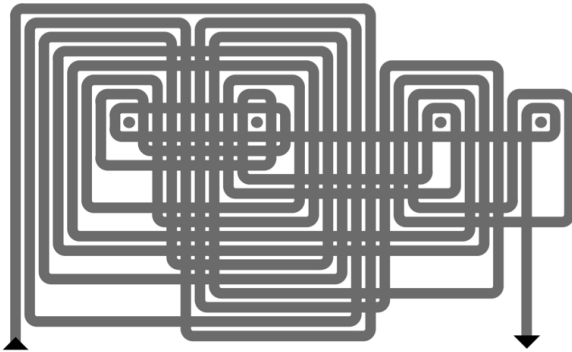


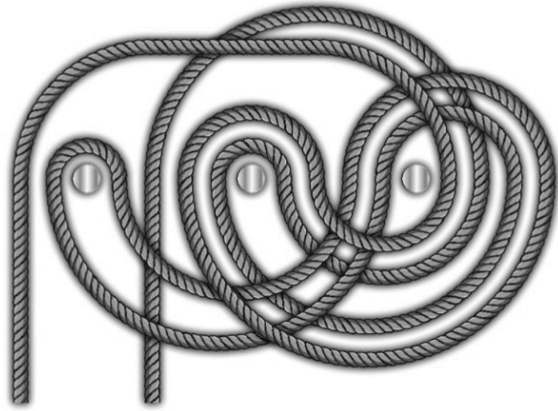
Figure 12: Solution to the 1-out-of-4 nail problem using the recursive method, given by $P_4=x_1x_2x_1^{-1}x_2^{-1}x_3x_2x_1^{-1}x_1^{-1}x_3^{-1}x_4x_3x_2x_1^{-1}x_2^{-1}x_3^{-1}x_2x_1^{-1}x_4^{-1}$. [7]



7 Other Problems

One interesting characteristic of 1-out-of- n picture-hanging puzzles is that the numbering of the nails is arbitrary. For example, in the 1-out-of-3 solution P_3 we can choose any nail to be nail 1, any other to be nail 2, and the last one to be nail 3. Then we can follow the sequence of turns described in Equation 2 to build the solution shown in Figure 13. This image looks simpler than the one shown in Figure 9, but they have the same number of terms. Intuitively, this makes sense since removing any single nail causes the others to cancel out.

Figure 13: Solution to the 1-out-of-3 nail problem. P_3 with the nails numbered 3, 1, 2 from left to right. [2]



Another way to think about renumbering the nails is to renumber the subscripts in the solution P_3 . We can rewrite P_3 in Equation 2 with arbitrarily indexed subscripts as $x_a x_b x_a^{-1} x_b^{-1} x_c x_b x_a^{-1} x_a^{-1} x_c^{-1}$. Then as we showed in Section 5.1, removing any single nail will cause the remaining terms to cancel out. We can let $a = 1$, $b = 2$, and $c = 3$ to get the solution seen in Figure 9 or we can let $a = 3$, $b = 1$, and $c = 2$ to get the solution seen in Figure 13. Note that in these cases the nails are consistently number 1 through 3 from left to right, while the sequences change.

We have thoroughly examined the 1-out-of- n picture hanging problem, but there are other variations of this puzzle that involve removing more than one nail. We will briefly describe the k -out-of- n puzzle. This problem consists of hanging the picture on n nails such that the removal of any k of them causes the picture to fall, but it stays hanging until all k nails are removed. For example,

suppose we are given a solution to the 3-out-of-10 puzzle. This means the picture is hanging on 10 nails and any two nails can be removed without causing the picture to fall. However, the third nail removed will cause the picture to fall. A solution to the 3-out-of-10 nail problem will follow this criteria no matter which combination of three nails are chosen. Solutions for this puzzle are rather complex and are found with the application of monotone Boolean functions. [2]

Another variation is the most general form of the puzzle. Let $X = \{1, 2, \dots, n\}$ be the set of nails. Let S_1, S_2, \dots, S_k be subsets of X . Each S_i is a set of specified nails. We want a picture-hanging for n nails such that the removal of any subset S_i falls the picture, but the picture also stays up if no complete set S_i has been removed. For example, the 1-out-of- n puzzle is the case where $S_i = \{i\}$ for all $i \in X$. The key for finding solutions to this puzzle involves treating each subset of nails as one unit, and then finding a solution for the 1-out-of- n puzzle for these units. For example, every clockwise turn around one nail entails a clockwise turn around the entire subset of nails. Similarly, wrapping counterclockwise around one nail entails wrapping counterclockwise around every nail in the subset. The order in which we choose to wrap the string clockwise around a subset of nails must also be reversed when we wrap counterclockwise around that subset. [2]

8 Conclusion

As we have seen, the 1-out-of- n picture-hanging puzzle has ties to both knot theory and free group theory. We showed that the problem of finding a picture-hanging that falls upon the removal of any one single nail is equivalent to transforming Brunnian links into picture-hangings. We then examined how the commutator of two nails can create a solution for the two nail problem. Then through recursively taking the commutator of the previous solution with one additional nail, we can create a sequence of terms that solves the picture-hanging puzzle for any number of nails. However, the length of solutions increases exponentially. The interval method still employs recursion, but it keeps the lengths of solutions much smaller than the previous method by

instead taking the commutator of one half solution with the other half.

A Appendix

1. Python code for calculating the lengths of solutions using the recursive method, as described in Section 6.1:

```
a = [0, 1]
for i in range(2, 101):
    a.append(2*a[i-1]+2)
```

2. Python code for calculating the lengths of solutions using the interval method, as described in Section 6.2:

```
b = [0, 1]
for i in range(2, 101):
    if i % 2 == 0:
        b.append(4*b[i//2])
    else:
        b.append(2*b[i//2]+2*b[i//2+1])
```

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[8] Image made using Knot Plot computer program.

Author's Note

The Picture-Hanging Problem initially drew my interest for two reasons. First, I have always been interested in puzzles so the problem itself drew me in. And second, I enjoy applying mathematics to situations that have no business being analyzed so thoroughly. Does the world really need a rigorous exploration of this puzzle? Of course not, so let's do it.

This paper was written as my senior project for Math 193. I graduated last spring with the class of 2018 as a math and physics double major and was encouraged to submit this paper.

I need to thank Professor Chris Jones for guiding me through this paper and learning about knots with me. I would also like to thank Professor Ellen Veomett and my entire Math 193 class for their feedback and encouragement throughout the writing process.

From “The At-Home and On-Campus Experiences of a First-Generation Latina Student: History Bleeding Into Present”

Karla Margarita Anaya

Introduction

She unlocks the door to her humble home and sets her bags down. One bag is full of clothes she brought home for break, the other is the backpack, full of assignments she knows will not get completed. She feels anxious on the train and car ride home because she knows home is no longer a place where she feels she belongs. Her chains to her family are reattached as soon as she steps off campus; her identity as a student must get left behind. While many of her peers talk about the vacations and friends’ houses where they will spend their nights, she lowers her gaze hoping not to be asked what her plans are. Numerous times she has been told by her parents that her curfew will never change, nor will their refusal to let her spend nights at friends’ houses. “Te vas cuando te casas;” You leave when you are married. Instead, her nights consist of doing the family’s laundry, and her days of running errands, cleaning the house, and cooking. Though to some this may seem extreme, she has learned that her role as the daughter away at university does not much affect her role as the daughter of two hardworking, immigrant parents. Sacrifice is a word that echoed through her upbringing; in this family, we make them to take care of each other, para seguir adelante. Therefore, she sacrifices being a student at home in exchange for the sacrifices her parents make to let her be a student away from home.

Every year millions of college students return to their communities during breaks. After having been introduced to a higher education, they go back home feeling wiser, more independent, and confident in their abilities to reach their goals. However, first-generation Latinas often have

different experiences over break. I am interested in the story behind the phenomena of why going home for First-Generation Latina Students (FGLS) is different from the common narrative. What is it about the intersectionality of FGLS that impacts their self-efficacy at home versus at the university? If they made it far enough in the race to catch up to other college students, why do their experiences vary so much so that they end up falling behind in every leg of the race?

When I go back home I do one of two things: run errands for my parents, and contemplate how I have gotten to the point at where I am in school. However, the earlier anecdote is not a personal one, but a counter-story. It is a short explanation to set up the stories of my peers and myself. Being raised in a strictly traditional Latino household surrounded by a predominantly Asian and white community meant I frequently experienced feelings of alienation. Fast forward to the present, where I became a Justice Community and Leadership (JCL) major at Saint Mary’s College of California. My passion for defining and critiquing systems of injustice led me to search for answers about my world. By reclaiming our stories, I am disrupting the storms that have brewed over us with the howl of the word “failure”. The reason I say “storms” is because I imagine a collection of degrading narratives we hear and tell ourselves hovering over us as excuses for why we cannot succeed.

In short, my thesis provides personal narratives in conversation with theory and research. These theorists include highly endorsed thinkers like Alma M. Garcia, Kimberlé Crenshaw, W.E.B. Du Bois, and Albert Bandura. I modernize the literature and empirical sources by agreeing

with and adding to the conversation through semi-structured interviews of my FGLS peers.

Literature Review

For years mentors and early outreach programs have targeted first-generation students in order to bridge gaps between their motivation and college success. However, in this paper, I am interested in the stories that are not always recorded; specifically my research focuses on the lives of FGLS and the ways in which they straddle home and school in their everyday experiences. The public and private experiences of FGLS in college falls into frameworks such as: Marianismo (NietoGomez, 1995) intersectionality (Crenshaw, 1989), perceived self-efficacy (Bandura, 1977), and Chicana feminism (Garcia, 1997). I combine the terminology of these frameworks with the history of Latinas to question the obstacles FGLS face in their homes compared to their college campus. The selected literature identifies historical context of these obstacles, the present-day pressures that come along with being an FGLS, and the possible futures these women are paving for themselves in the face of adversity.

Historical Background of Latina Culture and Religion

Anyone familiar with gender roles in our society would agree that mainstream culture plays a big part in reinforcing feminine archetypes. For example, some of the most common feminine archetypes include the mother, the virgin/maiden or the damsel in distress. From an early age, girls are fed images of Cinderella being saved by her prince, or the smiling maid set to cook and clean for the rest of her life. These mainstream images perpetuate dependence and limited opportunities for females. Likewise, the archetypes in Latino culture are presented in the early stages of a young woman, yet are reinforced by family — instead of mainstream society — for years into their adult lives. As a result, traditionally oppressive gender roles have eventually built up to create a glass ceiling above Latinas (Folley, Kidder, & Powell

2002; NietoGomez, 1995; Romero & Sy 2008).

According to Chicana scholar Anna NietoGomez (1995), one can identify the roots of the soul, mind, and spirit of la Chicana deep within the colonial period in Mexico. She argues one of the archetypes in Latino culture is the woman who is oppressed through religious obligations. For example, the history of the colonial Catholic Church provides us with the events that played major roles in forming the “sexual-social” roles of the Mexican woman (NietoGomez, 1995). These examples are illustrated as: the Christian conquest of Muslim territory, the *encomienda* or Spanish labor system, and the class relationship between the patron and the Indian slave woman.

All of these examples led up to what scholars have theorized as Marianismo (Nieto, 1975; NietoGomez, 1995; Kosmicki, 2017). The general way these scholars have defined Marianismo is as a veneration of the Virgin Mary. As the Virgin Mary became a prominent symbol of Catholicism, she also became the model of how to make oppression a religious obligation (Kosmicki 2017). NietoGomez describes the Virgin Mary as defining the “woman’s identity as a virgin, as a saintly mother, as a wife-sex object, as a martyr” (NietoGomez, 1995, p.49). She also addresses Connie Nieto, of Cal State University, Long Beach, who connects Marianismo to the Latina woman today. Nieto’s research on Latina students observes how Marianismo has manifested itself into the self-denial and self-silencing they feel in multiple ways.

To understand the depth of Marianismo it is important to look at the arguments against it being an oppressive ideology. SandraLuz Lara-Cinisomo, J. Wood, and E.M. Fujimoto (2018) conducted a systematic review of Marianismo in regards to perinatal depression and whether the concept provides religiosity risks or protective factors. They asked whether being a veneration of the image of the Virgin Mary — a very common maternal figure — is positive or negative for women who become mothers. The data of the 10 case studies they conducted (two women in Mexico, eight in the US) revealed an inconsistent correlation between Marianismo and the risk

for depression during pregnancy. However, two of every three studies significantly associated Marianismo with postpartum depression. Latina mothers-to-be were not reassured by the story of Virgin Mary and their postpartum stage brought more risks of depression because of the systematic oppression of Marianismo.

These findings extend my research into different realms of a woman's identity. Lara-Cinisomo, Wood, and Fujimoto's (2018) findings emphasize how limited a Latina can feel after Marianismo reinforces feelings of subjection after she falls into yet another category of the systemic oppression — the maternal figure. Similarly, Mia Kosmicki (2017) claims Marianismo is a gender role script. This means those who uphold it believe women should be the spiritual family leaders, remain abstinent until marriage, and be submissive to their husbands. Additionally, she examines the link between Marianismo and self-silencing, depression, and anxiety. Her data reveal a strong correlation between Marianismo and self-silencing, which led to the correlation between depression and anxiety. As astounding as the relationship between religion and mental disorder is, what I found to be more significant in Kosmicki's data was the fact that older women rated higher in Marianismo and self-silencing than younger women.

My research on FGLS intersectionalities and the impact of self-efficacy is rooted in this concept of Marianismo in many ways. NietoGomez introduces how the Virgin Mary became a model of religious oppression for women (1995). Nieto furthers this argument by linking Marianismo to the self-denial of the modern day Latina. Finally, Kosmicki (2017) and Lara-Cinisomo, Wood, and Fujimoto (2018) wrap this up through their findings of older women and new moms rating highest in self-silencing or depression. However, for Latinas like myself who are in college and therefore have the systematic opportunity to read and reflect on our experiences, Marianismo is likely to function as a system of oppression in distinct ways. My research adds to these insights from the literature by examining the intersections of home and school in the lives of Latinas.

Intersectionalities of FGLS: Familismo

The intersectionalities I am intrigued by are the identities of being the daughter of Latino parents and being an FGLS. Crenshaw is a well-known feminist who coined the term “intersectionality” under the umbrella of feminism. She reveals this phenomena as affecting women around the world in her 1989 landmark essay, “Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory, and Antiracist Politics.” Crenshaw highlights the marginalization of Black women, in collaboration with Devon W. Carbado, Vickie M. Mays, and Barbara Tomlinson (2013). Their findings have important implications for the broader domain of women identifying with each other after having realized the common language they share between their struggling intersectionalities.

Crenshaw's argument that intersectionality is a feminist issue is supported by Enriqueta Longeaux y Vasquez (1972) who begins her essay by questioning how women can be so “demanding” when their husband becomes “successful”. She asks, as “women demand more and more in material goods, can they not see what they make of their man? But then I realize: this is the price of owning a slave” (Vasquez, 1972, p.30). The materialism that seems to come from Latina women can be understood by their forced inactiveness; Vasquez explains a woman who has no way of expressing or realizing her full self has nothing to turn to but owning material things and being possessive of her family/home life. This seemingly comfortable lifestyle results in a lack of liberating self-awareness, mental and physical imprisonment, and complete dependency. On the other hand, Vasquez also describes the history of Latina women whose husbands do not become successful in the family. Their machismo (hyper-masculinity) makes them feel like they lost face, and it is through these times that Latinas face challenges. They must work three times as hard as the Anglo majority, they must muster up skills other than the ones their previous culture deemed valuable, and they will realize that society is “a racist, time-demanding monster who

will not take any excuses for her being a mother, a cook, and a maid at home” (Vazquez, 1972). The two roles Vasquez identifies are the maiden-like, stay-at-home woman who feels comfortable enough at home but mentally imprisoned, and the hardworking, suffering woman who will take any job to be able to afford her (and her families’) needs while not having any real time for herself. Drawing on Vasquez’ conceptual framework, I will investigate how these roles translate into the lives of FGLS through Marianismo and how both she and Crenshaw would describe the intersectionalities of these women of color as common, yet oppressive and unequal.

As critical as patriarchal oppression is to understanding the intersectionalities of women, Vasquez overlooks what I consider an important point about familismo. Though she touches on family dependency, other research has described familismo as a great influence in the jarring intersectionalities of Latinas (Vega 1990; Romero & Sy 2008). William A. Vega defines familismo as a cultural value pertinent in many Latino populations; he emphasizes family closeness and loyalty (1990). Furthermore, Susan R. Sy and Jessica Romero (2008) conducted semi-structured interviews with first- and second-generation Latinas to examine the contrast of individuality and independence emphasized in dominant U.S. culture. They concluded familismo — which requires an individual family member to put the needs of the family first, even if it means making personal sacrifices — heavily impacted their findings.

In the same way familismo is observed as an obstacle to the needs of individual family members, FGLS are constantly caught in the crosshairs of being a student and being an important member of the family. By focusing on the frameworks of intersectionality, familismo, and Marianismo, Crenshaw and others overlook the deeper problem of double-consciousness, which can unveil the ways in which overarching systems of oppression are implicated in the understanding of self.

Impact of Self-Efficacy and Double Consciousness

Of course, in evaluating the history of obstacles FGLS face, we must look at present day consequences, specifically the dichotomy of self-efficacy and double-consciousness (Bandura 1977; Du Bois 1903). Social psychologist Albert Bandura’s work on self-efficacy is applicable to my research as it offers a conceptual framework to examine the way Latina students approach their goals in higher education. Bandura explains self-efficacy as a main determinant of how much effort will be expended and how long it will be sustained in the face of obstacles and adverse experiences (1977). The other half of the dichotomy is Du Bois’ double-consciousness. Du Bois (1903) describes this concept as a sense of always looking at one’s self through the eyes of others, and of “measuring one’s soul by the

tape of a world that looks on in amused contempt and pity”. He also uses words like “twoness” and “the veil” to describe the feeling of multiple identities (Du Bois, 1903).

Ultimately, what is revealed here is the internal dilemma FGLS feel and how it impacts their self-efficacy in navigating through two worlds. George B. Yancey (2014) highlights some of Bandura’s frameworks that reveal possible causes behind low self-efficacy in FGLS. These causes include thought patterns, types of coping, and most significantly, the personal mastery which is developed by observing others. Yancey and Bandura’s studies further the literature on Marianismo by revealing the physiological processes behind the internal wars FGLS experience. Du Bois’ concept of double-consciousness paints the image of the FGLS torn between wanting to be successful students but held back by only having observed successful acts of Marianismo in the household.

Consider this: if an FGLS observes her maternal figures in life struggling to be assertive, independent, and self-defining, where will the example of self-efficacy develop when she is on her own in college? Sonia A. Lopez (1977), reaffirms

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this ideology as she identifies areas in which men feel “naturally” superior to women and how they manifest into an oppressive system. In educational institutions, she illustrates how women have been historically geared towards more feminine subject areas like home economics or secretarial classes, which lead them to domestic work. Some may argue these feminine “skills” — and even the religious obligations of Marianismo — have set Latina women up to be well-rounded in their education and in the American world. I am not saying it is impossible for Latinas to be assertive, independent, and self-defining in college. But even DuBois even introduces the veil as a “necessary second-sight in this American world” (1903). This second-sight takes years to master; all while the Anglo woman successfully navigates the world in the only way she has been taught how.

When the Latina woman chooses to advocate for her education, Lopez quotes a common saying in response, “Para que quieres educarte si de nada te va a servir cuando de cases,” [“Why do you want to educate yourself if it won’t be any use to you when you get married?”] (1977). This demonstrates a way in which the veil is counterproductive; What is the point of having a second-sight where you are not allowed one? Because many FGLS do not have a history of witnessing strong and independent self-efficacy from female role models at home, they need to have access to develop it via observation at school. On campus she has no shoes to fill, no pattern to be guided by, and is faced with a dilemma of pushing through or falling back. This becomes both a burden and an opportunity.

Findings & Discussion

I realized I view Saint Mary’s College as a microcosm of the world around me; it is an encapsulation of the problematic demographics I see around me. Since I arrived at Saint Mary’s, I started noticing the differences between the world

and me; I noticed where my place fell in it. As these experiences stacked up, I started asking questions about feeling like the other. The other refers to a feeling of isolation and not belonging. If I had not met certain peers who were also in my other group, I may not have found the words to form my questions for a long time. Those peers have tawny brown skin, with golden specks that are revealed in the sun. They have thick brunette or black hair and speak in different tongues. Though they are too young to have worry lines etched in their faces, I know that worries fill their heads at maximum capacity. The objective of my research is to open up the conversation around who and/or what is

behind these worries and in what ways they are impacting other first generation Latina students self-efficacy at their homes and universities.

In the process of feeling othered — and through that, belonging — I realized our stories weaved our experiences together and served to

strengthen our relationships through solidarity. There were times none of us wanted to leave for break because we were aware of the roles that awaited us. These times led to conversations: we are Latinas from immigrant households. We talked one another through navigating our identities, roles, and responsibilities. There were instances when we came back to school exhausted, and helped keep each other up late finishing homework, because after all, we have no room to fail: we are first-generation college students. Conversations like these made me notice there were far too many similar patterns present to call it just solidarity, much less a coincidence. Patterns like feeling a double identity, guilt for being a student, feeling trapped at home, made me question how our identities as FGLS impact our self-efficacy. My thought process in trying to reach a goal is constantly derailed by parts of my identity, and up until now, I always thought I was never good enough to achieve anything. I questioned how I became so unproductive compared to my

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perspective of the microcosm. However, when I realized there were other FGLS like me, I questioned what systems were in place that led me to these self-defeating beliefs.

Summary of Interviews & Autoethnographic Journaling

I will refer to my first two interviewees through pseudonyms: Luna and Sol. I interviewed these two FGLS because of their intersectionalities; they are both daughters of immigrants and attend school with me as first-generation students. Naturally, each agreed with the other on many topics such as: feeling like they work through multiple identities at home versus on campus, and feeling a sense of isolation from the dominant group on campus. It has also become common today to miss the students who are doing just well enough to stay off the radar. The next pair of interviewees I sat down with are greatly involved in their campus, overloaded with classes, and take advantage of the resources their school offers for HP students, yet they still experience the same challenges as Luna and Sol. However, this pair of interviewees — whose pseudonyms are Tierra and Cielo — brought up new concepts like machismo and imposter syndrome.

In the following sections I will identify each concept my FGLS peers directly or indirectly introduced. A lot of my discussions became enriched with the concepts I initially included in my literature review: double-consciousness, the veil, perceived self-efficacy, *Familidad*, and feminist theory. I put these concepts in conversation with my findings to show my understandings of social systems in place. Why do FGLS refuse to go home to work on their assignments? What about college makes their relationship to their parents a transformative one?

Twoness Resulting in Self-Denial

Packed in Luna's story about not feeling comfortable with her mom is the theory of double-consciousness. Du Bois introduces this term to paint the painful picture of twoness, an American and a Negro who are constantly warring against each

other to be wholly accepted in society (1903). Luna translates her twoness through being a student and a Latina whose traditions are very family-oriented (Romero & Sy, 2008). This is an anxiety-ridden war, as seen by Luna's claims that she cannot speak to her mother when she wants to escape the stresses of being a college student. I would like to support Luna's dilemma with the words of Du Bois (1903): "One ever feels his twoness...two souls, two thoughts, two unreconciled strivings; two warring ideals in one dark body...this longing to attain self-conscious manhood, to merge his double self into a better and truer self." Grappling with the idea that twoness must merge to become a whole, truer self is the same way in which Sol wants to be true to her mother in asking for support. Luna wants to be an older sister, a daughter, and a student figuring out school, not take up the role of her mother instead. Yet both hold back parts of their identities for fear they will not be understood.

This kind of dilemma causes a lot of personal and unnecessary stress for FGLS. Anyone familiar with feminist movements should agree that women have been historically thought of as incapable of being independent. However, we are using our strengths to take that story back, and prove at all costs that we can do things on our own. Particular to Sol and Luna's case in the feminist movement is the Latina component. This component emphasizes the term *Marianismo* as the image of the Virgin Mary, and the portrayal of the woman as semi-divine, morally superior, and spiritually stronger than her master because of her ability to endure pain and sorrow (NietoGomez, 1995). According to NietoGomez, this is our heritage: the concept of *Marianismo* became a model of how to make oppression a religious obligation. We, like the Virgin Mary, have been accustomed to being in the shadows, holding in our pains and sorrows but staying silent and strong nonetheless.

The Veil as a Gift

Latina students feel the impact of their surroundings every day and their resilience has allowed them to cope creatively. Through listening to the stories of my peers, I found silver linings to the

impacts of our intersectionalities on self-efficacy. In the same way each interviewee expressed a sense of isolation from their peers on campus, they also found a community. Furthermore, this community became the strongest sense of belonging each one had felt or been a part of. All four interviewees, including myself, claim most of our friends are either FGLS or have similar intersectionalities. This is where we find our strength and ability to own our identities instead of run away from them. Luna says, “I get my motivation from you all...I know you guys get what I’m going through, and I know our circles stayed close because of that.” Her words remind me of a feminist theorist Crenshaw (2013) and Sylvia Gonzales (1981). Crenshaw (2013) asserts her framework of feminist theory by highlighting the ways in which social movement advocacy suppress the vulnerabilities of women of color, particularly those from immigrant communities. Consequently, women of color form their own groups because they find solidarity in each other. In contrast, Gonzalez (1981) illustrates the ways in which Latina women initially struggled to organize. Though she does not deny that Latinos have had their share of failures in organizing, she claims “too many times we wonder why we can’t get it together” and explains it is partly due to her suspicions as to why the feminist movement and the Latino movement have not completely formed coalitions (1981). Because we have not yet profited from the movements our Latino brothers initiated, we are barely moving onto our own (Gonzalez, 1981). For example, as soon as Latino men are welcomed into the work force with equal pay as Anglo men, Latina women are still left behind in the household, thus creating a divide between what was once a struggle for solidarity. What this means is we have yet to realize the power we, as Latinas, have in our hands; only when we gather, and share out stories will we develop a positive awareness of our identities.

These two theorists suggest there is power in being with one’s own group. Luna’s example of feeling motivated by her FGLS peers at school is an example of Crenshaw and Gonzalez’ theories. Since FGLS are already using their

intersectionalities to enhance their self-efficacy, this leads me to another concept by Du Bois: the veil. Du Bois (1903) uses the veil as a metaphor for intersectionalities: “After the Egyptian and Indian, the Greek and Roman, the Teuton and Mongolian, the Negro is a sort of seventh son, born with a veil, and gifted with second-sight in this American world”. In this context, the second-sight refers to one’s ability to not only consider their personal perspective in viewing society, but also the capability to see themselves the way the rest of White America sees them.

On the one hand, Du Bois explains we may feel shut out from the world, as if a certain veil is separating us. However, as Crenshaw and Gonzalez reveal, there is an empowering feeling of determination and independence that we must accomplish ourselves to ever get ahead. Ultimately, it is not enough to use the veil as an explanation for our challenges with self-efficacy. Rather, it can be reclaimed as a gift that allows us to have knowledge of two cultures, two tongues, and two histories that keeps us from making any more mistakes than we have to.

How My Findings Fit Into the Research

As a result of double-consciousness and Marianismo, the legacy of suffering and self-denial is the middle piece in a Venn diagram of a Latina and a college student. All four of my interviewees expressed feeling suffocated in their homes, and at times, not even feeling like they have a home anymore. Essentially, these stories speak to the limited spaces FGLS feel they have to express their full identities; in this case, the home and university. As Du Bois wrote, “In this merging he wishes neither of the older selves to be lost. He simply wishes to make it possible for a man to be both a Negro and an American, without being cursed and spit upon by his fellows, without having the doors of Opportunity closed roughly in his face” (1903).

My findings insist the jarring identities of FGLS are not only felt by the persons themselves, but by the society around them — this turns into a vicious cycle of lack of misunderstandings. Because FGLS feel silenced against speaking

out about their at-home suffering, the distance increases between them and their community that raised them for so long. Even though distance from historical oppressions are what FGLS may need, it is not always without consequences. By distancing themselves from their Latina roots, they begin to lose the part of them that makes them so unique. The common saying of “neither from here nor there, neither brown enough nor American enough,” comes into play. Latino families and predominantly White colleges alike are responsible for reinforcing the divide between FGLS’ intersectional identities.

As my findings show, FGLS go back and forth with the veil and double consciousness daily. We have both the gift and the oppressive state of having multiple identities. The domino effect of stepping out of a traditionally non-liberating mindset at a young age can become catastrophic in a second. On the one hand, we can prove to our families that a higher education is worth leaving the family. The cultural background we carry allows us to be independent and persevering in the face of obstacles in college. This is the gift of the veil. However, the internal conflict of the double-consciousness of being both a Latina daughter and student is likely to eat away at us during our time in higher education.

Conclusion

One of my biggest revelations became the concept of familismo. This concept revealed all the baggage a family can carry; in this case of Latina culture, it is very heavy, oppressive baggage. However, based off of the different theorists of feminism like Crenshaw, Gonzalez, and NietoGomez, I was able to make the link between how necessary it is to foster solidarity among women with similar intersectionalities. Being a Latina and a first-generation college student creates a type of double-consciousness that allows FGLS to bond over shared experiences. This is a common way of finding solidarity and motivation

for Latina students whether it be on campus or at home. I used to think going home was something I had to do regularly to feel accepted by both my identities, but the pattern between my interviewees shows there can be a level of toxicity in a place that does not fully understand the other. To allow a flower to fully blossom, one must not take it into the shade just because they think it needs a change of scenery. Students blossom in many different spaces, and according to my research, FGLS self-efficacy is restrained by going home.

This interpretation challenges the work of those critics who have long assumed that women must be self-sacrificing because it is in their nature. The role of the Latina woman is changing because she is receiving more opportunities to become educated; therefore, her family and her brothers must learn to let go of the reins if they want to see a more equal world.

Although religious oppression (i.e., Marianismo) may seem obscure, it is in fact crucial in terms of the concern over Latinas’ liberation. The finding that familismo can also be oppressive should be of interest to the heads of families in Latina households. What may have once been opportunity for young Latinas to grow has been turned into a disservice by familial obligations. My findings show that being independent and away from home fosters the FGLS success and can foster the bond with the family.

There were limitations on my research because of the limited time I had to interview. Perhaps I could have found an FGLS whose parents did not immigrate but also did not attend college. While it is true that first-generation students are similar in many ways, it does not necessarily follow that their culture is the same at home. Additionally, I mostly interviewed Latina students who had experience living on campus while there are many FGLS who go through college commuting from home. To get a more comprehensive look at these dynamics, I would interview Latinas who are not children of immigrants and who have different

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college experiences than the dominant narrative (perhaps they commute, they are mothers, they are transfers, etc.)

These findings have important implications for the broader domain of FGLS. Historical underrepresentation in higher education has not only limited their self-efficacy but the realization of themselves. Future research in this field should focus on the internal double-consciousness many Latinas face in American culture. By assuming the technical solution like more academic or familial support, one is ignoring the fact that the sense of belonging is the most crucial piece of the puzzle. There is the constant fork in the road where FGLS are forced to choose their direction: Do I go and disappoint my family, or do I stay and risk sacrificing myself?

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Author's Note

For the first time in my life, I poured my emotions, unapologetic honesty, and hard-to-hear truths in a schoolwork piece; I was shocked to hear someone thought it was worth being read by a larger audience. There was a brief moment where I was hesitant and even afraid to allow this research project to bloom even further. But the word representation came to mind. I realized my voice matters because it symbolizes representation. This piece is for my sisters, my peers, and even my readers who share the intersectionalities of

being Latina and FGLS. I try to paint the picture of liberated Latina daughters in college; I try to shatter the glass ceiling silencing us.

Finally, I want to acknowledge the importance of representation of the 21st century immigrant family. This emphasis is influenced by Lin-Manuel Miranda's Broadway piece, *Hamilton*, and a remixed version of the track "Immigrants." The following phrase, "It's really astonishing that in a country founded by immigrants, 'immigrant' has somehow become a bad word" stands out for being the dominant narrative I constantly strive to prove wrong. Thank you to all the immigrant parents out there, especially my *mamá y papá*, for having the vision of a better life in the U.S., for allowing me to be a first-generation college student, and for ingraining in us that we have all the opportunities we work hard for.

My voice of representation would not have been discovered if it weren't for the HP Program. Thank you HP, for taking me under your wing and showing me how important speaking my narrative is; thank you my HP peers, for being beautifully vulnerable with me and sharing your stories that will hopefully empower those following in our footsteps. This paper would also not have been possible without my JCL Professors, Dr. Manisha Anantharaman in particular, who gave me the language to form my thoughts around these phenomena I so badly wanted to uncover.

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