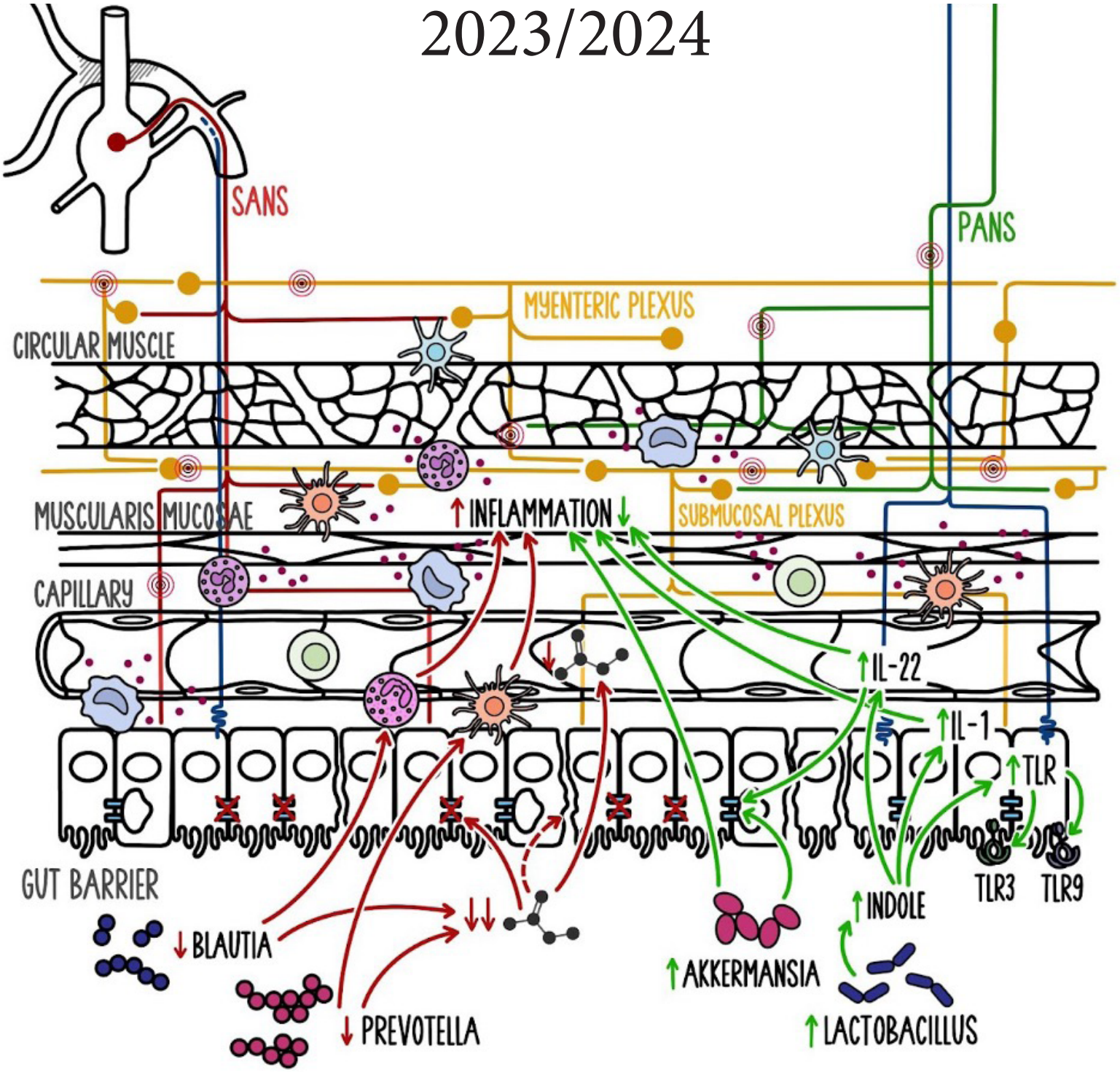
Journal of Undergraduate Research & Scholarly Excellence

2023/2024



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A letter from the editor

JUR Press is proud to present Volume XII of the Journal of Undergraduate Research and Scholarly Excellence. This volume showcases outstanding interdisciplinary works completed by undergraduates from around the world, each carefully edited and peer-reviewed to uphold the academic rigor and excellence we value.

We are a journal for undergraduate and by undergraduates. Our slogan – linking the global undergraduate community – captures our mission of connecting and elevating the voices of worldwide undergraduate thinkers, experimenters, writers, and artists. Our goal is to not only provide an accessible platform for students to publish and showcase their work but to also give students the opportunity to learn about the intricacies of the publication process.

As Co-Editor in Chief, I am honored to continue the legacy of excellence that defines JUR Press. This volume was crafted to exemplify this legacy through the thoughtfulness and novelty of its published research.

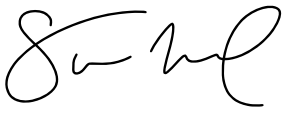
Publishing this volume was not without its challenges. This semester, we received a record number of submissions, emails, and inquiries. With these new demands, our editorial team expanded, and I am proud of how every member uniquely contributed to the collaboration and community we prize in our editorial staff.

For all we have accomplished this year, I want to congratulate each team member. You are exceptional individuals with a wide range of talents, and I am grateful for you and your dedication.

Finally, I would like to honor our published authors. Each of you are leaders of research in your fields, and I am inspired by your work and creativity. Thank you for choosing JUR Press to be a part of your academic journey, and I look forward to continuing to link the global community with you.

Congratulations on this remarkable accomplishment, and welcome to Volume XII of the Journal of Undergraduate Research and Scholarly Excellence.

With appreciation,



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How to maximize your learning in classes

By Erica L. Suchman, Ph.D.
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Colorado State University
Department of Microbiology, Immunology, and Pathology

How many students study

You have an exam in 3 weeks, and if you are like most students you will wait until a week (or maybe a few days?) before the test and review the material over and over again in a short timeframe. You will really feel like you are learning because you will be able to recall the material fairly quickly. This type of studying that education researchers call "massed studying" feels good, it *feels* like you are learning optimally. But what if I told you this type of studying only leads to short term memory and that you will not retain this information well for use later in the course? Or even worse, for future courses where mastery of this material may be necessary? Studies show that what students think feels like good learning does not translate to actual learning.[3]

I am going to show you data from MIP300 general microbiology, a course I co-taught with Dr's McLean, Popichak, Henao-Tamayo, and Mehaffy. In this course the instruction team wanted to help students avoid massed studying, so we created a series of conceptual questions, later called retrieval practice activities (RPAs), that students would take through the learning management software Canvas. The RPAs originally had due dates and students had to take them at intervals between each exam. The goal being that students would have to study to complete these RPAs through the semester instead of right before the examinations, thus avoiding massing their studies. However, when we analyzed data in which some students' sections took the RPAs and other sections did not, we saw no significant differences in aggregated student exam outcomes. Right about this time we met Drs. Folkestad, Moraes and Harindranathan from the School of Education, who wondered if the way with which students take the RPAs impacts their exam scores on midterms and the final exam. They used student usage data to analyze how students took the RPAs. The first thing we noticed when we analyzed the data was that many students were massing their study using these RPAs; they would do many attempts right before the due date until they achieved the maximal score possible. Thus, the RPAs were not achieving the stated goal and instead were contributing to the regular way of massed studying, which is most likely why we were not seeing an improvement in student achievement.

How should students be studying?

A large volume of research tells us that students retain information for long term use more effectively if they do the following things:

1. Space out their studying over time, allowing for periods of forgetting between study sessions.[1]

2. Interleave other information between study sessions. For example, if you are taking a biology course one day, you might study mitosis, and then the next day study meiosis before going back to mitosis rather than studying mitosis over and over and over again (massing).[4,6]

3. Active retrieval using no notes or the web, is superior to looking material up. In other words, the best way to learn is to test yourself. [5]

If you think about it, this makes sense. On an examination your topics will be interleaved, thus if you practice testing yourself on different topics, you will be better simulating the skills necessary to do well on examinations.

	Group 1 Least effective	Group 2 Moderately effective	Group 3 Highly Effective
Page blurring	high	medium	low
Quiz attempts	low	medium	high
Quiz spacing	massed	inconsistent	spaced
Quiz submission	at due date	close to due date	spaced

Table 1: How students were placed into groups based on their RPA taking behaviors. Page blurring is going to another website during the RPA, which is assumed to be to look up answers.

What did data from students in MIP300 General Microbiology show us?

Using learner usage data from Canvas, we analyzed students' use of RPAs and put students into 3 groups based on how effective their study habits were. Group one demonstrated the least effective practices, group 2 demonstrated moderately effective practices, and group 3 demonstrated highly effective use of the RPAs. See table 1 for the criteria used to put students into each of these 3 groups. We looked at all the criteria listed above except interleaving. We included page blurring where students left the quiz to look at other websites which we assume is looking up the answers rather than testing themselves. When we compared the exam scores for the students that fell into each group, clear differences emerged. The data showed that students using the highly effective study techniques achieved exam scores above the average, while students using the least effective techniques scored below the average and students with moderately effective habits scored most closely to the average or nearest to 0. Numbers above 0 are above the average and numbers below 0 are below the average (Figures 1 A-D).

Based on these data, we made major changes to the way we implemented the RPAs in MIP300. We started using the U-Behavior system created by Dr. Folkestad. This system involves providing the students with RPAs without due dates and training them in the best practices for taking these RPAs. Students graph their study practices and compare them to graphs of students using effective study habits, and then are graded on the quality of their graph/study habits rather than on the score they get on the RPA. This encourages students to engage meaningfully with RPAs rather than massing their studying or looking up answers to get the best score. Students are given a rubric that explains how their graphs will be graded and are able to generate their graphs at any time, thus allowing them to gauge the effectiveness of their RPA usage. They must do each RPA quiz at least once, and they need to do at least 70% of the RPAs at least 3 times and space each attempt by 24 hours. They must also interleave (or mix up the order of) greater than 40% of the RPAs. This also has the added benefit of allowing students to decide on optimal opportunities to study based on their schedules, health, etc. An example of a graph from a student studying using the most effective study habits is shown in Figure 2. An example of a student using the least effective study habits is shown in Figure 3. We found that most students improved their study habits using U-Behavior and that this led to improvements in their exam scores. Furthermore, we did a follow up study where students were asked to answer questions from course material the next semester; students who used the most effective study habits were compared to those who used less effective study habits. We found that students who used the most effective study behaviors performed significantly better than those who used less than effective behaviors. Thus, using the most effective study habits improves student retention of the material for use in future courses. Interestingly, a small percentage of the students in each section of the course continued to use the least effective RPA usage habits, and as such, score poorly on their graphs and examinations. We are currently trying to develop mechanisms to encourage these non-adopters to improve their RPA usage habits.

I hope this convinces you that study habits that might not feel the best are actually leading to increased learning as demonstrated on examinations. Furthermore, the study habits for RPAs are a model for how you should be approaching your study habits for all of your courses. Space your studies, interleave different information as you study, and test yourself often. If you can do this with other students, even better, as it is more difficult to fool yourself you know material if other people are quizzing you. For more information on how to study effectively, I would like to recommend a wonderful book written by faculty at Colorado State University. It is called *A Guide to Effective Studying and Learning* by Rhodes, Cleary and DeLosh.[7]

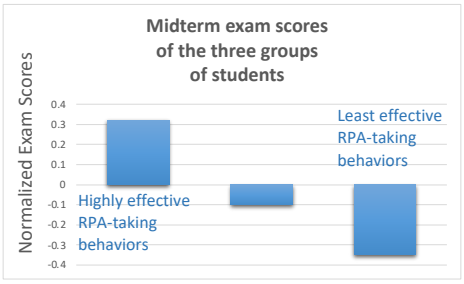

Figure 1A: trial #1 midterm exam score comparison

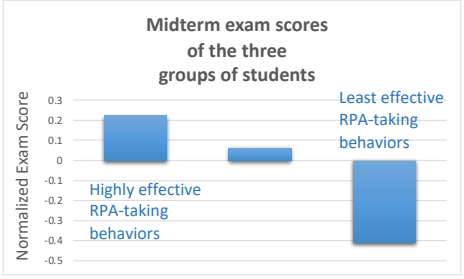

Figure 1B: trial #2 Midterm exam score comparison

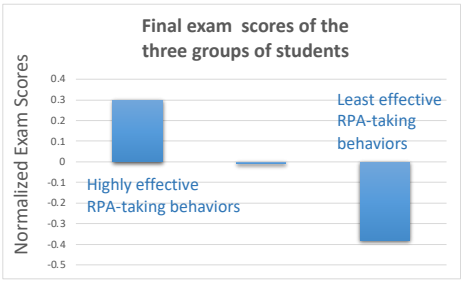

Figure 1C: trial #1 Final exam score comparison

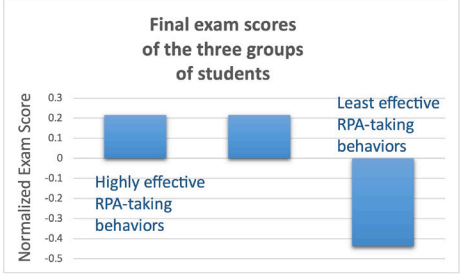

Figure 1D: trial #2 Final exam score comparison

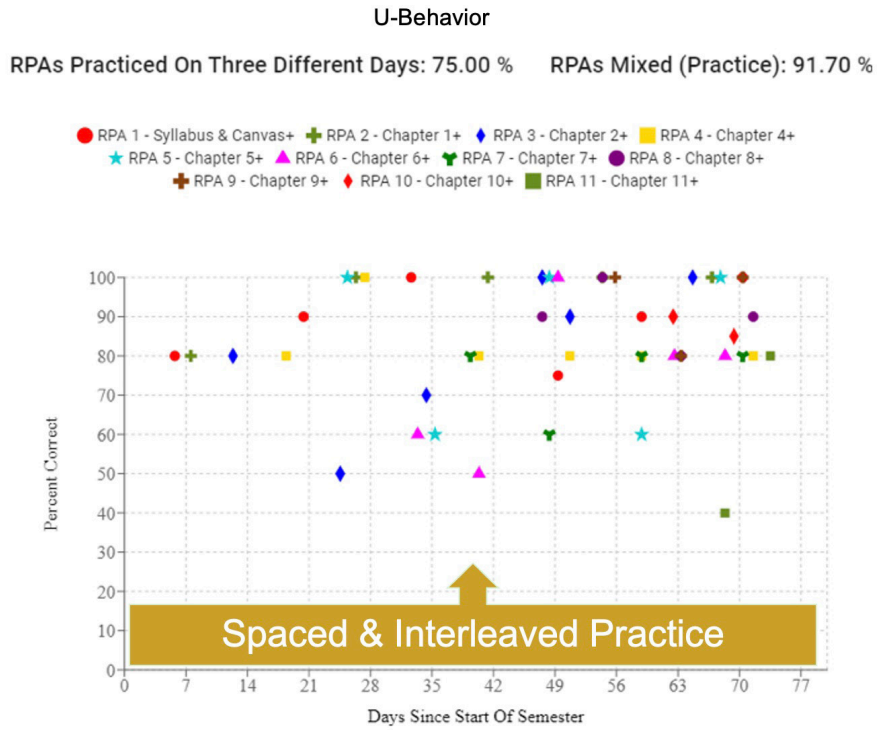

Figure 2: an example of a student graph demonstrating highly effective RPA usage habits.

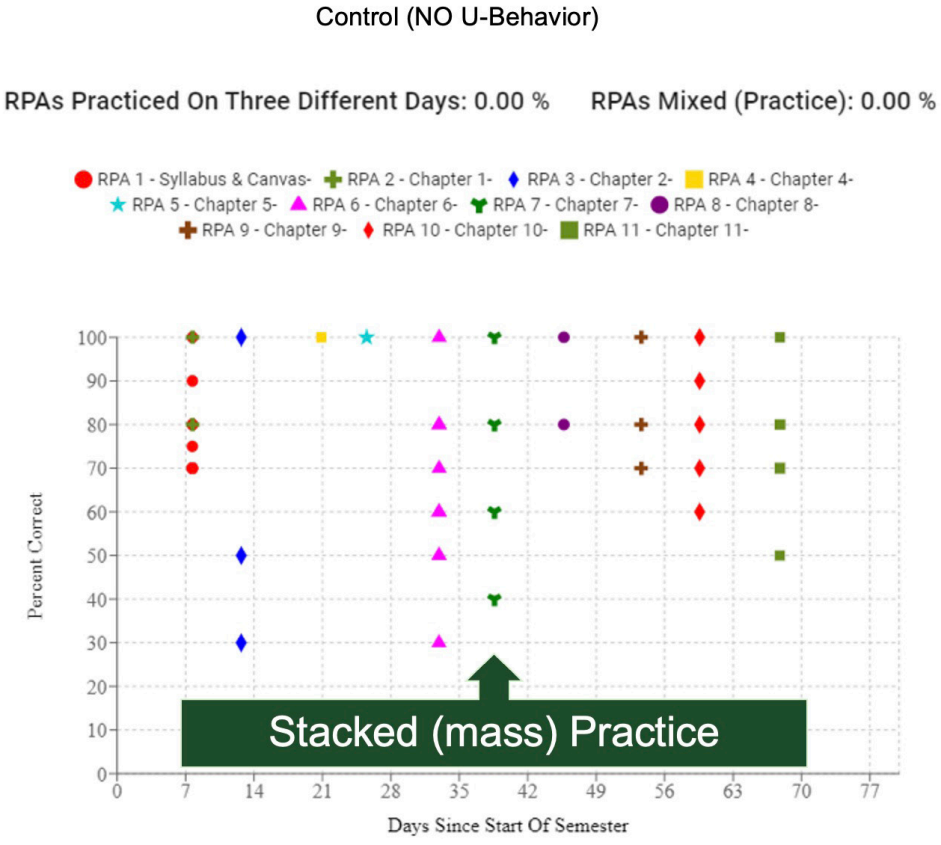

Figure 3: an example of a student graph demonstrating less than optimal RPA usage habits.

Acknowledgments: The information shared in this editorial was a team effort between the MIP300 general microbiology teaching team of the department of Microbiology Immunology and Pathology (Dr's Jennifer McLean, Katriana Popichak, Carolina Mehaffy, Marcela Henao-Tamayo), and the School of Education (Dr's James Folkestad, Marcia Moraes and Priya Harindranathan).

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Gut microbiome changes in patients with Parkinson's Disease

By Kallie E. Clements and Katriana A. Popichak
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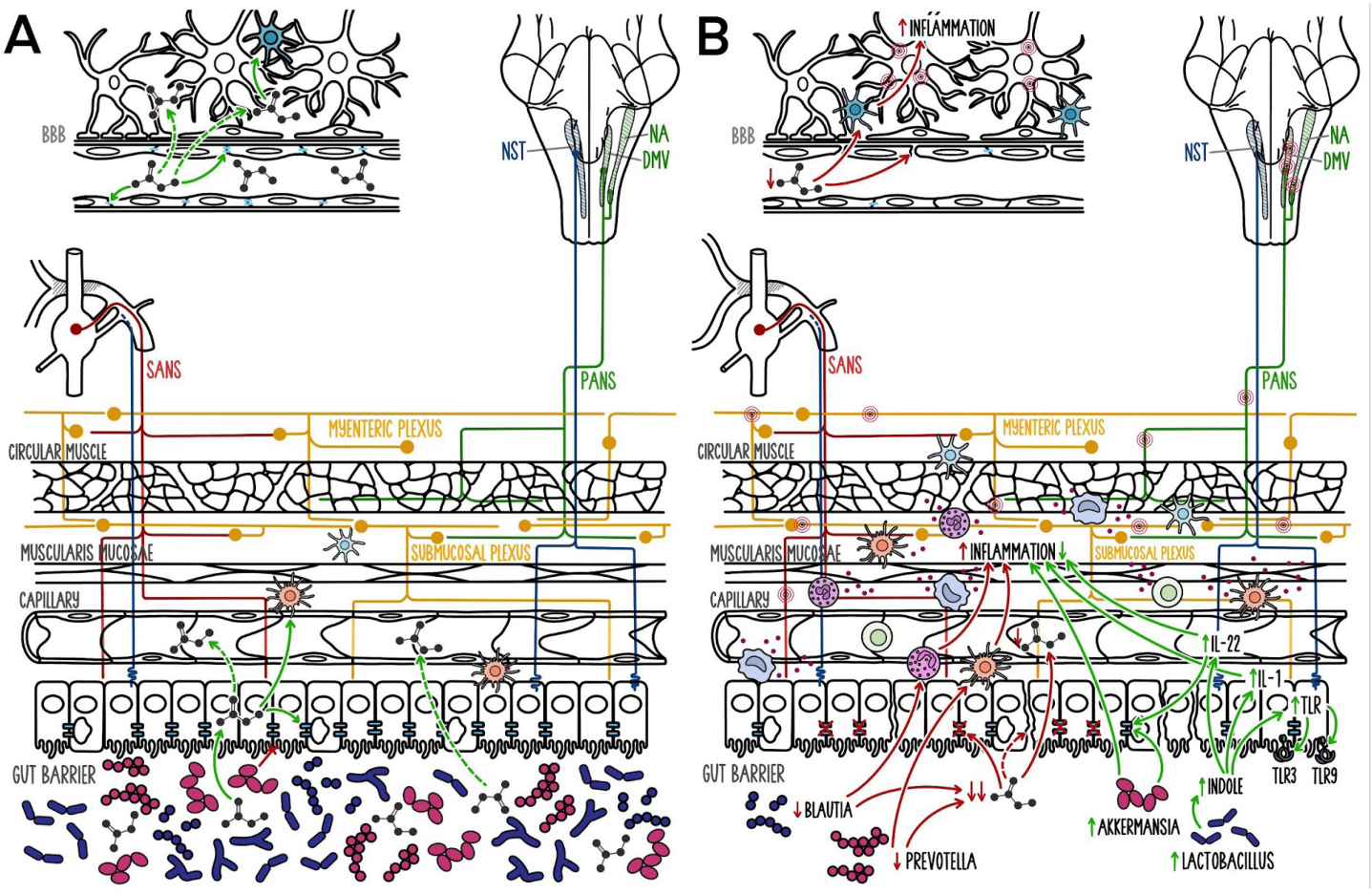
Department of Microbiology, Immunology, and Pathology

Graphical abstract



What is Parkinson's Disease?

Parkinson's disease (PD) is the second most common neurodegenerative disorder after Alzheimer's disease.[1] Current estimates suggest that PD affects approximately 1% of the population over the age of 60.[2] As the global population begins to shift toward a greater number of older individuals, the prevalence of PD is expected to rise. Researchers estimate in the world's most populous nations, the prevalence of PD is expected to double by the year 2030 based on a study from 2005, which does not account for the increased risk of exposures due to environmental toxins which play a role in the development and progression of PD.[3]

PD is a neurodegenerative movement disorder that causes systematic loss of dopamine-producing neurons, abnormal alpha-synuclein protein aggregation, and neuroinflammation that increases dopaminergic cell loss in the movement center of the brain, the substantia nigra. The cause of PD is still widely debated, but one fact remains: There is no cure. Current treatment options include medications that only lessen the symptoms, and nevertheless, PD progressively worsens. Common motor symptoms include tremors and limb rigidity, as well as gait and balance problems[4], but there are many non-motor symptoms that can appear years before the diagnosis of PD (Figure 2).[5] These non-motor symptoms include loss of smell, depression, constipation, sleep disorders, and more (Figure 2).[6] In particular, the non-motor symptom of gastrointestinal dysfunction may present as early as 20 years before the associated motor symptoms.[7] This premotor phase could provide insight into diagnosis and treatment that previously have been overlooked. Despite the progress in understanding PD and its progression, current treatments are not only limited, but fail to reverse neurodegeneration.

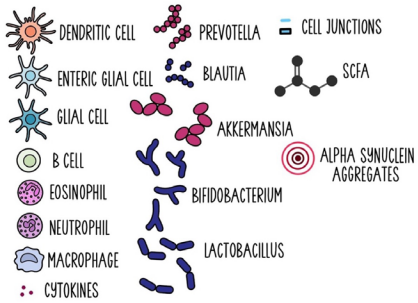
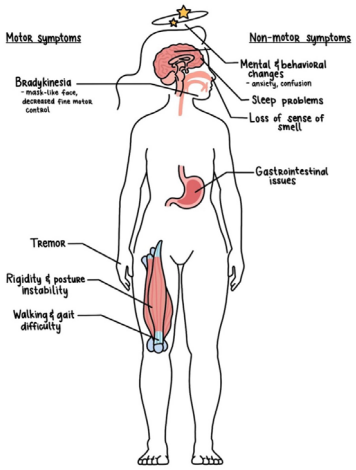


Figure 1: Graphical abstract representing the physiological responses to altered gut bacteria composition in Parkinson's Disease patients compared to healthy controls
1A: In healthy controls, there are abundant gut microbes producing short-chain fatty acids (SCFAs). The SCFAs are taken up by gut epithelial cells and act to strengthen and maintain gut barrier integrity. They also interact with innate immune cells in the gastrointestinal tract to decrease inflammation. SCFAs can also be absorbed into the bloodstream where they will eventually interact with the blood brain barrier and central nervous system. Here, SCFAs act to strengthen and maintain the blood brain barrier integrity and can be taken up into the central nervous system where they interact with inflammatory cells to decrease inflammation. In this depiction there is maintenance of epithelial junction proteins, lack of inflammatory cytokine production as well as minimal inflammatory cells. ENS neurons as well as autonomic neurons and cell bodies are without Lewy bodies or alpha-synuclein aggregates. Gut bacteria are retained in the gut lumen and are not able to pass into the mucosal layers of the gut epithelium. 1B: In Parkinson's Disease patients, specific alterations can be seen in the gut microbiome, including decreased Prevotella *and* Blautia *and increased* Akkermansia *and* Lactobacillus. *Loss of* Prevotella *and* Blautia *leads to a decrease in SCFAs in the gut lumen, the gut vasculature and the blood supplying the brain and central nervous system. This results in breakdown of the gut barrier and blood brain barrier and loss of barrier integrity in both the gastrointestinal tract and brain. Additionally, decreases in these bacteria lead to increased inflammation in the gut as well as increased release of proinflammatory cytokine but immune cells within the gut epithelium. Breakdown of the barrier allows commensal gut bacteria and potentially alpha-synuclein fibrils into the mucosa of the GI tract, where they can interact with ENS neurons as well as terminal regions of autonomic nerves from the parasympathetic and sympathetic branches. This is a proposed mechanism for alpha-synuclein spread from the GI tract to the ENS and eventually to the brain, initially to specific regions associated with the nuclei of the vagus nerve. Increased levels of* Akkermansia *and* Lactobacillus *may act as a counterbalance to loss of other microbes. These bacteria function to strengthen and try to restore the gut barrier as well as decrease local inflammation. Figure 1A and 1B extended figure legend: Red lines represent the sympathetic autonomic nervous system originating from thoracic and lumbar spinal column T1-L4, green lines represent the parasympathetic autonomic nervous system originating in the brainstem (and pelvic region) and blue lines represent afferent sensory nerves that can synapse in the spinal column and brainstem. Yellow lines represent the enteric nervous system neurons and cell bodies residing within the layers of the gastrointestinal tract and interacting with both the sympathetic and parasympathetic systems. SANS: Sympathetic Autonomic Nervous System, PANS: Parasympathetic Autonomic Nervous System, NST: Nucleus of Solitary Tract, DMV: Dorsal Motor Nucleus of vagus, NA: Nucleus Ambiguus, BBB: Blood Brain Barrier, TLR: Toll-Like Receptor, IL: Interleukin. Source: Kallie Clements original artwork*

Issues with diagnosis

Delayed diagnosis

Diagnosis and treatment of PD continues to be a challenge, but a major breakthrough in the stages of PD was presented in 2003 by Heiko Braak and his colleagues. By observing the spread of Lewy body pathology in post-mortem human brains, Braak hypothesized that PD begins when a "foreign body" enters via the nose or gastrointestinal system and then travels into the central nervous system. They noticed the



Key Concepts: Braak discovered that PD begins in the enteric nervous system of the gastrointestinal tract and ultimately travels to the brain via the vagus nerve.

Figure 2: PD symptoms
Motor symptoms of PD labeled on the left column and non-motor symptoms of PD labeled in the right column. Symptoms can impact various body systems and multiple organs. Source: Kallie Clements original artwork

presence of Lewy bodies in the enteric nervous system, which is present in between the layers of muscle in the gastrointestinal tract, as well as the peripheral nervous system and the central nervous system. Based on this data, Braak discovered that PD begins in the enteric nervous system of the gastrointestinal tract and gains entry to the central nervous system through the vagus nerve.[8]

Based on this pattern, Braak developed a staging system that characterizes the progression of PD. There are six stages; each stage shows Lewy bodies in a particular region of the body and brain. The type and severity of symptoms experienced by patients correlates to the progression through these stages. Early stages, such as stages 1 and 2, display Lewy bodies in the dorsal motor nucleus of the vagus nerve, olfactory bulb, and enteric nervous system and are predominantly characterized by non-motor symptoms. Motor symptoms typically begin to display around stage 3 when Lewy bodies reach the midbrain and substantia nigra. Cognitive symptoms arise in the later stages of 5 and 6 when Lewy bodies reach cortical regions of the brain.

According to the National Institute of Health, patients lose 60-80% of their dopamine producing neurons in the substantia nigra by the time of diagnosis.[1] Unfortunately, the onset and presence of motor symptoms is typically what prompts a diagnosis. To diagnose PD, doctors evaluate patient history, current medications, and perform neurological tests that assess agility, muscle tone, gait, and balance—all of which only present in the advanced stages of PD (stages 3 and 4).[9] Recent advancements in the development of brain imaging technology aid in the diagnosis of PD and other similar neurodegenerative diseases. Unfortunately, the National Institute of Health states that these scans "cannot diagnose PD, nor can they accurately distinguish PD from other disorders that involve a loss of dopamine neurons."[1] This is a gap that exists in research because diagnosis occurs too late for an interventional approach to be valid or to halt disease progression.

Key Concepts: Current methods of diagnosis are multi-faceted, but ultimately occur too late. More research is needed to aid in diagnosis prior to the onset of motor symptoms and significant neuronal loss.

Hallmark pathologic signs of PD

Abnormal alpha-synuclein aggregation

One of the hallmark signs of PD is the presence of Lewy bodies in the substantia nigra region of the brain. Lewy bodies are abnormal aggregations of proteins—primarily misfolded alpha-synuclein in PD. Misfolded alpha-synuclein form small aggregates that are resistant to degradation by common degradation pathways such as the autophagy-lysosomal pathway and the ubiquitin-proteasome system.[10] These small aggregates further combine into large fibrils which are the building blocks for Lewy bodies.

Current research suggests the Lewy bodies do not necessarily cause neuronal cell death, but when they impair normal functioning of neurotransmitter release, cell death is inevitable.[11] The function of correctly folded alpha-synuclein in the body is still an active area of research, but recent studies suggest that alpha-synuclein plays an important role in the early stages of development, and later seem to be important in the presynaptic terminal of the neuron by regulating neurotransmitter release.[12,13,14] Alpha-synuclein aggregation into Lewy bodies is a hallmark sign in the brains of PD patients.

The idea of a protein, normally found in the human body, misfolding and causing disease is not a new concept. Another protein that is found in healthy humans is the prion protein, which when it misfolds, causes further prion proteins to misfold and aggregate into large protein clumps. The idea of alpha-synuclein protein going from correctly folded monomeric form to a misfolded aggregate form is similar to that of prion protein. Like alpha-synuclein, prion protein is present in healthy humans, and its normal function has yet to be confirmed. Similarly, the prion protein also misfolds leading to a pathogenic form which promotes aggregation, neuronal loss and neuroinflammatory response.[12] The misfolded, pathogenic prion protein will further spread from cell to cell, causing the normal, cellular prion protein to misfold. Prion diseases, or Transmissible Spongiform Encephalopathies (TSEs), although rare in humans, can either be acquired from consuming contaminated

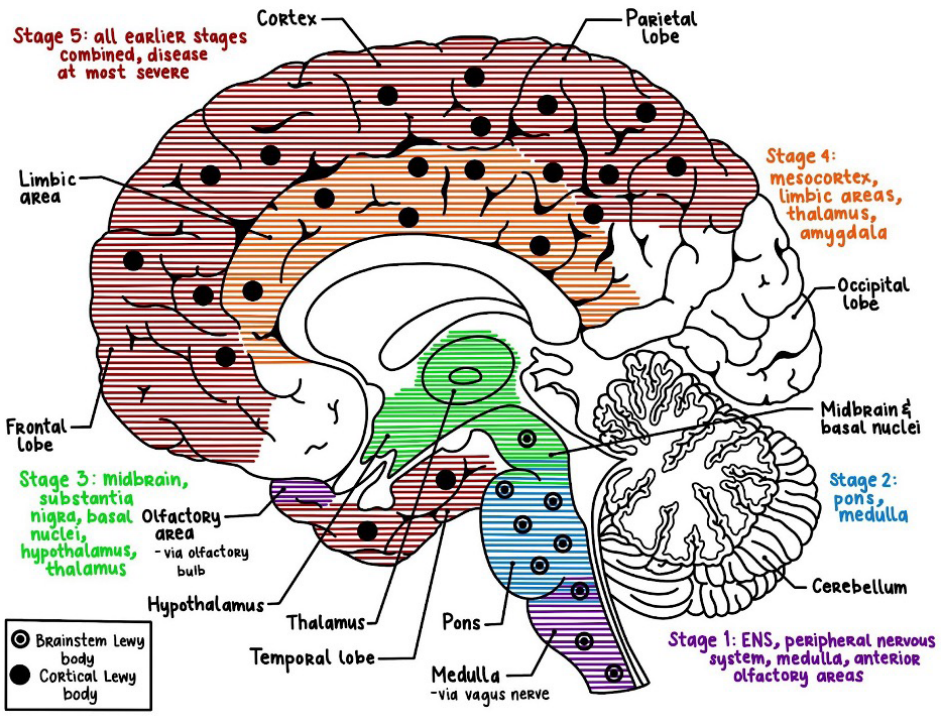


Figure 3: Progression of Lewy bodies given Braak's hypothesis
Stages 1 and 2 (Purple and blue, respectively): Autonomic and olfactory disturbances, primarily "pre-motor" symptoms. Stages 3 and 4 (Green and orange, respectively): Sleep and motor disturbances, primarily "motor" symptoms. Stages 5 (Red): Emotional and cognitive disturbances. Stage 6 is not depicted in the above image but encompasses all previous stages as well as further progression and involvement from stage 5. Source: Kallie Clements original artwork.

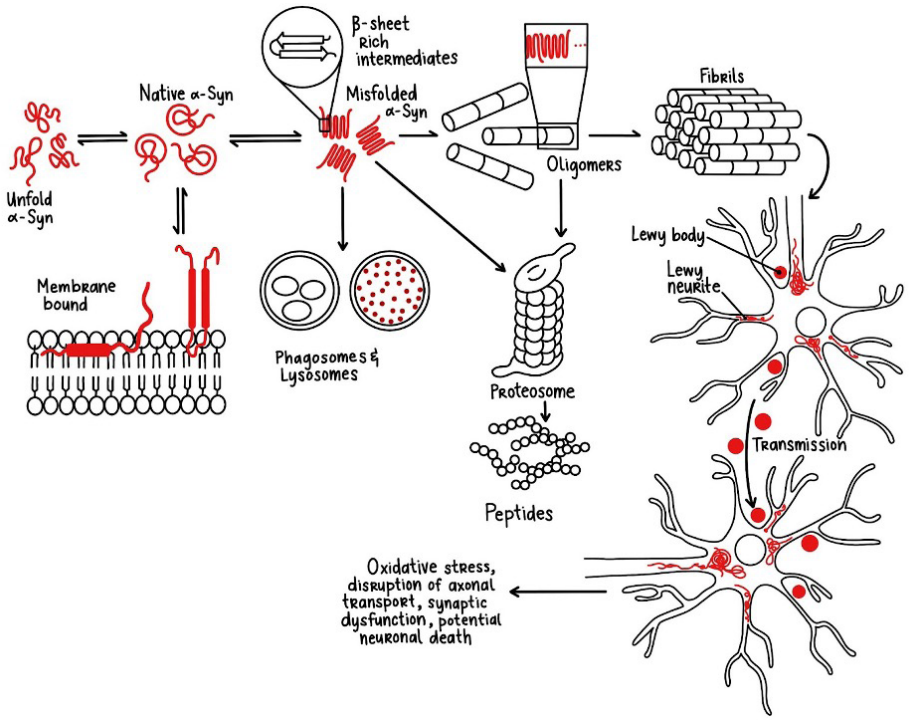


Figure 4: Alpha-synuclein misfolding to form fibrils and Lewy bodies
Diagram showing the process involved in alpha-synuclein misfolding and aggregation. Source: Kallie Clements original artwork.

tissues or through genetic predisposition leading to human prion diseases such as Kuru (which is now eradicated since cannibalism in the tribe it originated has ceased), variable Creutzfeldt-Jakob Disease (vCJD; human disease acquired from eating Mad Cow tissues), or Fatal Familial Insomnia (FFI; genetically inherited). Interestingly, Prion diseases have a similar pathology to PD in that they cause the death of neurons in the brain[15]; alpha-synuclein is described as having a prion-like spread because the misfolds aggregate propagate from cell to cell in a very similar manner. Although alpha-synuclein aggregation has been well established, Parkinson's disease and its classification as a prion-like disease is more recently acknowledged.

Inflammation and neuroinflammation

In addition to the loss of dopamine producing neurons and the presence of alpha-synuclein aggregates, chronic inflammation is another hallmark sign observed in PD.[16] Neuroinflammation in PD shows activation of glial cells, which are cells in the central nervous system that are vitally important in immune function; there are also increases in pro-inflammatory factors. These factors signal to surrounding cells that there is a potential infection and to release cytokines. While short-lived inflammation in any part of the body is important for recognizing and clearing infections, chronic inflammation can worsen the loss of dopaminergic neurons.[16] In PD patients, regions of the substantia nigra, the movement center of the brain, have higher levels of pro-inflammatory cytokines from activated microglia, which function as immune cells in the central nervous system. Initially, microglia are beneficial and have a protective role. However, chronic overactivation and thus increased release of pro-inflammatory cytokines lead to worsening degeneration of dopamine producing neurons in the substantia nigra. Activated microglia accumulate around cells that have alpha-synuclein aggregates and respond to misfolded alpha-synuclein.[16] Transient inflammation is important in healthy humans, but chronic inflammation becomes detrimental.

Chronic inflammation can also be seen in the periphery, which contributes to the progression of PD. Accumulation of peripheral immune cells, which are typically confined to only the periphery in a healthy individual, are detected in affected regions of the brain in PD patients.[16] Common peripheral immune cells, such as T- and B-lymphocytes, are typically not present in the central nervous system due to the

Key Concepts – Definitions:
Pro-inflammatory (Source): promoting inflammation, capable of causing inflammation.[17]
Anti-inflammatory (source): counteracting inflammation, used to prevent or reduce inflammation.[18]

presence of the blood-brain barrier, which actively selects "acceptable molecules" to enter the brain. Upon activation, these lymphocytes also act similarly to microglia by releasing inflammatory cytokines. These peripheral cytokines enter the brain, stimulate microglia, and initiate further release of inflammatory signals.[16] Peripheral immune cells and their metabolites only enter the brain if there is a breakdown or disruption of the blood-brain barrier, which has been shown in PD patients.[19] Chronic inflammation, which is less commonly talked about in relation to PD, is in both the periphery and brains of these patients.[20]

Developing treatment options

In terms of treatment options, the popular drug Levodopa (L-DOPA) can reduce motor symptoms. L-DOPA is used by clinicians as a treatment for loss of dopaminergic neurons, as it acts as dopamine replacement. L-DOPA, a precursor to dopamine, crosses the blood-barrier where it is then converted into active dopamine, aiding with symptoms of tremor and rigid gait.[21] Initially, L-DOPA is helpful for patients in dealing with the loss of their dopaminergic neurons, but it has adverse side effects. During the later stages of PD, L-DOPA can cause involuntary muscle movements, dizziness, nausea, and cognitive dysfunctions. To deal with the side effects that accompany L-DOPA, clinicians will typically administer more drugs to offset the initial side effects. This is less than ideal, as generally, the last thing a patient wants is more medication to offset the side effects from the initial drugs (not to mention increased cost as well as additional side effects associated with more drug use). In addition, the beneficial effects of L-DOPA can wear off as PD progresses and potentially cause drug-resistant motor symptoms and side effects in the patient, and increased motor symptoms associated with drug use.[1] Medications are often

Key Concepts: Current medication options only treat symptoms, and do not help with the underlying progression of PD.

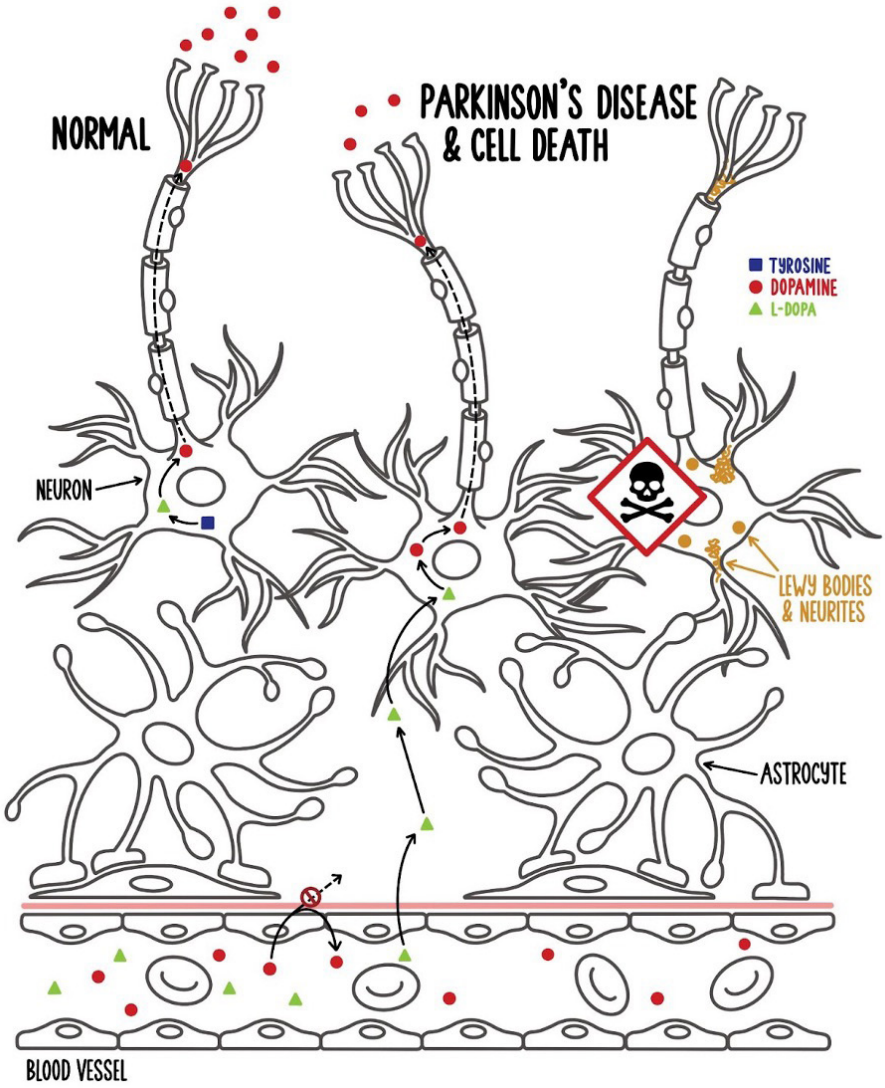


Figure 5: L-DOPA actions to help replace dopamine loss
Blue squares represent tyrosine molecules, red circles represent dopamine molecules, and green triangles represent synthetic L-DOPA molecules which are used in the treatment of Parkinson's Disease. Dopamine synthesis takes place in presynaptic neurons within the brain beginning with the amino acid phenylalanine (not depicted here), progresses sequentially through tyrosine, DOPA (dihydroxyphenylalanine), and finally dopamine.[22] Tyrosine hydroxylase, the enzyme that catalyzes the conversion of tyrosine to DOPA is the rate-limiting step in this pathway.[22] Dopamine molecules are not able to cross the blood-brain barrier and would not be helpful in treatment regiments intended to replenish dopamine levels. However, L-DOPA is able to cross the blood brain barrier and is acted upon by the same naturally occurring enzyme, DOPA decarboxylase, that catalyzes the conversion of DOPA to dopamine.[22] Thus, serving as means of supplementing dopamine levels within the brain. Source: Kallie Clements original artwork.

expensive and rather limited, only addressing symptoms rather than the underlying progression of PD.

A vagotomy is a surgical procedure that cuts portions of the vagus nerve supplying the stomach and is used for peptic ulcers. This type of surgery offers insight into a potential early PD treatment option. While surgeries such as vagotomies are not currently used as a treatment option for PD, preliminary studies show that severing portions of the vagus nerve has a protective effect on the risk of developing PD.[23] Researchers analyzed two primary types of vagotomies. The first procedure is a full truncal vagotomy in which both trunks of the vagus nerve that innervate the stomach are severed. The second procedure option is a "superselective" vagotomy in which only the branches of the vagus nerve supplying the fundus and the body of the stomach are cut. Patients with a full truncal vagotomy showed a clear reduction in risk for developing PD.[23] Researchers matched each patient that underwent a vagotomy procedure with 10 people who did not undergo the procedure and were the same age. Researchers found that patients who underwent a full truncal vagotomy had decreased risk of developing PD compared to patients who underwent the "superselective" vagotomy as well as the general population. A separate but similar study found evidence to support this conclusion as well[24]; however, other side effects are associated with vagotomy, including loss of appetite requiring patients to create an eating schedule.[25]

Currently, there is not a vagotomy-like surgical option for PD patients. Advancements in medicine have decreased the need for vagotomy-like surgeries, which are now currently only used in emergency situations and when all other methods fail to treat the condition.[27] This is a gap in treatment options that offers a potential alteration to the course of PD. Vagotomies should be investigated further as a treatment option for patients in the pre-motor phase, in which vagotomies are shown to prevent anticipated neurodegeneration; of course, diagnosis within this phase is difficult. Therein lies the complications with treatment. How does one halt neurodegeneration when, upon the timeline of diagnosis, the disease has progressed beyond reversal? This decreased risk of PD present in patients who have undergone a full truncal vagotomy lends insight to the important role the vagus nerve plays in the spread of PD from the enteric nervous system to the higher centers of the brain.

Deep brain stimulation (DBS) is a highly invasive and expensive option intended to access the regions deep within the brain that are most effected in PD, with the intention of promoting excitatory signals brain cells need to better function; however, over time, DBS diminishes as a viable option, too.[19-20]

Key Concepts: Vagotomies currently offer treatment for peptic ulcers but should be investigated further for a potential treatment option for PD as they are shown to have a protective effect.

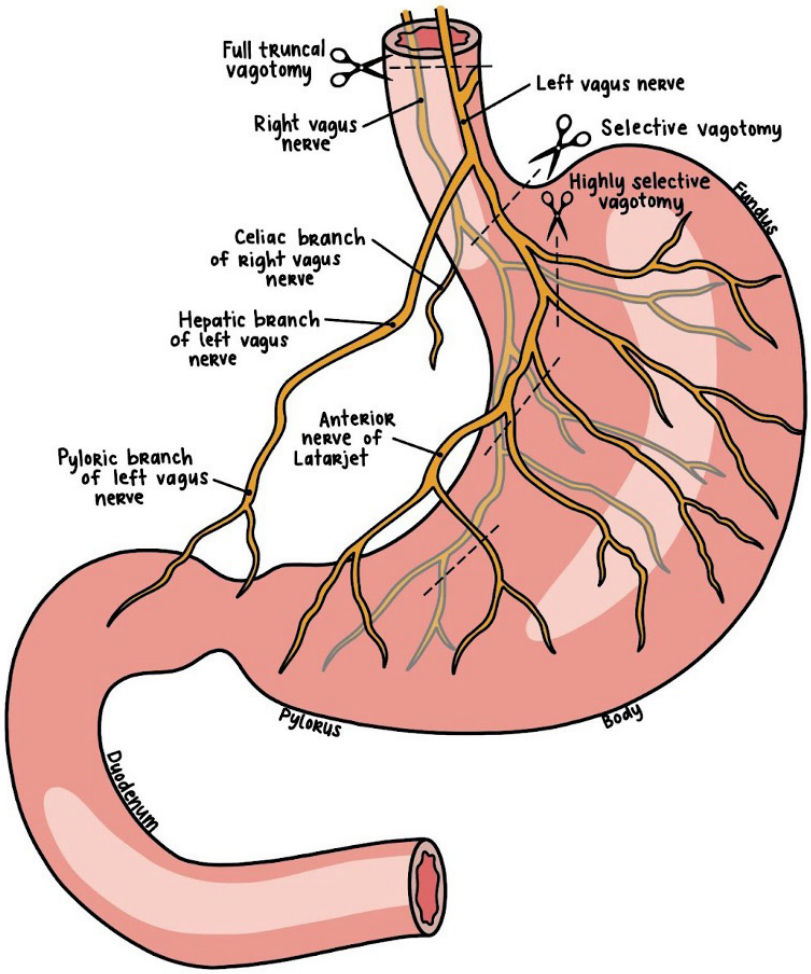


Figure 6: Types of vagotomies
Showing the three variations of vagotomy procedures. [Full] truncal vagotomy cuts the nerves at the gastroesophageal junction, impacting innervation to the liver, gallbladder, pancreas, stomach, and intestines. Selective vagotomy preserves the hepatic branch of the left or anterior vagus nerve and the celiac branch of the right or posterior vagus nerve, resulting in complete loss of innervation to the stomach but leaving branches and innervation to the liver and gallbladder intact. Highly selective vagotomy cuts the branches innervating the proximal stomach only, leaving all other branches intact.[26] Source: Kallie Clements original artwork.

The current treatment options for PD are ineffective and fail to reverse—or even halt—the progression of PD. For there to be intervention at an earlier point in PD progression, researchers need to develop a better understanding of the earlier stages.

Importance of the gut-brain axis as a communication pathway

The gut-brain axis (GBA) serves as a pathway for communication between the gastrointestinal system, specifically the enteric nervous system, and the brain. Information in this pathway travels in both directions, from the gut 'up' to higher order centers in the brain, as well as from the brain 'down' to the gut to influence gastrointestinal homeostasis. The GBA is an intricate communication system that plays a role in monitoring gut functions such as intestinal permeability, immune system activation, enteric reflexes, and endocrine signaling.[28] This communication pathway is very complex and affects many structures in the body.

The role that the Vagus Nerve plays

The communication system consists of three primary components. The first is the hypothalamic-pituitary-adrenal (HPA) axis, which releases hormones into the blood that travel to the gastrointestinal (GI) system. In response to stress, this system is largely responsible for the release of cortisol.[28]

Key Concepts: Efferent nerve fibers exit the brainstem and carry motor signals to target organs. Afferent nerve fibers carry sensory signals from organs to the brain.

The second is the sympathetic autonomic nervous system. This system consists of neurons traveling from the brain, down the spinal cord, and out to target organs in the GI tract. The third, which will be the focus of this review, is the parasympathetic autonomic nervous system, which consists of the vagus nerve that exits the brainstem and innervates the GI system.

The most important function of the vagus nerve is to bring information about the state of the internal organs, such as the gut, liver, lungs, and heart to the brain. After the skin, the gut has the largest surface area coming into contact with the outer world.[29] Vagal efferents are nerve fibers that send signals from the brain down to the gut and account for 10-20% of all the fibers in the body, while vagal afferents bring information from the gut up to the brain and account for 80-90% of fibers present in the vagus nerve.[30] These afferent fibers are responsible for activation and regulation of the HPA axis, which releases hormones in response to a variety of signals. Both neurons of the vagus nerve, as well as hormones released from the HPA axis, influence the cells that line the GI tract, as well as neurons of the enteric nervous system and smooth muscles surrounding the gut. The cells lining the GI tract are unique in that they are in direct contact with the contents of the GI tract, such as food, toxins, and microbes that live within or are passing through the GI tract. These microbes not only impact the cells they are directly adjacent to but also the nerves of the enteric nervous system. Given that the enteric nervous system interacts with the vagus nerve and signals higher-order centers within the brain, these microbes can also impact higher order brain processes, such as emotional and mental well-being.[31]

Enteric nervous system and how it connects to the brain

The enteric nervous system (ENS) is a nerve plexus embedded in the intestinal wall that extends through the entirety of the GI tract.[32] The ENS is referred to as "the second brain," given that its function and chemical coding are very similar to the nerve cells found within the brain.[33] The ENS consists

of two major plexuses—or intricate networks of nerves—which are the submucosal plexus and the myenteric plexus. The cells lining the GI system serve as a barrier between the contents of the GI tract, as well as the fluids and molecules that will be exposed to the internal body. The ENS regulates the majority of the enteric processes, including immune response, detection of nutrients, motility and circulation of food to and from cells of the GI tract, secretion of fluids, and barrier cell permeability.[32] With regard to the ENS, the microbiota found within the gut have important interactions with the GBA, interacting both with intestinal cells that make up the barrier of the GI tract and with enteric neurons, which have direct contact with the central nervous system.

The ENS resides directly adjacent to the GI tract and makes direct contact with the cells that make up the barrier of the GI system, meaning the neurons that make up the ENS can respond to metabolites and bacteria found in the lumen of the GI tract. If the barrier that separates the contents of the GI system from the ENS is dysfunctional, there is potential for pathogens to leave the GI tract and directly interact with cells of the ENS. The ENS neurons can be subject to pathogen or toxin exposure, that may play a role in alpha-synuclein aggregation.[34] Alpha-synuclein aggregation in ENS neurons leads to the potential spread of alpha-synuclein to connecting neurons and eventually to neurons in the brain.[35]

Bacteria and the gut-brain axis

Commensal bacteria benefit by living in and on our bodies without harming us under healthy conditions. Commensal bacteria in the gut aid in many vital bodily functions, such as metabolism of food, protection from pathogenic bacteria, and regulation of intestinal wall permeability. During metabolism, bacteria produce neuroactive chemicals (molecules that can act directly on neurons) such as short chain fatty acids, proinflammatory cytokines, and tryptophan metabolism, all of which impact host metabolism, gut function, and immune response.[36] Bacteria are distributed through the entire GI tract, are unique to each person, and depend upon age, diet, gender, and even the environment.[28] Although each person's gut microbiota is unique, relative abundance of certain bacterial families is typically similar among healthy individuals.[28] The gut microbiota plays an important role in the gut-brain axis through local interaction with intestinal epithelial cells and the ENS, as well as impacts the central nervous system through neuroendocrine and metabolic pathways.[28] While the effects of bacteria on the gut are more obvious, these bacteria also impact the whole body (including the brain) without direct contact with these other organs.

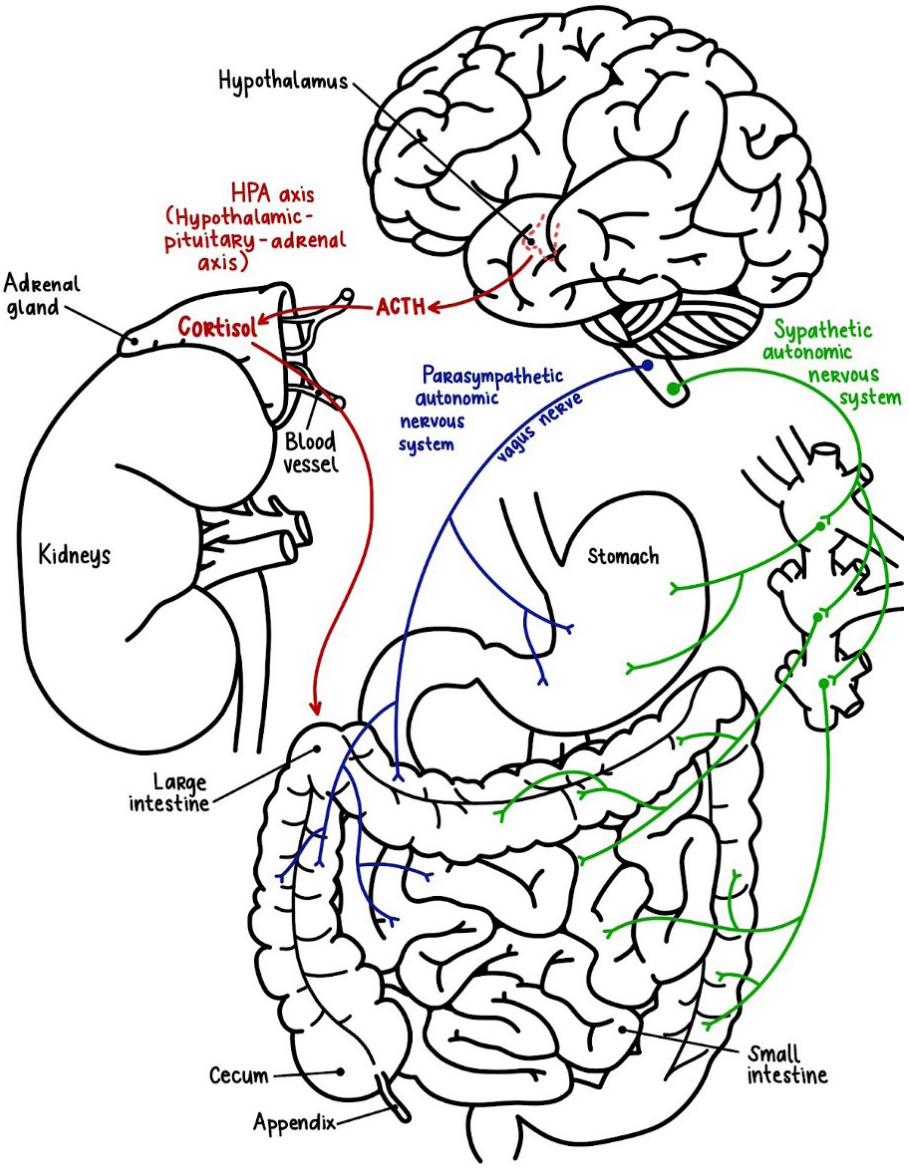


Figure 7: Large scale view of the gut-brain axis depicting the three primary components Simplified depiction of the gut-brain axis, highlighting the connections that exist between the various organs involved; Brain, gastrointestinal tract, and adrenal glands. Red lettering and arrows depict the pathway involved in the HPA axis, blue lettering and arrows represent the parasympathetic nervous system components, and green lettering and arrows represent the sympathetic nervous system components. Source: Kallie Clements original artwork.

Bacterial metabolites and the gut-brain Axis

Bacteria benefit from living in and on our bodies without harming us under healthy conditions. Bacteria in the gut aid in many vital bodily functions, such as metabolism of food, protection from pathogenic bacteria, and regulation of intestinal wall permeability. During metabolism, bacteria produce neuroactive chemicals, molecules that can act directly on neurons, such as short chain fatty acids, proinflammatory cytokines, and tryptophan metabolism, all of which impact host metabolism, gut function, and immune response.[18] Bacteria are distributed through the entire GI tract

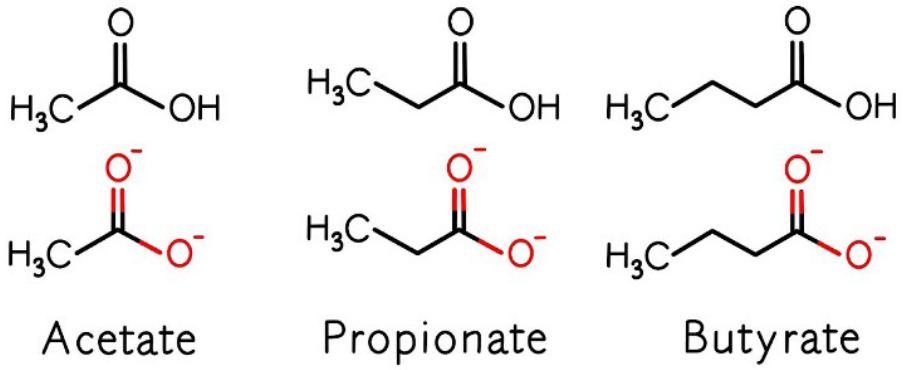
healthy individuals.[24] The gut microbiota plays an important role in the gut-brain axis through local interaction with intestinal epithelial cells and the ENS, as well as impacting the central nervous system through neuroendocrine and metabolic pathways.[24] While the effects of bacteria on the gut are more obvious, these bacteria also impact the whole body, including the brain, without direct contact with these other organs.

Gut bacteria play a role in healthy humans but are also implicated in the spread of PD. While the HPA and central nervous system signal down to the gut and control cells within this region, conversely, the gut microbiota can also control these cells from direct contact or excreting microbial metabolites that ultimately influence the signals that are sent back to the brain.

Short chain fatty acids (SCFAs) are short chains of fats—one–six carbons long—attached to a carboxylic acid. The main SCFAs produced by gut bacteria are acetate, propionate, and butyrate.[37] The majority of SCFAs produced are absorbed by intestinal epithelial cells. SCFAs play a role in maintaining the barrier in the GI system by increasing tight junction expression between intestinal epithelial cells and decreasing the ability of bacteria to cross the membrane.[37] SCFAs also help regulate the immune system, discussed in detail later in this review (see 'Increased *Lactobacillaceae*'). The small amount of SCFAs not used by the GI system will enter the systemic circulation and interact with a variety of organs, including the brain.[37] Interestingly, SCFAs can cross the blood-brain barrier, which is highly selective, and play an important role in maintaining its integrity. This has been shown in studies using germ free mice—mice without any intestinal microbiome bacteria—which show increased permeability of the blood-brain barrier and decreased expression of tight junction proteins.[37] Within the central nervous system, SCFAs influence neuroinflammation and mount inflammatory responses. Depletion of SCFAs produce an altered immune response that tends to be more pro-inflammatory in nature.[37] Many studies link the decrease in SCFA's with the progression of PD.[38]

Alteration of microbiome in PD patients

Alpha-synuclein accumulates in the gut prior to its presence in the brain and travels via the vagus nerve. Recent studies have shown that alpha-synuclein fibrils can travel from the gut to the brain via the vagus nerve. In a mouse study, scientists injected lab-made alpha-synuclein fibrils into the wall of the stomach of mice and then looked at the spread of alpha-synuclein over the course of 10 months. They found that alpha-synuclein traveled from the injection site through the vagus nerve up to the brain stem, and following that, into higher order brain structures. Their findings supported Braak's hypothesis that alpha-synuclein aggregation begins in the gut and uses the vagus nerve to travel to regions of the brain where it begins to cause the typical PD motor symptoms.[39]



Key Concepts: Chemical structure of acetate, propionate, and butyrate (top) and their respective deprotonated form (bottom)

Braak hypothesized that foreign pathogens entered via the nasal or gastrointestinal path, traveled via the vagus nerve, and caused the spread of alpha-synuclein. However, recent studies show that varied levels of bacteria native to the GI tract are responsible for aiding in the spread of alpha-synuclein. It is difficult to precisely pin down exactly what composes a "healthy" gut microbiome because the composition of an individual's microbiome changes depending on what a person eats, where they live, and the potential environmental toxins they are exposed to during everyday life. That being said, studies show there are detectable differences in the microbiome compositions of patients with PD and their healthy comparisons. There are four specific families of bacteria where levels are particularly altered in patients with PD.

Decreased Prevotellaceae

One specific study on the composition of bacteria in PD patients compared to healthy controls found that the abundance of *Prevotellaceae* in the feces of PD patients was reduced by 77.6%.[40] This decreased level is further supported by a second study that also reported decreased *Prevotellaceae*.[41] *Prevotella* belongs to the host's microbiome, and the family of *Prevotellaceae* has four corresponding genera, with the genus of *Prevotella* being common in the human gastrointestinal tract.

In a 2017 study, administration of *Prevotella* to mice with initially low levels of this bacteria caused decreased inflammation and reduced blood-brain barrier permeability and gut permeability.[42] In addition, *Prevotella* is associated with decreased production of certain proinflammatory cytokines, such as IFN-γ and IL-17, and increased production of the anti-inflammatory cytokine IL-10.[42] Together, these findings suggest that reduced *Prevotella* levels in the gut of Parkinson's patients can worsen the progression of PD through increased inflammation and increased blood-brain permeability. Additionally, increased gut permeability in those with PD would allow more bacterial metabolites, pathogens, and inflammatory factors to cross a dysfunctional blood-brain barrier to directly interact with the brain.

Prevotella is also associated with production of SCFAs, thiamine, and folate. A decrease in levels of *Prevotella* are accompanied by a decrease in the production of SCFAs as well as thiamine and folate.[40] Thiamine and folate, which are both "B-vitamins," are vitally important in the human body. Thiamine is important in breaking down carbohydrates and assists in the production of neurotransmitters. Folate is needed for DNA and RNA synthesis and is important in breaking down proteins.[43] DNA and RNA synthesis are both vitally important for the proliferation and function of cells; thus, cellular dysfunction contrib-

Key Concepts: Decreased Prevotella *correlates to increased inflammation, increased blood-brain barrier permeability, increased gut barrier permeability, and decreased SCFA production.*

utes to breakdown of the blood brain barrier leaving the CNS more susceptible to bacterial-mediated injury. Short chain fatty acids are important for many other functions as reviewed above.

There are some major shortcomings in research when it comes to analyzing changes in *Prevotella* in PD patients. Levels of bacteria have been compared between healthy controls and patients who have been diagnosed with PD, which means that they are well into the motor stage of the disease, but it is currently unknown if *Prevotella* levels are decreased in the premotor stage of disease. Further, current research on the changes elicited by decreased *Prevotella* are in relation to demyelinating diseases, such as Multiple sclerosis[44], and not PD. While the two diseases are categorized differently, they share aspects of underlying abnormal physiology; both have aspects of inflammation resulting in injury to the blood brain barrier, as well as neurodegeneration resulting from neuronal injury.[45,46] Additionally, there have been case reports of patients with MS who present with PD.[47] Bacterial interactions with the surrounding environment may differ between various diseased states, and interactions found in one disease may not directly relate to interactions in another disease.

Increased Verrucomicrobiaceae

Increased levels of the family *Verrucomicrobiaceae* are noticed in the GI tract of those with PD, particularly the genus *Akkermansia*.[41] These bacteria have been shown to bind human intestinal cells, strengthen the barrier of endothelial cells in the GI system, and to reduce systemic inflammation.[48] Based on all the available data, increased levels of this bacteria convey a positive overall effect on the gut, which poses a conundrum for the scientific community in regard to PD. In healthy adults,

Key Concepts: Current research on changes in Prevotella *levels do not provide a complete picture as they are done upon diagnosis of PD, and entrance into the motor stage and bacterial interactions have thus far only been studied in demyelinating diseases.*

Key Concepts: Increased Akkermansia *causes increased gut barrier integrity and decreased inflammation, conveying a positive overall effect.*

this bacteria is already in high quantities—it alone represents 3–5% of the bacteria in the GI tract.[48] A meta-analysis reports a nearly doubling of the quantity (log2 fold change of 1.140) of *Akkermansia* levels in PD patients compared to controls.[49] In diseases such as obesity, diabetes, and irritable bowel disease (IBS), levels of *Akkermansia* are decreased, and administration of supplemental bacteria shows increased tight junction strength, as well as decreased permeability of the intestinal epithelial barrier[48], suggesting that this bacteria may be a viable therapeutic.

Akkermansia administered via oral gavage in a mouse model decreased the infiltration of inflammatory cells into surrounding tissues.[50] IBS is a gastrointestinal disorder that is associated with changes in how the GI system works and has been linked to issues with gut-brain communication and potential microbiome dysregulation.[51] The similarities between IBS and the pre-motor symptoms of PD cannot be overlooked. There has not been significant research into potential consequences of introducing increased levels of *Akkermansia*, but given the positive effects seen in other diseases, it may be beneficial to alter the levels of this bacteria in Parkinson's patients.

Current microbiome research in PD patients only investigates bacterial changes after diagnosis, meaning these patients have entered the motor stages of PD. This may be too late for a sample given the irreversible loss of neurons and continued progression of the disease further exacerbating the debilitating side effects. Given the similarities between IBS and PD pre-motor GI issues, it would be wise to investigate the microbiome changes seen in IBS patients and monitor them over time to analyze if this potentially plays a role in an increased chance of developing PD. There are studies that show a moderately increased risk of developing PD in patients with IBS, Crohn's Disease, and Ulcerative colitis.[52] However, the exact mechanism is unclear and the bacterial changes over time in those who progress to PD are not well defined. This could potentially give medical staff and researchers an important biomarker for developing PD, as well as allow for potential interventional

Key Concepts: There is a pronounced gap in current microbiome research studies as they only analyze bacterial changes in PD patients once they have been diagnosed.

therapies to regulate levels of this bacteria at an earlier stage, and delay or prevent disease onset.

Increased Lactobacillaceae

Studies show an increase in the amount of family of *Lactobacillaceae* bacteria developing in patients with PD relative to healthy controls.[53] *Lactobacillaceae* family bacteria are responsible for converting lactic acid to sugars. This family contains three main genera, with *Lactobacillus* being common and important in the human gastrointestinal tract. *Lactobacillus* is important in converting tryptophan, an essential amino acid, to indole-3-aldehyde (I3A) which binds to intestinal epithelial cells. I3A has been shown to increase interleukin-22 (IL-22) production, which is a type of cytokine. IL-22 stimulates cell survival as well as the production of antimicrobial agents to protect against pathogenic bacteria. Pathways influenced by indole and similar molecules play an important role in gut immunity and maintaining intestinal epithelial barrier function.[54] While important, this is not the only pathway that plays a role in the GI tract.

Indole and similar molecules have many functions in the GI tract as well as in other body structures. By binding to GI tract cells, indole has been shown to change gene expression for epithelial cell barrier properties, toll-like receptor signaling, and inflammatory cytokines.[55] Indole significantly increases genes involved in the maintenance of intestinal epithelial cell structure and function. The *ocln* gene is involved in tight junction organization. Tight junctions are proteins (such as occludins and claudins) found between adjacent cells that help keep the contents of the gut in the lumen and do not allow contents to pass into the intercellular space. Another important gene that is increased by indole is the mucin production gene, which increases mucus barrier production at the interface between the lumen of

Key Concepts: Increased Lactobacillus *leads to increased gut barrier integrity and increases in anti-inflammatory pathways but can also lead to increased expression of pro-inflammatory cytokines and related receptors.*

the gut and the cell surface.

Furthermore, indole increases the expression of two important toll-like receptors—TLR-3 and TLR-9—which are proteins on intestinal epithelial cells, responsible for initiating immune pathways upon binding to pathogens or bacteria.[55] TLR-3 and TLR-9 are important in modulating intestinal inflammation and maintaining homeostasis.[55] These particular toll-like receptors are important anti-inflammatory receptors that initiate anti-inflammatory pathways in the body.

The latter are largely beneficial effects in relation to PD, but indole also increases expression for precursor to pro-inflammatory cytokine IL-1, as well as receptors to multiple pro-inflammatory cytokines: IL-2, 4, 18, 24, and 28.[55] This suggests that indole leads to increased levels of cytokine expression and signaling, which can lead to increased inflammation.

Indole can also be transported across the intestinal epithelial barrier and into the bloodstream where it is delivered to the liver and metabolized into indoxyl sulfate (IdS). IdS can potentially act as a toxin if not correctly excreted by the kidneys. IdS is associated with renal disease rather than gut dysfunction but could potentially lead to other medical problems. Present research supports that IdS toxicity is associated with renal and non-renal problems.[56] IdS toxicity is shown to have associations with progression of chronic kidney disease, cardiac dysfunction, coronary artery atherosclerosis, and potentially cognitive impairment.[56]

Increased *Lactobacillus* and associated indole in PD patients may have both pro- and anti-inflammatory effects; the first being that these bacteria increase as a result of increased inflammation associated with the progression of PD as a compensatory response. Although it is not known, the increase in *Lactobacillus* in PD patients may be the result of GI dysfunction leading to unchecked growth. This could potentially result in increased inflammation and worsening of disease progression.

Like *Akkermansia*, decreased Lactobacillus is similarly observed in patients with IBS. Further research would be beneficial to analyze the levels of this bacteria in patients with IBS over the course of the disease and potentially how it relates to PD progression. The levels of *Lactobacillus* may look different in the premotor stage as with *Akkermansia* and could potentially serve as a biomarker or an interventional measure.

Table 1: Summary of bacterial changes and physiologic consequences
Superscript "a" represents components that contribute to the larger effect of decreased inflammation and superscript "b" represents components that contribute to the larger effect of increased inflammation.

[Bacterial Family] Bacterial Genus	**Level in PD patients relative to healthy controls**	**Metabolite(s) produced**	**Physiologic alterations because of bacterial changes**
[*Prevotellaceae*] *Prevotella*	↓	SCFAs Thiamine Folate	↑ Inflammation ↑ Blood brain barrier permeability ↑ Gut barrier permeability ↑ IFN-γ and IL-17 ↓ IL-10 ↓ SCFAs, thiamine and folate
[*Verrucomicrobiaceae*] *Akkermansia*	↑	—	↓ Inflammation ↓ Gut barrier permeability ↑ Tight junction space ↑ Gut barrier strength
[*Lactobacillaceae*] *Lactobacillus*	↑	I3A	↑ IL-22[a] ↑ Cell survival[a] ↑ Production of antimicrobial agents[a] ↑ Gene expression of tight junction proteins and mucin production gene[a] ↑ Expression of TLR-3 and TLR-9[a] ↓ Inflammation[a] ↑ Pro-inflammatory cytokines (IL-2, IL-4, IL-18, IL-24, IL-28, and precursor to IL-1)[b] ↑ Inflammation[b]
[*Lachnospiraceae*] *Blautia*	↓	SCFAs (specifically butyrate)	↓ Butyrate production ↑ TNF, IL-6, and IL-1β ↑ Inflammation

Key Concepts: Like Akkermansia*, much of this research has been done with regards to IBS, and levels were analyzed during the motor phase of PD and may not accurately reflect the levels present in the premotor phase that could serve as a biomarker.*

Decreased Lachnospiraceae

Research shows decreased levels of bacteria of the family *Lachnospiraceae* in PD.[57] This family contains many important anti-inflammatory and butyrate producing bacterial genera such as the genus *Blautia*, which is significantly decreased in PD patients relative to healthy controls.[57] *Blautia* is one of the main SCFA producers in the human GI system.[58] Metabolite butyrate is produced by *Blautia* and plays a major role in regulating the immune system and its function.[58] Decreased *Blautia* correlates to decreased production of butyrate which can have negative consequences both in the GI system as well as in other organs.

Although butyrate's role has not been established in PD, there is research regarding butyrate's role in IBS and Crohn's disease. In a study analyzing butyrate's role in inflammation associated with Crohn's disease, researchers report that butyrate decreased the tumor necrosis factor (TNF), interleukin 6 (IL-6), and interleukin 1β (IL-1β) secretion.[59] TNF is a protein that is involved in regulating immune cells through a complex cell signaling pathway that

Key Concepts: Decreased Blautia *leads to decreased production of butyrate which leads to increased inflammation.*

Key Concepts: As with the other bacteria, Blautia *has interactions with the local environment which has only been studied in diseased states such as IBS and Crohn's disease.*

promotes the inflammatory response. TNF can be activated by a number of factors including IL-6 and IL-1β.[59] Increased levels of all three of these proteins and cytokines are observed in patients with Crohn's disease.[59] Butyrate's ability to decrease expression and secretion of these factors suggests that it has an anti-inflammatory effect in patients with Crohn's disease.[59] This anti-inflammatory role may also play a part in other diseases that are associated with intestinal inflammation such as IBS and PD. Decrease in levels of *Blautia* leads to decreased production of butyrate and overall increased secretion of inflammatory molecules and cytokines.

As mentioned previously, *Blautia* and butyrate's effects on intestinal epithelial cells have been studied in diseases such as Crohn's disease and IBS, but there are no studies on the role of this bacteria, or the byproduct specifically related to PD. This should be a future area of research as intestinal inflammation is seen both in the premotor phase, as well as in the motor phase of PD; the inflammation associated may also impact the progression of PD as well as leading to further dysbiosis of the intestinal microbiome.

Potential diet to regulate microbiome of PD patients

Many factors impact host microbiome composition (genetics, age, diet), but the one that can be most easily adjusted is diet.

Decreases in *Prevotella* and *Blautia* lead to a decrease in SCFAs, which are important in regulating inflammation and intestinal barrier permeability. SCFA enrichment is associated with a non-Western and high-fiber diet, as fiber is the primary substrate for making SCFAs.[41] A typical "Western diet" consists of high and regular consumption of red meat, pre-packaged foods, high sugar foods and drinks, and fried food. A non-Western diet consists of low intake of all of the above, high intake of fruits and vegetables, whole grains, grass-fed animal products (primarily white meat, fish, nuts and seeds).[60] In addition to SCFAs, supplements of thiamine and folate should be taken to make up for the decrease in *Prevotella* bacteria that produce these vitamins.

Bacterial levels of *Akkermansia* and Lactobacillus are 'high' in PD patients, but based on research, these higher levels of bacteria appear to be beneficial, with few negative consequences. The increased levels of these bacteria appear to be in response to disease progression. There should be more research on these specific bacteria and the effects of altered levels in respect to PD. Microbiome bacterial levels are fluid and vary between people, but 'too much' of any bacteria can be detrimental due to microbial products that can induce injury. To avoid significant increases in *Akkermansia* bacteria,

Table 2: Summary of bacterial changes in PD gut microbiome and potential dietary interventions
Superscript "a" denotes foods that contain acetate, superscript "b" denotes foods that contain propionate and, superscript "c" denotes foods that contain butyrate.

[Bacterial Family] Bacterial Genus	**Level in PD patients relative to healthy controls**	**Dietary components**	**Vitamins and Supplements**
[*Prevotellaceae*] *Prevotella*	↓	SCFAs – Dietary fibers such as wheat bran, corn bran, sugar beet pulp, oat bran, soybean hulls, and rice bran[63] High fiber foods such as beans, legumes, green beans, avocados, apples, oats and citrus fruits[64] Fermented foods[65] made by bacterial fermentation such as cheese[b,c], butter[c], vinegar[a], alcoholic beverages[a], pickles[c], sauerkraut[c], soy sauce, and yogurt[c]	Foods high in folate such as dark leafy vegetables (turnip greens, spinach, romaine lettuce, asparagus, brussels sprouts, broccoli), beans, peanuts, sunflower seeds, fresh fruits, fruit juices, whole grains, liver, aquatic foods, eggs, and fortified foods and supplements[43] Foods high in thiamine such as fortified breakfast cereals, pork, fish, beans, lentils, green peas, enriched cereals, breads, noodles, rice, sunflower seed, yogurt[66]
[*Verrucomicrobiaceae*] *Akkermansia*	↑	—	—
[*Lactobacillaceae*] *Lactobacillus*	↑	—	—
[*Lachnospiraceae*] *Blautia*	↓	SCFAs (specifically butyrate) Dietary fibers such as wheat bran, corn bran, sugar beet pulp, oat bran, soybean hulls, and rice bran[63] High fiber foods such as beans, legumes, green beans, avocados, apples, oats and citrus fruits[64] Fermented foods[65] made by bacterial fermentation such as cheese[b,c], butter[c], vinegar[a], alcoholic beverages[a], pickles[c], sauerkraut[c], soy sauce, and yogurt[c]	Fiber Dietary fibers such as wheat bran, corn bran, sugar beet pulp, oat bran, soybean hulls, and rice bran[63] High fiber foods such as beans, legumes, green beans, avocados, apples, oats and citrus fruits[64]

high fat intake should be avoided as these diets are correlated to increased levels of *Akkermansia*.[51]

Increased *Lactobacillus* leads to increased indole, and potentially increased levels of IdS (which can be potentially toxic) both to the kidneys and in PD.[61] Depending on how significantly increased levels of *Lactobacillus* are, physicians might recommend patients to take a supplement of oral charcoal adsorbent AST-120 which binds indoles in the gut lumen and reduces plasma IdS levels.[54]

Overall, PD patients and (data also suggests) healthy adults, should adopt a non-Western and high-fiber diet to increase levels of SCFAs and potentially stimulate growth of SCFA producing bacteria such as *Prevotella* and *Blautia*.[62] Patients should also take thiamine and folate supplements to account for decreases in *Prevotella* that produce these vitamins. Furthermore, to avoid stimulating further growth and risk of overgrowth of *Akkermansia*, research shows PD patients and all adults should avoid high-fat diets.

Current applications and the need for more research

The health care system currently has methods in place to obtain a sample of an individual's gut-microbiome. Obtaining a person's microbiome sample may seem invasive, but only a fecal sample is needed. Although it is not a perfect encapsulation of the bacteria present, it is sufficient to gather data of important bacteria levels. One way to obtain this sample is during a colonoscopy exam. The American Cancer Society recommends a colonoscopy be performed at 50 years old to screen for colon cancer. While there is no unified consensus on the exact age of onset of PD, it is generally observed that most patients are about 60 years of age or older when diagnosed.[67] Based on research that estimates pre-motor symptoms presenting up to 10 years prior to diagnosis, this timeline would correlate roughly to routine colonoscopies.[7] This procedure could be supplemented by taking a microbiome sample and analyzing the bacterial levels utilizing well-established methods and data banks to identify and characterize bacterial populations. If these samples are analyzed and recorded, they can be reviewed later if a person develops PD. This data could lead to the elucidation of bacterial biomarkers that can predict PD before the onset of motor symptoms. In addition to a traditional hospital setting, people can also use an at-home system such as Cologuard[68], that looks for colon cancer, or the product Everlywell[69], which offers at-home test kits for a wide range of GI issues. While these kits do not currently offer evaluations of gut microbiome composition, they both rely on fecal samples, which is also one of the main sources of assessing gut microbiome composition; this could easily be added on to the barrage of tests that the samples undergo.

Dietary changes as opposed to pharmaceutical approaches may be more accessible for some people. Older generations (the primary PD demographic) who are most commonly diagnosed with PD may be more accepting of adopting a dietary change before taking a pharmacological approach. If microbiota composition does indeed affect PD development, these dietary changes may be most effective during the premotor phase of disease, which unfortunately does not get diagnosed. However, it may still have positive effects in alleviating symptoms at later motor stages of disease. This approach could offer a first-line therapeutic prior to starting L-DOPA, or in the later phases to supplement the medications.

There are multiple studies that address the spread of alpha-synuclein, and many that address microbiome bacterial changes, but very few that integrate both ideas. Similar to what is previously addressed, bacterial changes have implications for inflammatory responses and barrier functions that have been studied in various diseases. However, the changes in inflammatory responses, barrier functioning, and bacteria levels impact the misfolding and the spread of alpha-synuclein is not nearly as well studied. This is a future area of research that needs to be addressed.

Conclusion

PD is a common and devastating neurodegenerative disease that affects 1% of the population over the age of 60. The scientific and medical community has seen significant progress made in areas of PD research, but unfortunately, early diagnosis and curative treatment have yet to be elucidated. Currently, diagnosis occurs well into the motor phase of PD, when neuronal loss is substantial, and treatments fail to stop the progression of the disease. Current research has begun to look at the bacterial changes associated with PD, but the changes in levels are analyzed well into the motor phase, and there is little research on these specific bacteria related to PD. While there is plenty of research relating to IBS, obesity, and other inflammatory GI diseases, different diseases can display markedly different responses to the same bacteria. Future research needs to look closer at pre-motor phase changes in microbiome bacterial levels. The pre-motor phase may present with similar levels of bacterial changes as motor stages, or the levels may be significantly different. This research would not only elucidate bacterial biomarkers for PD but could also shed light on potential interventional methods to reestablish normal bacterial levels to delay onset of the disease or halt further progression.

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Bound and born again: Russian criminal tattoos and identity conformity and expression

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Introduction

In Russian prisons, tattoos inscribe the lives of those living on the edge of Russian society.[1] From the shackles and chains tattooed on a prisoner's ankles, to the gods, past lovers, or a criminal code tattooed on a man's chest, these tattoos can speak for the bodies of a group of people incarcerated and cast aside. By permanently marking one's body with the labyrinth of internal codes, Russian prisoners immortalize their allegiance to their criminal community and their defiance of the law. Allegiance to a criminal society is nowhere stronger than in the brutal world of Russian confinement. One prisoner, who had been shot and killed for attempting to steal an officer's gun had "I am a Son of the World of Thieves" tattooed on his chest.[1] In this paper, I will explore how *The World of Thieves* is a coherent social order reflected in the tattoos of its members.[2] These tattoos created in prison serve as a ledger of status among prisoners and adopting them is an act of identity's "self-completion" that permanently aligns and commits oneself to the underworld.[3]

When a prisoner's movement, wardrobe, and livelihood become regulated in prison, cultivating an outward identity can be a difficult task for them to accomplish. Prisoners often then resort to bodily markings to distinguish themselves. However, as a ledger for an internal code, tattoos in Russian prisons are a regulated commodity. A prisoner without tattoos is the lowest ranking member in prison and he is treated by others as an outcast.[4] If one misappropriates a tattoo, they will be severely punished by their fellow criminals. The tension between tattoos as an identity marker and the reality of a tattoo as a status definer in Russian prisons leads to unresolved questions and we might wonder what personal purposes a tattoo might serve for a criminal on the borders of Russian society. Do Russian criminal tattoos work to create a new, rigid hierarchy—working to fill in the power vacuum that exists in the depths—within prison? Or do tattoos offer criminals a sense of escape and individual expression of identity while physically incarcerated? If tattoos allow criminals to reclaim their identities, to what extent do they have personal control over their identities?

I have concluded that Russian criminal tattoos serve a dual purpose: for one, they aim to organize and reinforce a cultural structure, and on the other hand they express deeply individualistic beliefs, emotions, and attitudes. Despite the new rules that tattoos represent and enforce, their adoption allows criminals to reconcile the conflicting loyalties and identities they hold, creating a new version of identity expression. Existing literature on tattoos tends to focus on two opposing motivations for individuals in their decision to adopt a tattoo: either a tattoo is a tool for self-expression, or it is a mode of group conformity. This paper, employing a lens of paradoxical self-expression, argues that tattoos can reflect dual, yet conflicting, motivations for an individual. I believe this framework offers a significant contribution to the way that sociology has viewed physical markers of self-expression: like an individual, tattoos are complex, often self-contradictory, and never one-dimensional. By arguing that tattoo adoption can follow these dual motivations, I believe this paper rightly departs from the literature it examines.

Criminal context: the Russian history of a dual system of law

In order to understand the effect of the codification of the *World of Thieves* with tattoos on the personal identity of criminals, we need to first understand Russia's history of contention with the law. While the *World of Thieves* was born out of a state of defiance against the law, its history of self-autonomy has led to its rigid internal structure. It is unsurprising that Russia, a large and ethnically diverse country, is difficult to police. Since its inception as a state—one crafted as a "patchwork of different climates and cultures"—Russia's state authority can be characterized by its struggle to enforce and impose itself onto the various villages it claimed.[2] The pre-industrial Russian Monarchy left pockets of local—or unpoliced—authority because it lacked resources to centralize enforcement power in certain villages. In these villages, *samosud*, translated literally as "self-judging," emerged as an alternative legal code enforced by the village members themselves. A "rich culture of resistance," born from the logistical problems of a relatively poor empire, extended Russia's vast territory.[2] The urbanization of post-industrial Russia condensed populations and made the enforcement of the law more manageable, but the culture of resistance to the law persisted. In urban slums, organized crime fashioned itself into the *vorovskoy mir*, or the "World of Thieves." Just as *samosud* had created a way for villages to impose their own moral and legal beliefs onto their communities, the *World of Thieves* was born as a complex and self-serving alternative world or law. This alternative order included its own economy and endorsed a "wide range of criminal trades," or careers, for

people outside the scope of the law.[2]

Thieves, by definition, having broken an established rule or code of conduct, are necessarily deviants (where deviance is defined as "the failure to obey group rules").[5] Deviants congregate for reasons both within and outside of their control; one voluntary reason is that it gives deviants a "sense of common fate" and community.[5] In authorizing their own world, Russian criminals can find community, but can also learn to thieve more efficiently, escape punishment and surveillance more effectively, and can learn the 'trade' of crime. But the scope of the power of the *World of Thieves* makes it, in my opinion, more than a deviant group. It is an effectively legitimate and alternative order; those properly initiated, incarcerated for most of their lives and deferred as outcasts in the eyes of the state, are called "legitimate thieves."[1] Given the wide scope of internal authority of the *World of Thieves*, its law can be seen not only as a form of resistance but as an alternative governing body. Those inhabiting the *World of Thieves*, drawn to crime for various reasons, are thus 'ruled' by overlapping social and political structures; the Russian state and the criminal world it condemns. Thieves in the *vorovsky mir* can thus be viewed as deviants and insiders, as outcasts and conformists. The tattoos of the *World of Thieves*, and the personal motivations behind their adoption, are reflective of this dual structure. This perspective is useful in viewing the adoption of this code through tattoos as serving a dual purpose for the individual.

The language of the *World of Thieves*

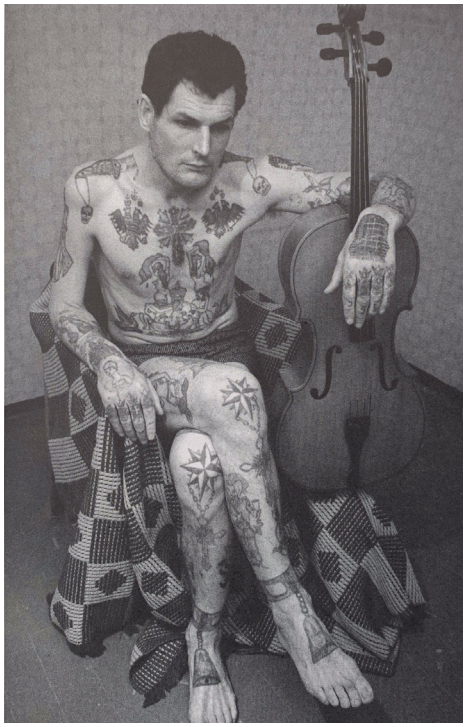
As a governing body, the *World of Thieves* must communicate its rules to its members. Its moral rules, behavioral code, and leger for status all must be enforced, and, as "language is fraught with a great deal of power," its enforcement must be understood to be received effectively.[4] Tattoos serve as a medium of communication and codify the "hierarchies, internal organization, and evolution" of the *World of Thieves*, and criminals become literate in this language in prison, often called the *academiya* or "academy" in criminal circles.[2] In prison, criminals become initiated to the *World of Thieves* by learning its rules as they are expressed in tattoos and then by observing their allegiance through incorporating the tattoo codes on their own body. The language of tattoos "represent[s] efforts at symbolic self-completion," where an initiate can attach themselves to the group permanently and unequivocally.[3] These tattoos immortalize membership status and the code they carry; "they are marks for life."[3]

In prison, understanding and observing the internal code of the *World of Thieve*s is an act of survival. The outward presentation of a tattoo relies on social exchanges and, as "becoming tattooed is a highly social act," Russian prisoners signal to other criminals solidarity and compliance to the code.[6] Russian Criminal tattoos can then be seen as creating and reinforcing a cultural and extra legal structure, where a prisoner submits to a regulated group and displays their permanent allegiance to the *World of Thieves*. Before assessing Russian criminal tattoos as modes of self-expression, I will examine their function in suppressing individualism in Russian prisons.

Russian tattoos as reinforcing a hierarchy

Russian Criminal Tattoos, as a language for a governing body, strictly enforce a cultural substructure. Often a criminal is coerced, either physically or socially, to adopt this code and observe its rule. In this section, I will highlight instances of tattoo adoption as acts of identity suppression in favor of group rules, where a prisoner's identity formation is beyond their personal control and decided by the *World of Thieves*.

Upon entering prison, a criminal without tattoos faces social pressures that incentivize getting them. While tattoos denote status, the absence of tattoos is also telling—it indicates that the prisoner is of the lowest ranks in prison.[4] Criminal bosses force the untattooed inmate into grueling fields of prison work, while other inmates are forbidden from communicating with them. The choice becomes clear for a new



Photograph credit: Sergei Vasiliev. Sergei Vasiliev was born in 1936 in the Chuvash region of Russia. He was a staff photographer for the newspaper Vecherny Chelyabinsk for over thirty years. He has received many honours including International Master of Press Photography from the International Organization of Photo Journalists (Prague, 1985), Honoured Worker of Arts of Russia, and the Golden Eye Prize. His work has been exhibited internationally and is held in numerous museum collections. He is author of more than twenty books, including Russian Beauty (1996) and Zonen (1994). Sergei Vasiliev died in 2021.

Figure 1

Figure 2

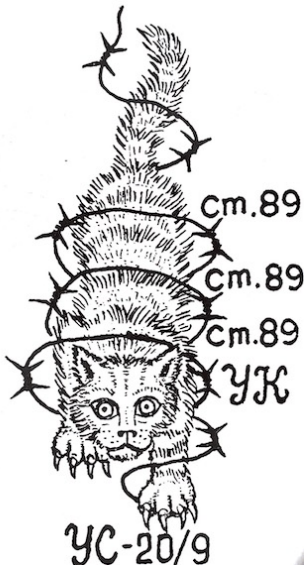


Figure 3

Figure 4

Figure 5

prisoner: they must become tattooed or face the serious cost of social exclusion and humiliation. When one does adopt a tattoo, they can choose to indicate a criminal career, or the type of crime they commit to specialize in. Markings of criminal careers serve to identify a Russian criminal with a subgroup of other criminals who share the same markings. When members of the same criminal career congregate in prison, they can share information useful to their specific area of crime. A tattoo of a rectangular card shape on a prisoner's fingers with a beaming cross over a sphere with four dots (fig. 1) is one such mark of criminal career, in this case the wearer was an "apartment thief" who robbed homes.[1] A prisoner can also reveal reasons for their committing of a specific crime. One woman wears a star of barbed wire that wraps around a sickle and hammer, decoded as "I began stealing out of poverty and hunger in this soviet life" (fig. 2).[1] Criminals can 'choose' their criminal career insofar as they make the final decision to, for example, rob a house. The conditions that led to their form of criminal career, however, are not always chosen, as evidenced by the justifications offered by some prisoners. In this respect, markings of criminal careers signal an identity that was not strictly chosen by the wearer and serve to fix a prisoner to a membership position in their criminal trade. Additionally, career markings serve as fixed responses to the commonly asked questions in prison: Why are you here? What did you do?

Additional questions follow in the *World of Thieves*. Among them: Can I trust you? Should I be afraid of you? Should you be afraid of me? Tattoos respond to these questions, either signaling to others preassigned authority or inferiority. The following tattoos of status continue to suppress individual autonomy to the benefit of the structure of the *World of Thieves*.

Prisoners of high status, whose authority are communicated through tattoos, enjoy benefits and security in prison. Oftentimes this status is earned, such as measuring one's authority by the amount of time they have spent in solitary confinement.[1] Other times status can be earned for acts committed outside of prison, such as a man with a tattoo with "cm.89" inscribed three times along a tiger's side (fig. 3).[1] This means that this prisoner is a recidivist convict, and he has been convicted under Article 89 of the criminal code of the RSFSR three times. The tiger may represent the danger that the prisoner poses in prison, evoking fear and distilling loyalty in those around him. Working within his trade, this criminal mobilized his status by becoming more deeply involved in committing crime. Where this criminal boss is deeply troubled in the eyes of the law, he is feared and regarded in prison.

The 'middle-class' prisoner in the *World of Thieves* is not subject to cruel treatment from other prisoners and simply "[observes] the laws" of the prison. They wear a filled-in rectangular card with a centered diamond and cross (fig. 4), indicating they are "within bounds."[1] This prisoner is not punished for their status, but they are a follower and bound by the rules of the *World of Thieves*. They neither enjoy the benefits of criminal leadership nor the pain of being at the bottom of the criminal hierarchy. In this middle ground, these prisoners find a way to live around and under the rules set by the criminal bosses, a preassigned status they did not choose.

The lowest part of the underworld is an ugly place. Relegated from even their status as deviants, the criminals who make up this group are pariahs in prison. Tattoo markings of a lower-class criminal permanently associate the wearer as an outsider among outsiders, and self-removal of these tattoos using a knife can leave a permanent scar. One way a prisoner is subjugated to this status is determined by the type of crime they committed outside of prison. For example, a prisoner who is convicted for rape often wears the "Shaggy Face" tattoo, a rectangular card with a heart in the center (fig. 5).[1] This tattoo, along with others that signal low rank, are often forcibly and violently applied by other prisoners onto the lower-ranking member. This marking signals that not only does the wearer bear low status in the *World of Thieves*, he is also subject to nonconsensual sodomy by other prisoners.

Another way a prisoner is defined as an 'untouchable' is by their sexual preferences. Homosexuals are treated cruelly; a man who engages in gay sex can be forced to wear either a beehive on his buttocks or a bee on or near his genitals.[4] According to the code of the *World of Thieves*, a man who wears this tattoo may be stripped and raped by any prisoner. Consecrating one's outside status forever, by means of the painful and involuntary engraving onto the skin, serves to immortalize "conspicuous humiliation" for the wearer.[4] Denied by the law and lawful society, those occupying these ranks are further denied by the criminal community. The unforgiving and permanent language of tattoos humiliate him forever, binding him to his preassigned inferior identity.

The enforcers of the codes created by the *World of Thieves* are marked as well. On

the shoulder, the "Orthodox" thief wears a tattoo of a skull impaled by balanced scales of justice (fig. 6).[1] The criminal who wears this marking is a judge who decides cases amongst thieves in their commitment to the laws of crime. He is 'orthodox' because he has never broken the laws of the community, and he strictly observes and enforces its internal rules. There is order in the seemingly chaotic world of Russian prisons, and the *World of Thieves* is organized by a strict internal structure and hierarchy. This hierarchy is a system of control for those at the top, the 'criminal bosses,' who benefit from their leadership status. Joining this hierarchy is not an option in prison, for those who refuse tattoos in their entirety will either receive one involuntarily or be shunned for their refusal of the *World of Thieves*. There is no easily bending this order; a prisoner who misappropriates a tattoo of a criminal from a different trade or status can be punished or killed. When a lower ranking criminal does 'fall in line,' or submit to the order, their commitment to the code "[reinforces] the power and control of the heads of the hierarchy."[4]

A criminal, upon entering prison, finds himself caught between two power structures: that of the state, and that of the *World of Thieves*. A prisoner renounces the state by committing a crime, finding himself in a seemingly lawless world. Yet, in prison, the code of the *World of Thieves* ultimately dictates a criminal's status, assigning who is punished, who is rewarded, and who is inbounds. Having renounced the laws of the state, prisoners are punished and controlled in the criminal world as well, and when they comply with its code of conduct, they thereby submit to its rule.

Tattoos not only serve as a means of status definition for prisoners, but they also function as a form of protection, reflecting the need to craft a survival identity within the prison system. According to the suspended model of identity, prisoners live between two identities: the person they were before incarceration and the hardened persona they create to protect themselves from the threats of prison life.[7] Tattoos are one way that prisoners express this survival identity. For instance, one man displays a tattoo on his chest of a growling, half-man, half-wolf figure (fig. 7). Beneath the image, the words read, "Don't touch me if you want to live!"[1] This werewolf symbolizes the danger the prisoner presents, signaling that members of the *World of Thieves* should respect and fear him, regardless of his actual status within the prison hierarchy. Whether or not the prisoner truly views himself as dangerous is irrelevant; the tattoo communicates this persona to others. The wolf represents the 'monster within,' a tough outward persona the prisoner wears to ward off threats. By revealing no internal fears, only a desire to be feared, the tattoo acts as both a shield and a crafted identity. It reflects the perilous environment of prison, where survival depends not on personal expression, but on the creation of a fearsome image.

Tattoos as a source for individual expression

When analyzing Russian criminal tattoos, a conflicting view of their purpose emerges. One may argue, incorrectly I believe, that tattoos primarily serve to express individual identity and allow a prisoner to escape the physical confines of prison. This view would suggest that the controlling aspects of criminal tattoos are overcome by their liberating qualities and is supported by surveys conducted in Russian prisons.

A 2017 survey of Russian criminal tattoos found that an overwhelming majority of tattoos were "about a belief, passion, or life history," rather than being linked to one's status. Additionally, identity can be expressed through outward appearance, as people often communicate their identity nonverbally through what is known as "identity talk"—the use of appearance to signal moral obligations and allegiances.[8,9] From this perspective, the person signaling their identity, the 'speaker' holds primary agency in conveying their sense of self to others. By examining the tattoos a prisoner voluntarily adopts, while excluding those that are forcibly applied, we can gain insight into what these prisoners seek to communicate about themselves and their worldview.

Some prisoners may create an identity through their tattoos signaling their defiance to the Russian state or the *World of Thieves*. One prisoner, who claimed he had been falsely removed of his status by other criminals, wears an eight-pointed star—inside the devil hisses and bears his fangs (fig. 8). The tattoo means, "Crush the regime. I have never been happy in this country ."[1] The regime to which he refers is ambiguous; it could be the state that imprisoned him and subjected him to harsh conditions, including 70 days in solitary confinement.

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Alternatively, he might be referring to the criminal hierarchy within the prison, which rewards those who fully commit to the criminal world, often through increasingly severe crimes to gain status. This is the same regime that had falsely stripped him of his status and leadership position in the *World of Thieves*. As an outcast in both regimes, this man is openly defiant of the country and the criminal hierarchy. His tattoo expresses his anger, and ultimately his unhappiness with his life and the power structures that confine him. It provides him with a means to express this dissatisfaction—a statement that might not have been possible without the system of widely recognized tattoos.

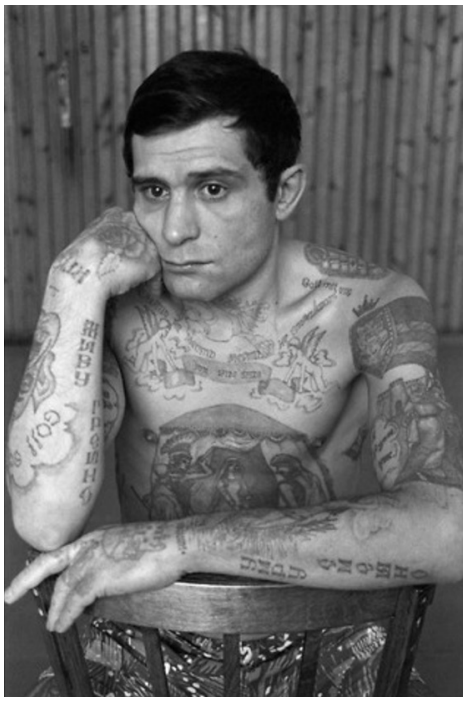
Another way a prisoner can work within the bounds of the prison codex to create an identity is through tattoos signaling their deeply held personal beliefs and attitudes, which Scott Jacques describes as "Lombrosian" tattoos.[8] Jacques finds that Russian criminal tattoos are mostly expressive, serving as a pictograph to display one's inner thoughts and attitudes. A prisoner can explore these beliefs through topics of love, death, and God through simple pictographs accumulated in prison. A popular tattoo among younger convicts in Russian prisons is an oval containing two birds in flight. This tattoo means "Love and cherish freedom" (fig. 9).[1] Birds are a universal symbol for freedom because they are untethered to a particular place, antithetical to the situation of a young Russian convict, who did not choose the conditions that led to their criminal career or the codes of the hierarchy in prison. A young convict may be forced to provide labor in prison for the state or to provide services to the heads of the *World of Thieves* and may be tempted to prove their commitment by alienating themself further from lawful society. By adopting a tattoo symbolizing freedom, a young convict expresses this desire and identity to the world using the same mode of communication that also displays their rank.

Those at the lowest rungs of society can reclaim dignity and identity through storytelling; low status Russian criminals can express stories on their bodies as tattoos.[10] For example, a woman who killed her lover at seventeen has a cryptic tattoo of a naked woman on her hip (fig. 10). A cloud of smoke borders the woman in the tattoo, and the criminal code of murder is inscribed by her feet. Barbed wire, often associated with imprisonment, laces around the woman, forming a halo around her head. This tattoo prompts others to inquire about her story, allowing her to fill in the gaps not explicitly mentioned in the tattoo. Given this opportunity, the woman who turned eighteen in prison, can redefine or reframe the story of her conviction. The female convict's act of murdering the man she loved naturally leads to many questions. Whether she responds truthfully or not, her tattoos provide her a chance to tell her story.

Tattoos as a paradoxical expression of self

To say that Russian criminal tattoos work to express identity is insufficient, although not incongruent, with my findings. Tattoos undeniably tell stories and express personal beliefs, but at the same time they undoubtedly enforce group structure. To posit that the overall purpose of a body of tattoos, or a single tattoo, primarily serves one purpose is a unilateral approach at observing a mark of identity. Identities and their mode of expression, are often 'contradictory, conflictual, and paradoxical,' and to take a unilateral approach in understanding identity leaves one misguided.[11] Instead, I believe that Russian criminal tattoos serve a dual—yet conflicting—purpose: these tattoos are a tool for both conformity and expression.

People carry multiple identities, due to the multiple factors that shape their lives. These factors are on the individual level, such as a life-altering event, and the societal level, such as status, nationality, and class. Prisoners within the Russian criminal system carry their criminal career and past, the circumstances that led to them being in prison, and the "master status" of being a deviant in society, a characteristic that trumps all others.[5] Oftentimes, the many aspects of a person's identities not only converge, but collide, where the wants of the individual are confronted by the larger power of the group. The result of this conflict is that people are forced 'to confront questions of loyalty to individuals and groups,' and Russian criminals form



Photograph credit: Sergei Vasiliev.

Photograph credit: Sergei Vasiliev.

their identities by negotiating between what the group demands of them and what is demanded of themselves.[11] In navigating a world between two rigid power structures, as well as a criminal's own personal beliefs, a criminal reflects the ugliness of their world in the tattoos of their choosing. He submits, defies, reconciles, and permits this world unto himself, using 'identity talk' to communicate different identities.

In a settlement in Ushakovka in 1967, a 'legitimate thief' and high-ranking member of the *World of Thieves* wears an eight-pointed star with a centered grinning skull (fig. 11). This tattoo is a widely recognized authority symbol, decoded as "Devoted to the cast of thieves until the end of my life."[1] At one point in the prisoner's life, he wore this tattoo proudly as a symbol for his earned status, yet during the tattoo survey, he admitted that his views had changed. During the interview, he said that over the span of his criminal career he concluded that the powers of the prison hierarchy and the powers of the Communist Party were "essentially identical."[1] After the prisoner had spent his life yielding the benefits of a power structure that placed him at the top, he radically changed his views and defied the *World of Thieves*. In one life, the prisoner held two identities, evolving from his commitment and rejection of the underworld.

While his tattoo once served as a declaration of authority, it now serves as a reminder of the injustices of prison power, and its meaning changed as its wearer's conception of the world was remodeled. This conception of tattoos as a paradoxical expression is a significant new lens to view the sociology of tattoo adoption. Tattoos should not be classified corresponding to a single assumed personal purpose, and they should not be read as contributing only to group structure. While these tattoos in social interaction represent an unequivocal commitment to the *World of Thieves*, their initial commitment is not the final word of the tattoo. Instead, criminals can work within the world they have pledged allegiance to and exist as evolving individuals with conflicting motives. Even if a tattoo has one meaning to the group, such as a criminal authority tattoo, its meaning may be different to the wearer, and its meaning may change over the course of the wearer's life. This application is also a development in the suspended identity model, introducing what a material expression of a suspended identity may look like. Furthermore, this development has implications for the adoption of any mode of 'identity talk' as having inherent constraints, such as the need to use fixed codes when engaging in self-expression.

Conclusion

In Russia, the *World of Thieves* was born from a culture of resistance to state rule. This spirit of defiance became embedded into the language of this alternative world—marked and communicated with tattoos adopted in prison. Although this world existed in defiance, it maintained its own strict and harsh rules applied to its members. At the top, heads of the criminal hierarchy were rewarded with security and respect. At the bottom, Russian criminals were raped, brutalized, and humiliated. The language of this world reflects the harshness of this structure, and a prisoner's status was easily identified by their tattoos. Interestingly, tattoos also recalled intimate details of a prisoner's life—their past lovers, their view of the political state of the world, and their views of death, among other topics, are explored. This tension between personal purpose and group control is what led to my conclusion; tattoos as operative of paradoxical purposes, and thus reflective of a paradoxical identity. Prisoners must negotiate with their safety and public regard with their own values, and the result is a compromise that reflects the ugliness and the hope in their world. Dignity can be gained in the undignified, and through storytelling with tattoos a Russian criminal can both submit and defy a social order, imposed by the language of the *World of Thieves*. This conclusion has implications for assessing how an individual in any group must negotiate their 'self' and may adopt a worldview that conflicts with their personal, 'inner' identity.

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Sweet Tooth

By Ella Keenan
Colorado State University

Artist's Statement

This sweet piece was created during my painting studio class, with a focus on bright color and striking composition. The uneven apples mixed with the dripping honey convey a sickly sweet message, providing the viewer with sweet but mild discomfort, similar to that of a candy-caused toothache.

Acrylic, “16 by “20, 2024

A Tiny Waste Management System in the Human Brain

By Joshua M. Venegas, Evan P. Chase, and Seth A. Roper
Bob Jones University
Department of Biology

Abstract

The glymphatic system is a recently discovered network of passageways in the brain involved in waste clearance and volume regulation of the central nervous system during sleep. Substantial amounts of research have been conducted in the past decade with the purpose of better understanding the glymphatic system, producing a large pool of implications, correlations, and unaddressed questions. In this review, both the anatomical and pathophysiological aspects of the glymphatic system are discussed in detail, beginning with the structures and locations involved. After reviewing the perivascular anatomy of the network, we briefly discuss several methods by which the glymphatic system can be monitored. Two-photon microscopy was once the traditional method of assessment, but it has recently been replaced with MRI tracing procedures. Finally, the correlation between the glymphatic system and various pathological symptoms is examined, with an emphasis on therapeutic treatment options.

Overview

Until 2012, the brain was considered to be the only organ in the body without lymphatic vessels of some kind. In fact, for years, researchers have assumed that the central nervous system (CNS) was cleaned only by diffusion and contained no pathways whatsoever for lymphatic drainage.[1] However, in 2012, Jeffrey Iliff and his colleagues published a research article in the journal Science, which described a newly discovered perivascular pathway in the brain that channels cerebrospinal fluid (CSF).[2] The researchers claimed that this set of microscopic tunnels is formed by astroglia and facilitates both the removal of toxic solutes and the exchange of nutrients between the CSF and interstitial fluid (ISF) in the CNS. Because this system works through 'bulk flow,' or convection to channel CSF throughout the brain, it is significantly faster and more efficient than diffusion. The term 'glymphatic system' was coined by the paper's senior author, Danish neurobiologist Maiken Nedergaard, to describe this unique pathway. She combined the words 'glial' and 'lymphatic system' to form the phonetic label.

Since its discovery, various controversies and questions have been raised about the glymphatic system (GS) and its function. Some debate the sources that drive glymphatic clearance, many have questioned its specific mechanism, and still others dispute the best method for monitoring its function. A wave of primary research articles has emerged over the last few years with hopes of addressing these issues. Links have been made between the GS and a host of risk factors, diseases, and symptoms. There remains a need, however, to sort through these studies and elucidate the major opinions and areas of consensus in this growing sector of research.

Various other reviews of our emerg-

ing understanding of the GS exist, and we refer the reader to these to pursue further research.[3,4,5] In this evaluation, we will focus on 1) the anatomy of the GS, 2) methods for tracking and monitoring glymphatic clearance, and 3) the implications of glymphatic malfunction for both neuropathological onset and secondary symptoms.

Glymphatic System Anatomy

In the CNS, three major extracellular fluids provide circulation of nutrients and waste: blood, CSF, and ISF. Unlike other organs, the CNS parenchyma (functional tissue) is separated from direct contact with the blood by the blood-brain barrier (BBB). This allows selective nutrient exchange between the blood and CSF in the subarachnoid space, the area that surrounds the brain's surface.[6] The CSF must then exchange nutrients and waste with the ISF through the pial-glial basement membrane, which separates the parenchyma from the subarachnoid space.[7] The GS allows this to happen efficiently by channeling CSF along many of the arteries entering the brain (Figure 1). It rapidly exchanges CSF with ISF and terminates by draining its contents into the body's lymphatic system.

2.1 CSF channeling through perivascular spaces

Periarterial channels begin in the subarachnoid space and direct the influx of CSF along the arteries entering the brain, as indicated by tracking the flow of CSF tracers in mice. Injection of tracers into the CSF results in rapid tracer accumulation along outer aspects of penetrating arteries in the pial-glial basement membrane.[7] This flow of tracers indicates that the pial layer and glia limitans (a thin layer formed by podocytes) enshroud penetrating arteries to form a narrow perivascular space (PVS) beginning at the arteriole level and extending to the capillaries. Aquaporin-4 (AQP4) water channels line the outer walls of the PVS, allowing diffusion from the CSF to the ISF.[8] As for its specific location in the brain, electron microscope imaging of samples from human patients has confirmed the presence of significant PVS in cerebral white matter and basal ganglia while indicating minimal or no PVS in the cerebral cortex.[7]

Consensus in the literature about the driving force and efflux of fluid after CSF-ISF exchange is less established. Generally, the GS functions via convective transport through the parenchyma, where bulk flow drives CSF movement through and out of the parenchyma.[9] The predominant mechanism supported by smooth muscle imaging indicates that PVS arteriole and capillary pathways continue through to venules and veins, forming a system that flows in one direction.[8] Conversely, tracers have also been found to exit the brain along 'intramural peri-arterial drainage' (IPAD) pathways after CSF-ISF mixing. These IPAD pathways are small passages located in the tunica media of the incoming blood vessels, directing fluid 'back upstream' relative to the incoming CSF (Figure 2).[7] Confirming the function of these structures will require further research.

The structure of the PVS must be delicately arranged to provide optimal hydraulic flow by minimizing hydraulic resistance. Some studies have modeled the PVS around penetrating arteries as circular rings concentric to the enshrouded blood vessel to propose a structure that could match observed pulsatile flow.[10] However, hydraulic resistance is proposed to be quite high in this concentric model. Flow rate is maximized (lower hydraulic resistance) when more fluid flow takes place away from resistance-inducing walls.[10] Consequently, optimal flow rate and minimal resistance are proposed to

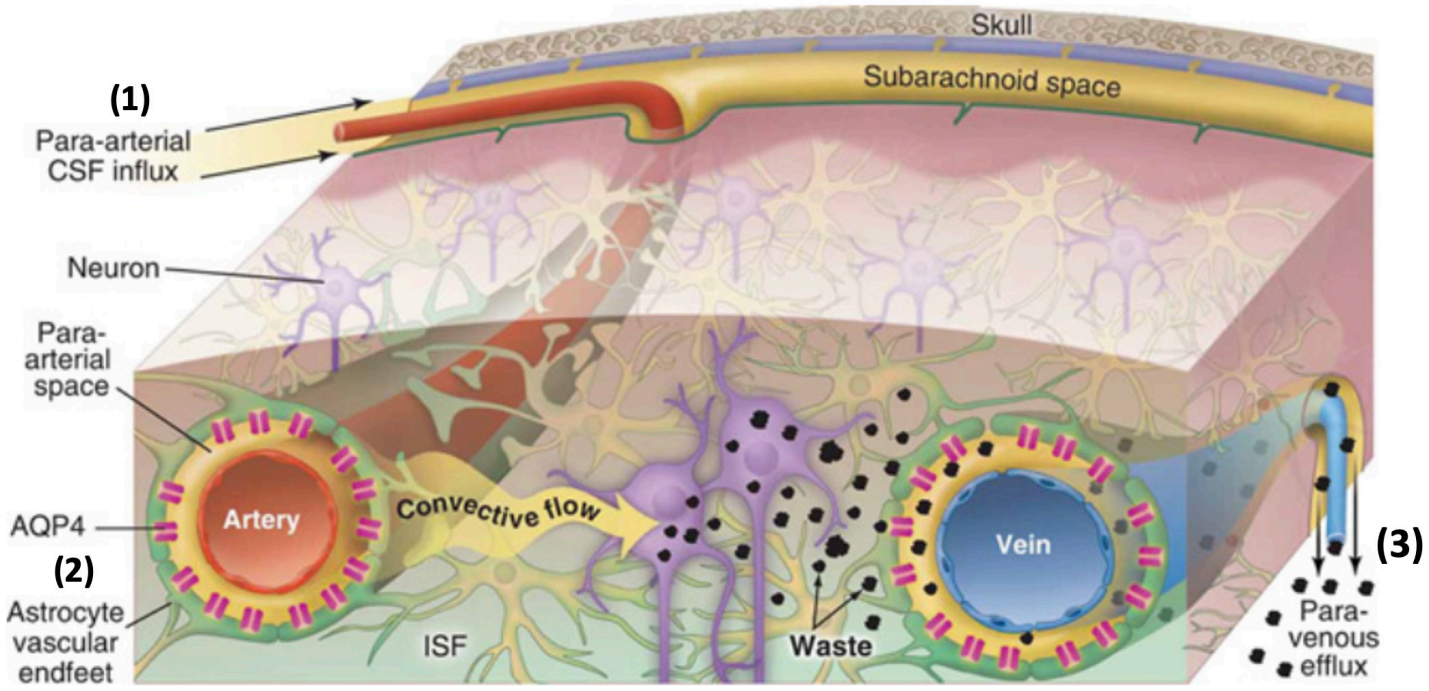

Figure 1: Glymphatic system model overview. (1) CSF influxes through the PVS of pial arteries into the penetrating artery PVS. (2) These spaces are enshrouded by astrocyte vascular endfeet containing large numbers of AQP4 channels. Bulk flow of fluid occurs from the penetrating artery PVS into the parenchyma interstitial space before (3) convective flow forces the fluid and waste products into the venous PVS for efflux out of the CNS. Diagram adapted with permission from Mestre et al.[5]

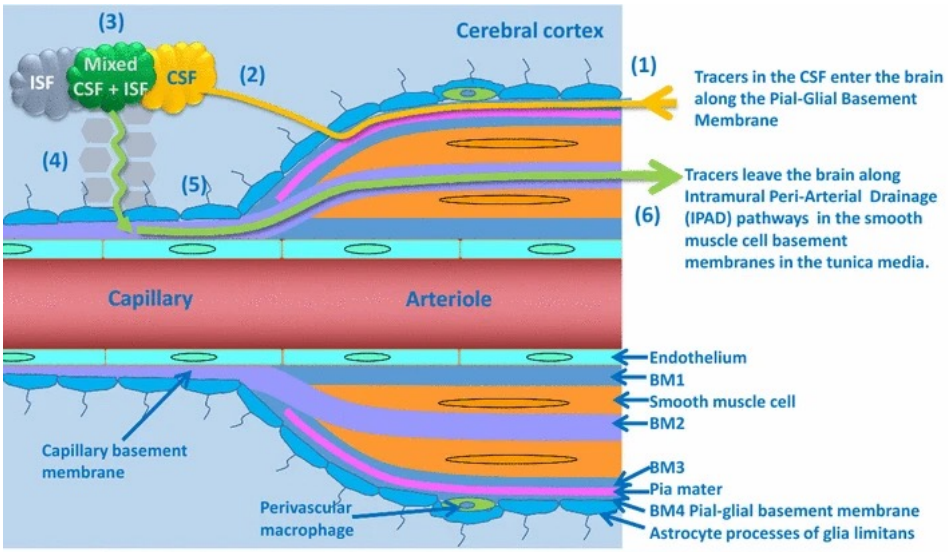

Figure 2: Glymphatic system alternate influx and efflux pathways. (1) Tracers in the CSF enter the brain along pial-glial basement membranes in the penetrating artery PVS. (2) CSF enters the brain parenchyma through AQP4 channels to (3) mix with ISF. (4) The CSF/ISF mixture flows through extracellular spaces or AQP4 channels to enter (5) the penetrating capillary PVS. The fluid then drains from the brain along (6) the IPAD pathway in the arteriolar and arterial tunica media. Diagram adapted with permission from Albargothy et al.[7]

occur with increased eccentricity and maximized cross-sectional area, which are present in elliptical annuli. Unsurprisingly, PVS in mice have been modeled and observed to be eccentric, elliptical annuli, which provide optimal flow rate.[10] Additionally, the PVS has been observed to be of significant size around penetrating arteries, where pulsatile flow is the greatest.[11]

2.2 Lymphatic linkage

The GS eventually empties into the lymphatic system through three potential pathways. One major proposed pathway for humans and other mammals is along the olfactory nerves, through the cribriform plate of the skull, and into the nasal lymphatics.[12] The blood vessels along the olfactory nerve have PVS enriched with AQP4 channels, much like the PVS in the brain. When tracers are injected into the CSF around the brain, they have been found to travel along these blood vessels, across the cribriform plate, and into the intranasal lymphatics. Ablation (targeted destruction) of olfactory nerve bundles in mice resulted in decreased CSF outflow intranasally and increased drainage of CSF down the spinal cord.[12] Interestingly, intranasal administration of tracers in rats and primates also resulted in rapid tracer distribution across the brain and in PVS pathways. This rapid distribution suggests a connection between the nasal epithelium and lymphatic drainage, possibly due to converging networks between arterioles or direct PVS linkages between arterioles and venules.[6] Damage to this intranasal CSF pathway also correlates with decreased or total loss of smell and reliably precedes several neurological diseases.[12] This leaves several physiological directions to explore involving sense of smell and GS clearance.

Additional potential outflow pathways for the CSF are the meningeal lymphatics around the brain and the cervical lymphatics in the neck. Tracers injected into the brain parenchyma are transported along the PVS, through the intranasal passageway, and into deep cervical lymph nodes.[6] However, conditions that inhibit CSF exchange in mice and rabbits, such as experimental hypercapnia, did not affect cervical lymphatic drainage. Ablation of the meningeal lymphatic vasculature did inhibit glymphatic drainage.[13] Thus, though not entirely clear, these results may indicate that the GS is functionally linked to the meningeal lymphatics.

Though most studies of the GS have been conducted in rodents and smaller mammals (which have non-gyrencephalic, or smooth-surfaced brains), glymphatic pathways in gyrencephalic brains are significantly more prevalent and efficient in comparison. Gyrencephalic brains (those of larger mammals such as pigs and humans) have indentations called sulci and bulges called gyri that are absent in the brains of rats and mice. Distribution of CSF tracers indicates that the depth-increasing influence of sulci in gyrencephalic brains enhances CSF dispersion and influx compared to non-gyrencephalic brains. For example, PVS influx density was observed to be 400% greater in pig brains compared to mice brains.[14] The enhanced CSF dispersion is largely due to increased surface area from folding of the brain into sulci and gyri, which allows for more optimized hydraulics. Moreover, the increased number of vascular connections in gyrencephalic brains further enhances CSF distribution. Fissures housing large arteries, such as the anterior cerebral and middle cerebral arteries, provide more potential space for the PVS to expand its cross-sectional area.[14] The increased cross-sectional area and proximity to vascular pulsations ensure optimal fluid flow through fissure PVS.

Monitoring Clearance in the Glymphatic System

Most conclusions about the anatomy and physiology of the glymphatic system have been drawn from data acquired by tracing glymphatic clearance. Many studies involving the GS have involved the usage of model organisms such as rats, yet some human studies have also been performed. Three main tracing methods have been utilized since the GS's discovery: two-photon microscopy, magnetic resonance imaging (MRI), and optimal mass transport (OMT). These methods have given researchers greater insight into the connection between glymphatic anatomy and function, allowing them to model the GS with considerable accuracy. Additionally, glymphatic tracing has elucidated the connections between the GS and the lymphatic system, which may have clinical significance.

3.1 Two-photon microscopy

Early investigation of the GS involved the use of two-photon microscopy. This technique provides excellent spatial resolution and a three-dimensional image of living cells deep within thick brain slices or living animal specimens.[15] The initial description and model of the GS were formulated using ex vivo two-photon microscopy analysis on mouse brains. Some studies involved the injection of low molecular weight

fluorescent tracers into the cisterna magna, subarachnoid space, and interstitial fluid of the brain,[16] while other mouse specimens were injected with high molecular weight fluorescent tracers.[17] Thick slices of brain tissue were then extracted from the specimens and were visualized using two-photon microscopy. These studies showed that glymphatic clearance and efficiency can depend on molecular size, as large molecular weight tracers were not observed to pass into the interstitial fluid.[17] Another GS analysis using two-photon microscopy gave the first representation of the GS as a brain-wide anatomical system that facilitates the clearance of interstitial solutes and waste.[18]

Although tracing of the GS was first dominated by two-photon microscopy, the limitations of this technique are significant. These limitations include its invasive procedure, low penetration depth, and inadequate ability to image small areas of the brain cortex.[19] Thus, two-photon microscopy has lost its popularity as a GS tracing technique to more advanced procedures such as MRI.

3.2 Magnetic resonance imaging

Magnetic resonance imaging (MRI) has been a crucial tool for modeling and tracing the GS in recent years. Using MRI, researchers can achieve high penetration depths and whole-brain imaging, both of which are impossible with two-photon microscopy.[19] Also, MRI imaging techniques provide minimally invasive, real-time evaluation of the GS. Real-time imaging allows for visualization of glymphatic clearance as it occurs, giving researchers a greater understanding of glymphatic clearance efficiency. This technique exhibits great promise for modeling whole-brain glymphatic function.[20]WMRI works by exploiting the magnetic properties of water in biological tissues.[21] To enhance the visualization of glymphatic clearance with MRI, physiologists often use gadolinium-based contrast agents (GBCAs).[22] GBCAs are passive contrast agents that enhance the T1-weighted MRI signal of the CSF and can be administered into the CSF surrounding the spinal cord or into the veins.[21,23] After entering the bloodstream, GBCAs leak into the subarachnoid space of the brain and onto the surface of the spinal cord. Once in the subarachnoid space, these agents enter the brain parenchyma by way of the GS.

One study involving rodents used contrast agents injected directly into the cisterna magna, a CSF-filled space at the back of the brain. This study showed that tracer molecules in the subarachnoid space moved rapidly along pial arteries and then slowly filtered into the brain parenchyma.[24] At this point, glymphatic clearance of the contrast molecules back into the subarachnoid space was further monitored by MRI imaging. The researchers noted that the most rapid glymphatic clearance in rodents was in the brainstem, hypothalamus, olfactory bulb, frontal cortex, cerebellum, and the ventral hippocampus.[24]

Similar experiments using GBCAs and MRI have been conducted on primates. These experiments showed similar results as in the rodents, with the most significant clearance being in the brainstem, cerebellum, frontal cortex, and limbic regions.[24] MRI imaging with GBCAs has also provided evidence that AQP4 inhibition slows CSF clearance, providing a mechanical link between contrast agent clearance and glymphatic function.[21] Thus, both rodent and primate studies have validated the efficacy of MRI imaging for assessing glymphatic transport.

Although MRI imaging has shown promise in modeling the GS, this technique does have its limitations. The greatest limitation is its lack of a quantitative system of measurement.[20] Glymphatic models derived from MRI only take bulk fluid transport, or advection, into account.[19] By ignoring other possible glymphatic clearance methods such as diffusion, the models formed from MRI may not provide a full picture of glymphatic function.

3.3 Optimal mass transport

To better visualize glymphatic transport kinetics, MRI techniques have been coupled with optimal mass transport (OMT). OMT is a computer formulation that calculates the most efficient way to redistribute mass from one area to another while minimizing the energy cost of transportation.[26] According to Koundal and his colleagues, using OMT in the study of the GS provides a powerful and dynamic computational fluid formulation that gives the most efficient path of transportation with minimal energy expenditure.[27] In the traditional OMT formulation, only pulsatile bulk flow of CSF (advection) is involved. However, new optimal mass transport formulations have now been modified to include diffusion, a process that occurs

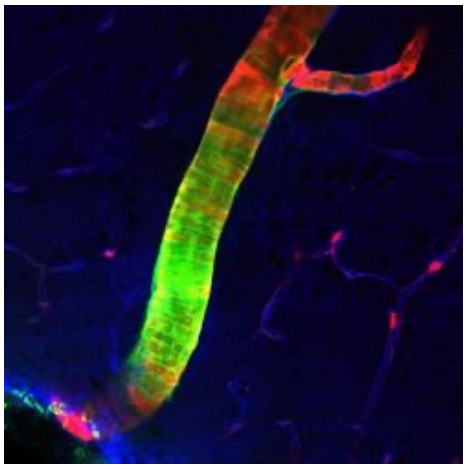

Figure 3: MRI imaging of an artery in the brain of a mouse. CSF is labeled with a fluorescent green tracer, showing the perivascular passageway surrounding the blood vessel. Picture by Jeffrey Iliff at the University of Rochester Medical Center.[25]

continuously in the brain. One study coupled MRI contrast imaging data with an rOMT framework (a regularized formulation for calculating optimal mass transport), producing a more comprehensive model of glymphatic dynamics than either MRI or conventional OMT formulas could provide individually.[27] The rOMT framework was then able to formulate a comprehensive figure of glymphatic clearance, giving detailed information concerning particle clearance trajectory and flow volume while reflecting the total flux of cleared particles from the GS. In this way, OMT is an advancement in existing methods of glymphatic tracing.

Using this formulation, researchers have discovered variability in solute clearance speed across the brain.[26] This corroborates well with MRI evidence that greater clearance occurs in specific brain regions. Another study was performed using a framework that included the diffusion term in its optimal mass transport equation. This study produced a novel physiological model of the GS, showing that when diffusion is left out of the optimal transport algorithm, the data acquired using optimal mass transport is not consistent with MRI evidence of glymphatic clearance.[26] However, when diffusion is weighed more heavily in the OMT formulation, the data correlates more strongly with MRI imaging. Therefore, optimal mass transport provides convincing evidence that glymphatic transport is governed by both advection and diffusion. By coupling both MRI imaging and OMT formulations that

factor in these important terms, quantitative maps of glymphatic dynamics and structure can be reliably developed.

3.4. Implications for measuring clearance

Data obtained from these three GS monitoring methods allow for detailed system modeling that would otherwise be entirely speculative. Being able to model and trace the GS has allowed researchers to assess factors that affect its physiology. The current model shows that blood pressure, sleep, body posture, and aging all have effects on the GS.[19] For example, MRI data shows evidence that ventricular shrinkage may lead to significant reductions in glymphatic clearance. Other studies on mice have drawn a correlation between reduced glymphatic clearance and impairment of meningeal lymphatic function, which could play a role in the onset of Alzheimer's disease.[19] Thus, studies in glymphatic clearance may give insight into natural and even pathological risk factors for its impairment.

Additionally, glymphatic tracing methods provided the first evidence that glymphatic clearance is linked to the rest of the body's lymphatic system, a network whose function has broad clinical relevance.[28] Studies have also documented CSF drainage from the brain parenchyma into the cervical lymph nodes, as discussed in the previous section.[26] These connections are important because they may allow physicians to more easily assess a patient's glymphatic clearance. Such information could lead to improved diagnoses of certain neurological diseases and give better insight into the physiology and treatment of these pathologies.[29]

Pathophysiological Implications of the Glymphatic System

Considering the critical role that both CSF and ISF play in brain solute homeostasis, any structures involved in the clearance of these fluids are likely to have significant pathological implications. When solutes such as amyloid-β peptides, tau protein tangles, and α-synuclein build up in the brain parenchyma, they are often implicated in cerebral conditions such as Alzheimer's, other forms of dementia, and even Parkinson's disease. Fortunately, new methods of monitoring glymphatic clearance make it easier than ever to investigate the potential impact of diseases on the GS and vice versa. Unfortunately, most medically implicated studies on the GS provide information that is merely correlational. Thus, in many situations, there remains a question as to which comes first: the impairment of the GS or the onset of a neurological disease. For many slow-onset pathologies, it might make sense that a gradual degeneration of GS function could result in the symptoms characteristic of these chronic conditions, yet the reverse is also a possibility. Perhaps the progression of a neurological condition or the damage caused by a cranial injury causes the impairment of the GS, resulting in further neurological symptoms and triggering an ever-worsening spiral. Many researchers emphasize either one causal relationship or the opposite.[20,30,31] Others refrain from speculating entirely and simply describe the correlation.[32,33] In reality, the true progression of a given condition is likely more complicated than a simple causal relationship. For this reason, targeted research is suggested to fully elucidate the etiology of each specific neurological condition.

4.1 Factors and mechanisms of glymphatic influence

As with most pathologically implicated systems in the body, GS function (or lack thereof) has been correlated with a plethora of risk factors and medical conditions.

4.1.1 Factors influencing the glymphatic system

Perhaps the most natural of these is the process of aging, which has traditionally been associated with a decline in mental acuity and anatomical function. In a study that evaluated CSF-ISF exchange in 'young', 'middle-aged,' and 'old' mice, a decline in GS efficiency was observed as the age of the mice increased.[34] Part of this decline was due to a substantial decrease in the vessel wall flexibility of the rodent's brain, while an accompanying loss of AQP4 water channels throughout the glymphatic pathway was also a heavy contributor.[34] The implication of this research is that the traditional hardening of blood vessels and down regulation of certain membrane proteins associated with advancing age have a significant impact on the GS. Practically, this could predispose elderly individuals to neurological malfunction caused by the accumulation of toxic solutes.

Several medical conditions have also been implicated as potentially damaging to the glymphatic system, with diabetes being a prominent example. Type 1 and Type 2 diabetes have both been found to accelerate the progression of atherosclerosis in a patient's blood vessels, making these conditions major risk factors for vascular disease. In 2016, researchers investigated the relationship between GS and diabetes by observing CSF clearance in Type 2 diabetes mellitus rats.[20] Using MRI and a contrast tracer, they found that a threefold decrease in glymphatic clearance was observed in these rodents compared to a control. Additionally, cognitive function in the rats declined sharply, suggesting that glymphatic impairment had a marked impact on cognitive deficits.[20] This connection is noteworthy as it implies a relationship between vessel hardening and GS impairment. It also provides a possible explanation for the neurological symptoms often present in diabetic pathology.

Traumatic brain injury (TBI), though not a chronic condition like diabetes, has been shown to have a similar detrimental impact on waste clearance in the brain.[31] In fact, glymphatic system impairment after brain injuries may help to explain the increased prevalence of neurological degeneration and dementia in patients who undergo these types of traumas. These issues may not present themselves until years or even decades into the future, suggesting some type of long-term, slow-acting damage that could be attributed to a compromised metabolite clearance system. Diabetes and TBI are a pair of cardinal examples, but many other medical conditions have been implicated with GS impairment. Subarachnoid hemorrhage, ischemic stroke, and even juvenile myoclonic epilepsy have all been correlated with severe damage in GS structures and function, leading to the dangerous accretion of toxic solutes.[33,35]

A third category of risk factors for GS impairment involves anesthetics and remedial medications with undesirable, GS-related side effects. Some drugs that have been demonstrated to have an inhibitory effect on CSF clearance include the anesthetics ketamine and isoflurane.[36] Yet in different dosages, combinations of ketamine and xylazine (a veterinary tranquilizer) have been observed to increase GS flow.[37] One explanation for this complex relationship between anesthetics and the GS proposes that the arousal state may be a link.[38] Studies have shown that the GS and arousal state have a correlative relationship, while anesthesia induces lower levels of mental

arousal. Because anesthetics also directly impact respiratory and cardiac rates, which play a role in driving glymphatic function, an indirect relationship may exist here as well. This factor is important to consider during clinical studies, especially in those that involve anesthetizing subjects to monitor glymphatic clearance.

4.1.2 Mechanisms of glymphatic system impairment

To understand how the GS can be impaired by a disease or any other external factor, the mechanisms that drive its function must be considered. The primary driving force of CSF movement was first thought to be the pulsation of the choroid plexus, which is also responsible for secreting the fluid.[39] However, growing evidence has indicated that CSF movement is synchronous with the pumping of the heart.[16] If this is the case, the choroid plexus may have a smaller role as a mediator between cardiac pulsation and CSF flow. With the heart playing a significant role in CSF movement, glymphatic drainage is also likely to be significantly dependent on this organ's function. Thus, some conditions that chronically affect cardiac function may have an impact on the glymphatic system. While more apparent in diseases such as diabetes and ischemic stroke, other medical conditions that affect blood pressure or vasculature may also impact the GS indirectly. Respiratory function also influences CSF flow through the GS.[40] One study found that during normal breathing, the direction of net CSF flow changes directions when a person switches from inspiration to expiration.[41] Other groups of researchers have come to similar conclusions that the mechanisms of breathing affect CSF movement, strengthening the proposal that respiratory complications may impair the GS.[42]
Due to its unique role in exchanging solutes with the brain parenchyma, the GS also relies heavily on efficient absorption and secretion mechanisms to accomplish its responsibilities in the brain. Disease states can detrimentally impact these mechanisms, providing a window into how these diseases could affect overall GS function. For instance, idiopathic normal pressure hydrocephalus (a subtype of dementia) was recently found to alter the expression of AQP4 in patients, resulting in increased levels of astrogliosis.[30] Since AQP4 is a crucial water channel in the GS, abnormalities in its expression can have severe consequences for CSF clearance. To prove this point, Iliff et al. illustrated that genetic knockout of AQP4 causes permanent malfunction of the GS in 8- to 12-week-old male mice, leading to hazardous amounts of neurodegeneration.[31] However, damaged or absent AQP4 is not the only route for reduced glymphatic exchange. Among other possible mechanisms for GS impairment are both impaired CSF circulation and BBB leakage.[3,43] These complications cause significant issues with absorption and/or secretion in perivascular pathways and have been implicated in multiple progressive neurological disorders.

4.2 Speculative correlations and therapies for glymphatic system impairment

As has been demonstrated, many factors can play a role in influencing glymphatic efficiency, including many disease states. The symptoms that result from glymphatic impairment are also significant and may help to explain some complex neurological impacts of non-neurological disorders. Indeed, sometimes the line between the impact of glymphatic impairment and the mechanisms that first influence the GS can become blurred, leading to a broad range of causal propositions and speculation. In this review, factors that influence glymphatic function are discussed separately from the implications of glymphatic impairment for the purpose of clarity, but it is important to remember that these topics are inherently intertwined.

4.2.1 Complications of glymphatic system impairment

Complications resulting from glymphatic malfunction can be divided into two categories: 1) symptoms resulting from non-neurological diseases and 2) symptoms resulting from diseases that are traditionally considered neurological. Diabetes is a prominent, largely non-neurological condition, yet it can have numerous neuropathological symptoms, including peripheral, proximal, and autonomic neuropathy. These symptoms have been partially attributed to the accumulation of toxic proteins and amyloid-β plaques in the cerebral vasculature.[44] Thus, impairment of the GS, an amyloid-β clearance system, may be a significant contributor to the onset of these symptoms.[20] Neurological impairment after ischemic stroke may also be a consequence of GS damage caused by secondary issues such as brain edema. When glymphatic pathways fail to clear CSF and solutes, fluid accumulates in the sealed compartment of the skull. In severe cases, this can result in cerebral edema, which greatly reduces neurological recovery in affected patients.[4] Neuroinflammation can occur in many other non-neurological disease states, exacerbated by the buildup of wastes and protein aggregates in the CNS. Though not enough evidence currently exists to draw a direct causal relationship between the GS and diseases that involve neuroinflammation, such a connection is a strong candidate for future research. As for neurological diseases, a large body of evidence suggests a strong interaction between glymphatic function and the progression of cognitive dysfunction in these conditions.[3,31,45,46,47] The GS drains both amyloid-β and tau protein aggregates from the interstitial and cerebrospinal fluid to prevent their deposition, two solutes whose accumulation are hallmarks of dementia, and more specifically, Alzheimer's disease. In the past few years, researchers have used laser-guided dyes and multiphoton tomography to elucidate ISF clearance in the living mouse brain, directly demonstrating the importance of glymphatic function for preventing the development of Alzheimer's.[45,31] Additionally, blocking drainage to induce abnormal protein accretion was found to aggravate the symptoms of Parkinson's disease.[46] Abnormal amounts of toxic α-synuclein have also been found to play a critical role in the etiology of Parkinson's, suggesting that any impairment of the critical glymphatic clearance pathways may accelerate the progression of this disease.[48] Similar concerns have been voiced for the symptoms of perioperative neurocognitive disorder, idiopathic normal pressure hydrocephalus, cerebrovascular disease, and Lewy body disease, emphasizing the harmful consequences of GS impairment in nearly every case.[3,5,38,47] These complications demonstrate the risk of damaging this recently elucidated system and should motivate further investigation of its impact.

4.2.2. Therapeutic implications and targets of the glymphatic system

The homeostatic importance of glymphatic function has been a hot topic in therapeutics due to its pivotal role in the onset and progression of various medical conditions. As an important regulator of brain solute balance, the GS's critical role in

the CNS has been relatively well established despite the recency of its discovery. Evidence suggests that the presence of the system's most closely implicated membrane protein, AQP4, is important for synaptic plasticity, neuronal function, and even neuroimmunological induction (initiation of the brain's immune response).[49] It accomplishes these many roles through its function in water homeostasis, which can indirectly influence ion and protein gradients by altering their concentrations. The GS also clears dangerous toxins such as amyloid-β, tau protein, and α-synuclein from the brain while facilitating the movement of chemical signals and growth factors through the brain parenchyma.[2,50] Furthermore, it allows for the diagnosis of brain injury by depositing biomarkers into the circulation.[29] These cytosolic proteins (S100 calcium-binding protein β, glial fibrillary acidic protein, neuron-specific enolase) are important in characterizing the extent and severity of a traumatic brain injury.

Driven by a search for pharmaceuticals that can combat the effects of neurodegenerative diseases, several specific therapeutic targets have been proposed to restore and enhance glymphatic clearance. Direct manipulation of the AQP4 protein has been suggested by multiple authors, with varying treatments suggested based on the specific medical condition. One study suggests blocking the AQP4 channel after ischemic stroke due to the natural overexpression that typically occurs at the ischemic site.[32] Other researchers have investigated the effects of AQP4 stimulators and modulators with varying levels of success.[51,52] Unfortunately, AQP4 and aquaporins in general can be quite difficult to target because their generic outer structure imparts exceptionally low druggability.[53] While failing to clearly demonstrate the utility of AQP4 inhibition or stimulation, the results from these studies provide enough interest to provoke further research.

Some ion channels may also serve as viable drug targets to modulate glymphatic function. Specifically in cases of brain injury and edema, ion concentrations can build up to dangerous levels in the brain. This accumulation causes mild cellular edema to develop into a much more serious vasogenic edema.[54] Thus, the activation or deactivation of GS ion channels through methods such as osmotherapy may be an efficient way to minimize some of the most debilitating symptoms. For instance, Wescott et al. propose that by inhibiting the production of the nonspecific cation channel SUR1/TRPM4, a normally absent channel that is only upregulated in response to injury, the formation of cerebral edema after ischemic stroke may be entirely prevented.[55]

A final therapeutic intervention involving the GS involves shunt surgery, a last-resort technique that can nonetheless have substantial potential upside.[3] Brain shunt surgery is the process of placing a narrow tube into the brain or spine to help drain CSF in conditions of severe drainage issues such as idiopathic normal pressure hydrocephalus. The system involves a proximal catheter, a valve, and a distal catheter connected together and used to provide a pathway between the damaged ventricle in the brain and an absorptive cavity in the body, such as the heart or peritoneum.[3] Due to the substantial risk and invasive nature of this surgery, individual assessments with extensive diagnostic testing are required to decide whether the intervention is appropriate. If necessary, however, early shunt surgery can considerably improve GS function and may even stave off the development of dementia in patients.[56]

Conclusion and Perspective

Glymphatic system anatomy provides an intricate PVS pathway to exchange and filter CSF that ultimately drains into the lymphatics. With tracing methods such as two-photon microscopy, MRI, and optimal mass transport, researchers can gain great insight into glymphatic clearance and can model its pathways with remarkable accuracy. The GS may also be a key to developing directed therapies for neurological disorders and symptoms, yet it can be difficult to establish whether its impairment is the primary cause or a secondary effect of many diseases. For this reason, specific investigations are recommended to elucidate its impact on individual conditions. One important future goal is to establish a general standard for base-rate glymphatic clearance. Typical experiments over the past few years record differences in glymphatic clearance based on a percent change from the subject's baseline; however, baseline clearance in the healthy individual should be approximated to better understand and compare results between studies. Additionally, having a 'normal' range of glymphatic clearance will allow doctors to identify abnormal clearance. This standard is crucial for diagnostic testing and research alike.

It would be most helpful to pursue human investigations in future studies, as much of our existing knowledge of the GS is based on experiments performed on rodents. In studies without human subjects, however, creative research design is recommended to tease out the complex causal relationships between the GS and specific pathologies. Finally, multiple potential targets for novel therapies exist in the GS. However, further studies are required to determine which drugs and targets result in the most improvement for patient outcomes. The glymphatic system is a recent discovery, but substantial progress has been made in the past decade to elucidate its biological significance. By sorting through some of the controversies and questions surrounding the GS, we hope to have elucidated the path forward by exposing areas that deserve further research.

Disclosure Statement

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Author Contributions

JV conceived the main outline. JV, EC, and SR wrote the manuscript. EC and JV includ*ed and formatted the figures. JV took charge of the manuscript correction and editing. All authors contributed to the article and approved the final version.*

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"I AM Capable!" A Study Examining the Relationship Between Identity and Academic Achievement among STEM Black college women at HBCUs

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Abstract

Black students' persistence in science, technology, engineering, and mathematics (STEM) may be affected by factors, such as their social identities. Though Black college students remain underrepresented in STEM fields, historically Black colleges, or universities (HBCUs) are instrumental in educating Black students who go on to pursue doctoral degrees in STEM. Intersectionality, the main theoretical framework utilized in this study, emphasizes how aspects of a person's social and political identities, such as race, socioeconomic status, and sexuality, combine to create different modes of discrimination and privilege.[1] For example, studies have found that Black college women in STEM, specifically, experience gendered racial oppression and inequalities within STEM spaces due to their intersectional gendered racial identity. Yet, few studies have evaluated the influence of Black women's intersectional identity on their academic achievement and motivation among those pursuing a STEM degree at an HBCU. The present exploratory study examined perceptions of identity and academic achievement in STEM by conducting a focus group with three Black undergraduate women majoring in STEM at an HBCU. Results revealed that three themes emerged: 1) perceiving the STEM field as White male-dominated, 2) experiencing imposter syndrome in STEM, and 3) community and institutional support for Black women in STEM. Findings can be used to develop educational programs for faculty and administration on how Black college women's identity plays a crucial role in their motivation and persistence in STEM.

Introduction

Black women consistently have had unique experiences due to their position in society. Discriminatory social constructs such as the combination of racism and sexism (e.g., gendered racism)[2] can create difficulties for Black women navigating through the American education system. Yet still, in some disciplines, Black women encounter systemic challenges. Specifically, science, technology, engineering, and mathematics (STEM) disciplines are areas where Black women typically encounter structural barriers (e.g., being viewed as less competent) that impact their persistence and success in STEM.[3-4] Indeed, the percentage of bachelor's degrees in STEM awarded to Black students (12%) from 2015 to 2016 was lower than the overall percentage (18%) of bachelor's degrees awarded in STEM fields.[5]

Yet, these percentages should be contextualized; where Black women choose to study STEM and earn their STEM degrees plays a significant role in their overall journey. For example, attending culturally significant institutions, namely historically Black colleges or universities (HBCUs), is crucial in recruiting and retaining Black women in STEM in their pursuit of bachelor's degrees.[6] Despite HBCUs only accounting for 3% of postsecondary institutions in the United States, of the top eight institutions that matriculate Black STEM students that go on to earn graduate degrees, seven are HBCUs (NSF, 2020). While, in recent years, there has been an increased focus on encouraging Black women to pursue STEM studies and careers in various disciplines,[7] there is still a significant lack of research exploring the unique circumstances of Black women in STEM. Few studies have evaluated the influence of identity and HBCUs on the academic achievement and motivation of Black women undergraduate students in STEM. Therefore, the current study aimed to explore the following research question: How does the intersectionality of one's race and gender identity influence self-perceptions of academic achievement, persistence, and motivation in STEM among Black female undergraduate students at HBCUs?

Theoretical Framework

There are themes surrounding Black women scholars that should be explored to better understand their ability to thrive in STEM.[8] Thus, the main theoretical framework employed in the present study is intersectionality theory. Intersectionality is an analytical framework for understanding how aspects of a person's social and political identities, such as race, socioeconomic status, and sexuality, combine to create different modes of discrimination and privilege.[9] Intersectionality theory was appropriated in a study done by Smith and colleagues[10] to evaluate how the intersection of racial and gender identity influences academic identity and achievement in Black women in their STEM majors. The findings showed that Black women were unable to conceptualize their race and gender separately. Thus, intersectionality theory assists in exploring how the perception of Black women's intersectional social identities, such as their race, gender, class, may influence their ability to thrive in STEM. Additionally, this framework enhances one's understanding of how Black women navigate STEM educational experiences that shape their identities.

Motivation and Persistence of Black women in STEM in Higher Education

Higher education research has shown that academic discrimination and stereotyping are reoccurring themes related to Black women who are graduate students or faculty in higher education.[11,12] These stereotypes have been shown to directly affect Black women as they are more likely to receive lower employment opportunities than their White male counterparts.[13] Furthermore, the National Science Foundation (2015) found that Black women make up only 2% of practicing scientists and engineers due to severe underrepresentation, which was found to contribute to the issues Black women face early in their STEM careers. McGee and Bentley[14] conducted a study to examine the impacts of structural racism, sexism, and discrimination related to their identity as Black women in STEM. The findings revealed that Black women often encountered many discriminatory and micro-aggressive experiences, including their credibility being questioned, causing individuals to feel like they must prove themselves to counteract these negative stereotypes.[14]

Similarly, Ireland et al.[3] conducted a theoretical study to evaluate how intersectional approaches have produced new knowledge about Black women and girls in STEM education. This study revealed the need for educational interventions to maintain Black women's persistence in STEM. More specifically, the findings emphasized how learning environments impact academic outcomes[15] in that Black women at undergraduate and graduate levels continue to experience micro-aggressive learning environments, negative stereotypes about their capabilities, alienation from study groups, and feelings of isolation.[16,17] In contrast, Cocker[18] noted that Black women identified extrinsic and intrinsic factors, such as familial and community support, as factors that foster their motivation to navigate higher education. Though studies have investigated factors that influence the persistence of Black women in STEM at predominantly White institutions (PWIs), more research is needed to explore the persistence of Black women at HBCUs.

Identity Formation among Black Women in STEM

Previous literature has shown that to attain and maintain high academic success, Black women may feel pressured to de-emphasize their racial and gender identity.[19,20] Therefore, due to this stigma, some Black people, including Black women, in educational settings may downplay their racial identities and de-associate themselves from their same-race peers to reach high-achieving success as defined as displaying academic excellence.[21,22]While much of the present literature has focused on the educational experiences of Black men,[22,23] there has been little research that has focused on Black women's educational experiences. For example, in a qualitative study examining challenges and issues regarding the identity of high-achieving Black women students, Marsh[22] found that Black women students were able to emphasize and stay connected to their racial and gender identity by maintaining close connections to community members and resources. More specifically, it was shown that the Black women students in the study did not attempt to minimize their racial identity due to the acknowledgment of challenges in associating with distinct racial/ethnic groups and embracing these challenges in academic settings.[22]

Regarding gender identity, it was found that these Black women demonstrated their "womanhood" by adjusting their social groups to include whoever cultivated or delayed their academic success.[22,24-25] While academic identity has been studied with more attention in the literature, do-

main-specific STEM identity has not been investigated as much.[26] Previous studies suggest that Black women may have more difficulty adopting a concrete science identity due to negative stereotypes about one's racial and gender identity (e.g., angry Black woman stereotype), lack of Black representation in science professions/fields, and lack of acceptance from White peers or counterparts.[27,28] Moreover, Carlone and Johnson,[28] emphasized that when science identity is not incorporated in Black women's gender and racial identity, it may contribute to the challenges that Black women in STEM may face. In this qualitative study, the authors found that science identity consists of performance, recognition, and competence. Carlone and Johnson[28] defined performance as social performance, which measures how an individual achieves goals and creates value; recognition as the acknowledgment of oneself by themselves and others; and competence as knowledge of science. In conclusion, it is shown that Black women often are not able to fully express their identity due to negative stereotypes and perceptions.

Recently, Smith and colleagues[10] explored the relationship between racial and gender identity on the development of science identity and academic achievement among Black women undergraduate students at an HBCU. In this study, the authors utilized intersectionality theory,[1] the interconnectedness of social identities that cause prejudice and discrimination against a specific social group, and social identity theory,[29] the closer a variable to one's identity exhibits a direct positive correlation on how the variable is regarded. In a mixed-methods study, Smith and colleagues[10] found that Black women students in STEM with high-achieving abilities often felt like they had to de-emphasize or compartmentalize their identities to maintain success and avoid discrimination. Overall, the complexity of understanding identity development and formation among Black women in STEM merits further examination.

Motivation and Persistence of Black women in STEM

Specific to STEM, previous literature has shown that environments or institutions that provide continuous support, encouragement, and community are more likely to encourage student engagement and persistence in STEM.[30] As an example, Bryant[31] found that Black women view the support of STEM faculty and mentors as essential to their persistence in STEM disciplines. Moreover, Bryant's[31] findings also showed that exposure to underrepresented faculty in STEM encouraged and motivated Black women to stay within their STEM disciplines. Similarly, Morton[32] examined perceptions and experiences of Black women in STEM and how these experiences contribute to their engagement and persistence in science. This study showed that Black women who develop their identity using positive and inclusive strategies feel authentic and included within the research process and are willing to persist in STEM despite challenges concerning their identity.[32] Elsewhere, environmental, and contextual factors such as nuanced experiences have been found to play a significant role in Black women's engagement and persistence in STEM.[33,34]

Conversely, Black women have been found to be less likely to attain a STEM degree due to a lack of support in academic environments.[35] In particular, their persistence and engagement can be altered due to the lack of access to Black women faculty, mentors, and research projects that focus on Black women in STEM[28] and the lack of representation and stereotypes that negatively impacted their journey in the sciences.[3] The combined findings of the literature exemplify the need for a more in-depth analysis surrounding the relationship between identity and academic achievement and persistence in STEM among Black women studying at HBCUs.

Academic Achievement of Black women in STEM

Limited studies have evaluated academic achievement among Black women in STEM careers. Previous literature has shown that Black women remain underrepresented in STEM fields due to their educational experiences being affected by the dual presence of their racial and gender identity.[36,37] Research has also shown that despite the dual existence of race and gender amongst Black women, another factor limiting the educational attainment of women and students of color in STEM includes insufficient resources, support, and preparation from prior schooling and current colleges/universities.[6] As this trend has been emphasized in research, it has been found that students attending colleges/universities that serve primarily Black populations and women show higher rates of educational attainment in STEM.[38] According to the Integrated Postsecondary Education Data System (2004), it has been found that HBCUs are a vital source of STEM degrees and professional attainment among Black women.

In summary, previous research has emphasized the importance of exploring how self-efficacy (an individual's belief in their capacity to reach a goal) among Black women's educational attainment in STEM fields, along with inefficient resources and preparation and stereotype threat may influence their motivation to persist in STEM.[39-41] However, research has also shown that HBCUs and women's colleges effectively address these structural barriers that limit Black women's STEM educational attainment.[6,42,43] Therefore, this current exploratory study sought to close the gap in literature, evaluating the perceived role Black women's colleges play in the academic achievement of Black women in STEM fields.

Current Study

Few studies have evaluated the perceived influence of identity and the HBCU context on the academic achievement and motivation of Black women undergraduate students in STEM. Therefore, this qualitative exploratory study aimed to evaluate the self-perceptions of identity and academic achievement in science, technology, engineering, and mathematics among Black women undergraduate students at an HBCU. Given the intersectionality theoretical framework, we developed the following research question: How does the intersectionality of one's race and gender identity influence self-perceptions of academic achievement, persistence, and motivation in STEM among Black female undergraduate students at HBCUs?

Method

Participants

The participants from this study were recruited from a women's HBCU in the Southeast region of the United States. A convenience sample was utilized to recruit the participants via emails and flyers. A total of three Black women between the ages of 18-22 were recruited to participate in this study. As shown in Table 1, all the participants consisted of undergraduate STEM majors. The specific majors of the participants were chemistry and biology.

Pseudonym	Gender	Age	Race	Education Level	Major
K.J.	Woman	19	Black	Sophomore	Chemistry
Abby	Woman	20	Black	Sophomore	Biology
Paris	Woman	21	Black	Junior	Chemistry

Table 1: Participant Demographics

Measures

A demographic survey in Qualtrics was utilized to assess background information such as race, age, education level, and years of experience studying math and science. Additionally, a set of questions was administered to participants that centered around their achievement, persistence, and science identity.

Procedures

Participants participated in one focus group, a semi-structured interview, and a group interview where only a set few of questions were asked and the others were not planned in a specific order, that lasted about 45 minutes via Zoom. The participants were shown an informational sheet about the study via Qualtrics and consented to participate in the focus group and consented to have their responses audio recorded. Each participant was asked to use pseudonyms. In this focus group interview, participants were asked questions about their achievement, persistence, and science identity in STEM. Some of these sample questions included: "Do you feel that your professors provide support and are invested in your success in STEM?" and "Do you think that your grades in your STEM courses are a reflection of how well you can do in these courses? Why or why not?" After the interviews, participants were compensated $10 for their participation. All data from the interviews were stored on a password-protected computer and analyzed for themes.

Positionality

As Black undergraduate women in STEM, we have had the opportunity to analyze this study while being in a similar position to the participants. We are all Black women from different backgrounds but share the similarity of attending HBCUs as social science STEM majors. During our time as Psychology majors, we have all questioned our science identity at some point. We have experienced being told by our professors that we were not good enough and that we should choose another path. Being doubted by our professors had a negative impact on our confidence level as STEM majors. Even though this affected our persistence and how we viewed ourselves, we did not allow these doubts to affect our achievements. Therefore, we approach the analysis of this data from an insider's perspective. We very much relate to the position of the participants.

Data Analysis

This study utilized a qualitative design that consisted of a focus group interview. The focus group data were transcribed and then analyzed using phenomenological analysis, a methodological framework in qualitative research that examines how individuals make meaning of their lived experiences.[44] Furthermore, this analysis consists of identifying, analyzing, and interpreting patterns of meaning within qualitative research.[45] This type of analysis was used to examine the themes and subthemes that may influence the self-perceptions of identity and academic achievement Black women STEM undergraduate students at HBCUs. To reach an intercoder agreement, we refined our main themes and subthemes and finalized each of our counts for each subtheme. Then, the intercoder agreement was calculated based on each of the coder's final counts. The steps to conducting a phenomenological analysis[46] include:

Step 1: All raters read through the focus group session transcript and took notes on initial patterns.

Step 2: Generated initial codes/subthemes and color code highlighted sections of the transcript to correspond with the code/subtheme.

Step 3: Reviewed subthemes and developed main themes and defined main themes.

Step 4: Refined final themes and subthemes and calculated the cut-off value.

Step 5: Calculated percent agreement based on final themes and subthemes by evaluating intercoder agreement of all subthemes.

Findings

There were seven preliminary themes that arose from this study. However, five major themes were chosen due to the selected cut-off value of a frequency of three. This cut-off value was chosen to determine the most prominent themes that arose in the study from the participants. The percent agreement for the final major subthemes was 100%. The final constructed major themes were a) science Identity, with subtheme past STEM interests/experiences, b) managing persistence in STEM, with subthemes preparation and self-motivation, c) community of support, with subtheme peer support, d) identity challenges in STEM, with subthemes gendered racism in STEM, imposter syndrome, credibility questioned, and underrepresentation in STEM, and e) learning barriers, with subthemes unfavorable learning and resources availability. These major themes point to how the intersectionality of Black women's identities may influence perceived challenges in persistence and motivation in STEM. The findings are summarized in Table 2 which shows the theme, subthemes, definition of each subtheme, and an example of each subtheme.

Science Identity

The first theme that emerged was science identity, which participants discussed how they developed their science identity through experiences and research. With a frequency of three, participants discussed how past STEM experiences and interests before college led to their interest in STEM. These findings are consistent with Wallace's[47] findings that participants credited early influences prior to college for stimulating their STEM interest. Additionally, extracurricular STEM-related experiences during their college matriculation, such as summer internships and research, had a significant impact on participants' formation of their STEM identity. One participant discussed her experiences in STEM during her K-12 education.

"I became interested in STEM in

Table 2: Focus Group Themes and Subthemes

Theme	Subtheme (f = total frequency)	Definitions	Examples
Science Identity - Discussion of how participants developed their science identity.	Past STEM Interests/ Experiences (f = 4)	previous K-12 experiences, or experiences before college, that led to the interest in STEM	"I became interested in STEM in elementary school because I liked the structure of STEM, so especially science and math, and that it felt like a puzzle to me..." (Abby, Sophomore, Biology)
Managing Persistence in STEM - Discussion of ways persistence is managed in STEM.	Self-Motivation (f = 10)	one's ability to strive and take initiative in order to execute one's tasks and goals through challenges and adverse experiences	"...And like, really the work ethic that I have, if I want to maintain that work ethic, then I have to really believe in myself and not look towards anyone else for validation." (Paris, Junior, Chemistry)
	Preparation (f = 3)	engaging in behaviors in the classroom to become "ready" for a specific event such as exams, homework assignments, essays, and/or other projects related to STEM	"Of course, I went to office hours, study gap partners and stuff to help me." (KJ, Junior, Chemistry)
Community of support - A description of support factors for Black women in STEM.	Peer Support (f = 3)	tools, skills, knowledge, or other forms of encouragement provided from peers	"My peers from home and from school definitely pushed me to keep going because the peers that I have that are STEM majors, it's helpful to have someone who just understands, and it makes you feel less like you're crazy for feeling the way you feel. " (Abby, Sophomore, Biology)
Identity Challenges in STEM - Discussion of identity challenges within STEM participation.	Gendered Racism in STEM (f = 3)	experiences of prejudice or discrimination in STEM due to one's identity	"And that really affected how people spoke to me, I really experienced a different type of racism, where it's like, you're being treated as if you're incompetent. " (Paris, Junior, Chemistry)
	Imposter Syndrome (f = 3)	the state of doubting one's abilities or future in STEM	"One is definitely myself. I learned what imposter syndrome was in college and definitely say that it sucks, and you feel it a lot. " (Abby, Sophomore, Biology)
	Credibility Questioned (f = 4)	one's competency is questioned by other peers in STEM	"And a lot of the students when you're a minority student in a stem class, like they're not really reaching out to you like that." (Abby, Sophomore, Biology)
	Underrepresentation in STEM (f = 4)	the lack of Black women representation as faculty, staff, and students in STEM	"I would consider my grandma a stem role model. And she is identifies as female, and she's a black African American woman. And she went back to school when she was older and pursued a graduate degree. And she was like one of like four women in the whole group." (Abby, Sophomore, Biology)
Learning Barriers - A discussion of learning barriers that Black women face as they navigated through STEM.	Unfavorable Learning (f = 3)	unpreferable learning environment (remote/in-person) or learning style	"This is Kj and one of my top concern is not getting the full experience of everything. Being online, I just do not feel like I'm learning." (KJ, Junior, Chemistry)
	Resources Availability (f = 3)	support provided from high school and current college institution (i.e., tutoring centers, counseling centers, career centers) with the intention of increasing STEM matriculation	"And I also believe that this my university has a lot of different resources, such as the Success Center, where you can talk to a success coach, if you need help, like with really just be being successful in your courses, and in life as well." (Paris, Junior, Chemistry)

> elementary school because I liked the structure of STEM, so especially science and math, and that it felt like a puzzle to me..." (Abby, Sophomore, Biology).

In reflecting on her STEM experiences in elementary school, Abby spoke about how using math and science to solve real-world challenges and problems was fascinating to her. Furthermore, Paris spoke about how their past research experiences helped form her science identity.

> "I've had different research opportunities and experiences. And I feel like they've really impacted me... and finding my own authentic self within the scientific field." (Paris, Junior, Chemistry).

In sum, the results demonstrate that the development of Black women's science identity is largely influenced by past STEM encounters. Most participants discussed how the nature of their STEM courses and involvement in STEM activities outside of the classroom, helped them develop a science identity and interest in STEM.

Managing Persistence in STEM

The second theme was managing persistence in STEM. In this theme, there was a focus on ways persistence is managed in STEM for Black women. Several participants shared the necessity of having preparation and self-motivation to be successful in their science studies, as this subtheme held a frequency of 10. Self-motivation was a significant subtheme defined as one's ability to strive and take initiative to execute one's tasks and goals through challenges and adverse experiences. Participants also noted that preparation and self-care are also important aspects of maintaining persistence in STEM. Paris, for example, discussed how she had to believe in herself and work hard to be successful in her STEM major.

> "...And like, really the work ethic that I have, if I want to maintain that work ethic, then I have to really believe in myself and not look towards anyone else for validation" (Paris, Junior, Chemistry).

To reinstate the importance of self-care, Paris says,

> "I'm really just focusing in on self-care and knowing that you need to take care of yourself and take time out for yourself to avoid burnout and stuff."

The necessity for self-motivation and self-care was shown to be a significant factor in the undergraduate experience and is supported by the literature. Blakely[48] emphasizes these sentiments in that Black women who are pursuing STEM paths are found to be more successful when they obtain motivation and inner drive.

Community of Support

The third theme is community of support, and it acknowledges various factors of support in STEM, such as family, peers, and faculty. Peer Support was found to be the most significant subtheme and area of assistance, with a frequency of 3. Participants communicated the ways in which they received tools, skills, and other forms of positive engagement from HBCU faculty and peers, family, and friends. As such, KJ spoke about the dynamics of her relationship with her mother and how her mother encouraged her to keep going.

> "...My mom is very motivational. She always motivates me to keep on pushing to never give up. " (KJ, Junior, Chemistry).

In addition, Abby discussed how it was motivating to have faculty at her HBCU who believed in her success as a Black woman in STEM.

> "I think, at{my institution}, there's definitely a good group of professors that are interested in seeing our success as women of color… My peers from home and from school definitely pushed me to keep going because the peers that I have that are STEM majors, it's helpful to have someone who just understands and it makes you feel less like you're crazy for feeling the way you feel." (Abby, Sophomore, Biology).

From the participants' acknowledgments, it is evident that support in various forms is integral to their ability to maintain their sense of capability and perseverance. It is also evident that HBCUs provide a culture where Black students, including Black women, feel a sense of belonging and support that helps them develop a positive identity and helps them succeed in their STEM education.

Identity Challenges in STEM

The next constructed theme was identity challenges in STEM, and this theme highlighted identity challenges within STEM participation as Black women. The most prominent subthemes were credibility questioned (f = 4) and underrepresentation in STEM (f = 4). Students expressed the various issues they faced being Black women studying STEM, such as gendered racism and imposter syndrome.

> "And a lot of the students when you're a minority student in a stem class, like they're not really reaching out to you like that." (Abby, Sophomore, Biology).

Here, Abby emphasized that as a Black woman, she was not viewed as being capable and knowledgeable of the material, so her abilities and identity as a competent student in STEM were disregarded. Additionally, Paris stated how she encountered gendered racism during her STEM experiences.

> "And that really affected how people spoke to me, I really experienced a different type of racism, where it's like, you're being treated as if you're incompetent. " (Paris, Junior, Chemistry).

The participants' statements demonstrate their awareness of the negative narrative and stereotypes about Black women in STEM broadly. In addition, they spoke about their experiences of prejudice and discrimination, and feelings of doubt about their abilities in STEM educational experiences (e.g., conferences and internships). Also, participants discussed their knowledge about the lack of Black women representation as faculty, staff, and students in STEM and how that had an influence on their perceptions of their ability to persist in STEM.

Learning Barriers

The final theme was learning barriers, and this theme focused on the many learning barriers among Black women during their education in STEM, such as the availability of resources. Along with

resource availability, unfavorable learning was the most significant subtheme, with a frequency of three. Students explained that experiences with faculty's limited availability due to competing faculty demands, posed a challenge to their learning experience in addition to unpreferable learning environments (remote/in-person) or learning styles that are not the most conducive to knowledge acquisition.

> "One of my top concerns is not getting the full experience of everything. Being online, I just do not feel like I'm learning." (KJ, Junior, Chemistry).

As this data was collected during the beginning of the COVID-19 pandemic, KJ spoke about the difficulty of learning amid a pandemic and racial unrest that was plaguing the Black community. In addition, Abby spoke about challenges with getting in contact with professors when the entire college was online.

> "There has been a huge difference in the way professors choose to interact with students – they don't respond to your emails, it's easy to avoid your students online virtually." (Abby, Sophomore, Biology)

The participants discussed these barriers, such as the overall low faculty interaction, which included faculty being unresponsive to online communication during the start of the COVID-19 pandemic. Participants emphasized the many obstacles they encountered which impacted their persistence and motivation in STEM during the pandemic.

Discussion

Due to the lack of research addressing Black women's challenges and support through their persistence in STEM at HBCUs, the current study aimed to explore perceptions of identity and academic achievement in STEM by conducting a focus group with three Black undergraduate women majoring in STEM at an HBCU. Overall, the findings illustrated how Black women in STEM experienced identity challenges in STEM and science identity. Participants in this study also emphasized how past STEM experiences in grades K-12 and STEM experiences throughout college matriculation contributed to developing a positive science identity. In general, the current study illustrates the perceived influence of being bother Black and a woman, on how Black women navigated their experiences in STEM at a HBCU.

In the findings, participants became interested in STEM before attending college, and these interests persisted through internships, jobs, and/or summer research opportunities. Wallace[47] found that participants credited early influences before college for stimulating their interest in STEM. Another common finding regarding their decision to become a STEM major was the amount of exposure students had to STEM coursework at a young age. This exposure came in many forms, including STEM camps, teacher recommendations for classwork, college visits, and meeting other professionals of color in the STEM field. Previous literature has shown that students' early exposure to STEM allows them to be exposed to the environmental and technical style of STEM, which could attract their attention and prevent a lack of retention in this field.[55]

However, participants in the current study also encountered various barriers related to their identity in their persistence in STEM. Some of these barriers included experiences of gendered racism in STEM, low self-efficacy feelings (imposter syndrome), questioning regarding their credibility, and underrepresentation, which was found to be supported by previous literature.[15, 56] These findings align with previous literature in that one's belonging to a particular social group among a larger population with different identities will often experience imposter syndrome or feelings of inadequacy.[55] Participants stated that being one of the few minority students in STEM K-12 classes, they were often singled out or excluded in their science classes by their classmates. This also aligned with our findings in that participants experienced multiple forms of stereotyping, prejudice, and microaggressions related to their credibility. More specifically, participants in our current study expressed how individuals spoke to them, which was in a way that judged their credentials or capability in STEM.

Additional themes that arose during the focus group interview were strategies for participants to manage their persistence in STEM. Black women in the current study mentioned two strategies that positively manage their persistence in STEM, self-motivation, and preparation. As shown in the findings, self-motivation was one of the most prevalent subthemes in the current study (f = 10). Self-motivation contributed to Black women's persistence through college and pursuing graduate school and STEM careers, which was found to be a goal of all participants in the current study. Despite previous research which found that encountering negative barriers of gendered racism negatively influence career aspirations[52], according to Watson[53], there was a connection highlighted between internal and external motivation influencing Black women to enter and succeed in STEM fields. As an example, Strayhorn[56] found that motivation and self-determination were key factors in overcoming barriers formed by Black women's racial and gender identity. Therefore, similarly to our findings, the literature has shown that self-determination and motivation are essential to determining success in STEM for Black women. Preparation was another subtheme that frequently arose during focus group interviews. Participants in the current study attended an HBCU, which was found to positively influence their perceived academic achievement and strong persistence in STEM careers. Thus, one participant in the study emphasized how attending a women's HBCU had a positive influence on STEM motivation among Black women due to strong faculty support. Perna et al.[6] emphasized benefits that women's HBCUs hold, such as embracing various institutional approaches that seek to promote Black women students' academic and psychological readiness to pursue STEM degrees and careers. In addition, such institutions encourage the importance of obtaining supportive and cooperative peer relationships, all of which promote academic achievement.[6]

Relatedly, community of support was found to be a significant protective factor in Black women's attainment and academic achievement in STEM. In pursuing advanced degrees and careers in STEM, previous studies have found that family support, intrinsic motivation, perseverance, and teacher encouragement served as the main factors in STEM persistence for Black women.[17] Consistent with previous literature, in this study, faculty, family, and peer support were reported to be the largest support streams that influence Black women's success in STEM. According to Sanchez and colleagues,[55] Black women in STEM face

many challenges because they are underrepresented and do not have enough support such as access to mentors. These findings align with the findings of the current study because participants expressed the importance of faculty support and mentorship in their confidence in STEM (science identity), and their willingness to persist in STEM. In further support, strong peer mentoring has also been found to be a positive mechanism that strengthens Black women's retention in STEM.[6,56,57] In conclusion, support was found to be a significant protective factor in maintaining Black women's persistence and motivation in STEM.

Finally, STEM learning barriers, such as unfavorable learning, which is a learning style that negatively impacted the participants, was also a major theme that arose during the focus group interviews. Participants in the current study emphasized their dissatisfaction with their learning style and accessibility to their instructors, mainly throughout the COVID-19 pandemic. A study conducted by Wester et al.[58] found that during COVID-19 remote learning, there was found to be a significant decline in attitudes toward science, meaning that students felt like their skills weakened throughout the pandemic, and there was an overall negative shift in engagement. Furthermore, these variables, also considered social stressors, were found to contribute to the decline in an individual's mental and physical health.[59] However, despite these challenges, it was found that Black women persisted in their discipline through community support, which was found to be the primary protective factor in the academic achievement of Black women in STEM60. In conclusion, the COVID-19 pandemic served as an additional barrier to Black women's STEM experiences.

Limitations

Despite the strength of the research design, this study has a few limitations. First, the preliminary study consists of Black women in only two STEM majors at one HBCU. Due to the study being exploratory, there were only three participants, and the findings may not reflect a representative view of other Black undergraduate women majoring in STEM at a women's HBCUs. Secondly, the data collection method being a focus group interview could have impacted how the participants answered the questions presented. Social desirability could be a potential limitation, which is the idea that individuals answer based on socially acceptable answers as opposed to their true feelings. For example, in the focus group interview being in a group with other participants may take away participant speaking time, causing them not to share their honest opinion freely. Furthermore, this could cause bias as sharing in groups can influence their answers. Nonetheless, through the strategic research design, this study provides insights into the relationship between identity and academic achievement in STEM among Black female undergraduate students at HBCUs.

Future Research and Implications

There are a few implications for this study. First, future research should build on and consider the insights of the participants in this study. At the institutional level, researchers and stakeholders should explore how institutions can make sure Black women are confident, embraced, and feel seen while being STEM majors. This can be done by implementing intervention and educational programs such as STEM clubs led by Black or Black women STEM faculty. Such programs would allow Black women STEM majors to feel a sense of comfortability in the STEM field at their school.

Additionally, developing such strategies in assisting Black women with reducing the barriers they face (such as finding their science identity) could positively contribute to Black women's STEM experiences. As an example, the implementation of STEM events on campus that cater to Black women, such as panel discussions. This would allow Black undergraduate women in STEM to network and possibly find a mentor or role model. Atkins et al.[61] emphasized, after conducting a qualitative study, that mentorship in STEM plays a huge part in one forming their science identity as well as viewing themselves as scientists. It is important that institutions have appropriate faculty members who want nothing but the best interest of Black STEM students. This could be accomplished by faculty of color or other allies such as diversity program coordinators that can help Black undergraduate women navigate STEM. Atkins et al.[61] also found that students strongly resonated with mentors with whom they shared demographics or values with. A particular recommendation is that each student be assigned to an engaged STEM advisor that they can connect with early in the degree progress. Regarding Black women's K-12 educational experience, future research should also explore ways to ensure the preparedness of Black women interested in pursuing STEM majors. As such, pre-college prep could be implemented by requiring Black women interested in STEM majors to participate in a summer STEM prep program at their institution in order to promote readiness before starting undergraduate studies. This will allow future STEM pursuers to get a sense of college-level STEM courses and possibly receive credit that will put them ahead in their degree progress.

Lastly, regarding support, it is critical that Black women have the support of others, especially family and friends, as they progress in STEM. Families and friends can better support their STEM scholar by serving as a source of encouragement by making themselves aware of negative stereotypes about Black people and women in STEM. This could help foster a sense of belonging for Black women knowing there is someone rooting for them.

Conclusion

The current study found that Black women matriculating through STEM at an HBCU experience identity challenges such as imposter syndrome and additional learning barriers related to their gendered racial identity, which was found to influence other factors such as their science identity. However, despite these barriers, resilience factors such as a community of support and the HBCU context were found to strengthen this persistence in STEM among Black women. As with previous literature, the current study emphasized the importance of strong peer relationships, family relationships, and faculty-student relationships in the success of Black women in STEM. Based on the results of the current literature, more institutions should adopt policies and characteristics that promote academic and psychological readiness among Black women students to influence persistence and academic achievement in STEM courses and careers.

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Topography-based Tectonic Evidence for Longitudinal Magma Migration Under the Southern Mid-Atlantic Ridge

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Abstract

Mid-ocean ridge systems are essential for the generation of new crust and are important sources of volcanism, but many aspects of the tectonic forces governing their dynamics remain unresolved. In this study of the Mid-Atlantic Ridge system over latitudes between the equator and 30 ° S, mapping of ocean floor topography reveals tensional stresses between ridge and transform segments. Orthogonal fracture sets provide evidence of rotation, faulting, and shearing during ridge evolution. Current models of magma genesis suggest the vertical and lateral movement of melt generated by decompression is associated with asthenospheric upwelling and plate divergence. The conceptual model presented in this research evaluates the potential of magma migrating northward in addition to upwelling, extending the traditional two-dimensional model of a triangular melt generation region to a three-dimensional triangular prism. Variations in lithostatic load may slowly drive longitudinal migration of melts northward toward the equator. Shear forces arising from Coriolis effects may act on northward-flowing magmas resulting in increased stress exerted on existing faults to produce the observed geometry of the southern Mid-Atlantic Ridge system.

Introduction

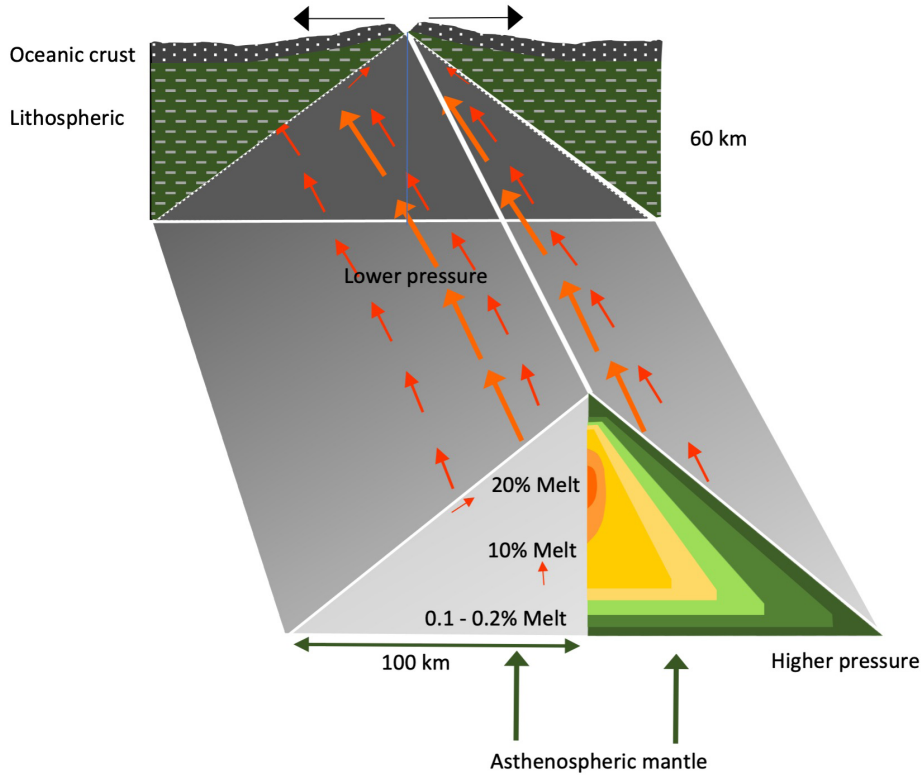
Our understanding of mid-ocean ridge (MOR) systems is coming into clearer focus with increased knowledge of ocean floor topography as well as geophysical insights into subsurface structure and properties. Structural understanding of the fracture and fault orientations represented within the topography of MOR systems may elucidate corresponding stress regimes, providing insight into tectonic forces. After reviewing major MOR systems around the world, we chose to examine interactions between topographical structures and forces affecting magmatic and tectonic movement in the southern Mid-Atlantic Ridge (MAR) system between latitudes 1.5 ° S and 30 ° S. This region was chosen for the relative simplicity of its tectonic setting. The lower-latitude southern MAR where the South American and African plates diverge from each other is flanked on either side by passive continental margins, reducing the effect of lithospheric slab pull on local ridge system dynamics. It is also distanced from triple junctions where plate movement is more complex. This study area covers a broad range of latitudes, accommodating a series of ridge segments that trend slightly west of north. In comparison, the longitudinal differences are small, primarily consisting of offsets arising from transform faulting. Within the defined study area, the goal of this research

is to describe structural patterns in the MAR ocean floor topography that may reveal unidentified stresses. We also explore the possible role of magma movement in generating these tectonic forces.

Magma Generation

Magma movement below the mid-ocean ridges begins with the creation of magma through decompression melting and volatile enrichment. The leading mechanism for magma generation is decompression melting, which occurs as hot mantle rock rises into areas of lower pressure. These low-pressure areas are produced by the divergence of lithostatic plates, allowing high-temperature rock to partially melt under reduced pressure as it rises through the mantle.[2] According to a one-dimensional model of upwelling magma below MOR systems, melting originates in the mantle near a depth of 60 km.[1] Based on this estimate, we performed analyses of magma migration at 50 km below sea level, within the melt triangle supported by theory.[2,3,4] Although slab pull from subduction zones at the opposite end of the plate is considered to be the primary driving force for plate movement,[5,6,7] magma generation may also contribute to a positive feedback system of ridge push characterized by diverging tectonic movement. The newly deposited lava at the ridge axis has a lower density than the neighboring crust, providing an area of decompression below the ridge. As the ridge is pushed up and away from the center of the earth due to its relative buoyancy, gravitational forces pull the areas adjacent to the ridge axis down and further apart. This allows for continued decompression and the upwelling of magma plumes into a triangular region under the MOR system,[8] as shown in Figure 1, where the triangle is extended as a prism under a ridge segment. The second mechanism for magma generation is induced by volatiles such as water and CO2 that produce localized melting deeper within the mantle. Specifically, an increase in water through the hydrothermal alteration of primarily anhydrous silicates results in an increased melt volume resembling the effect of increased temperature.[8,10,11] This melting allows smaller amounts of magma to form below the typical solidus depth and rise into the larger magma regime, influencing asthenospheric mantle convection.[2]

Figure 1: A magmatic prism below a mid-ocean ridge segment. A magmatic prism is produced by decompression melting under divergent segments of a MOR system. The lower limit of the magmatic prism represents the solidus bound by pressure and theupper limit represents the solidus bound by temperature.[9] Melt focuses in the central region of the prism moving vertically through buoyancy and laterally as a result of pressure.[3] Lateral movement from higher pressure toward lower pressure is depicted.



Magma Migration

After magma is formed, it tends to migrate upward as a result of buoyancy. Since hot magma is less dense and more buoyant than the residual solid, it will rise into mid-oceanic ridge systems as a component of upper mantle convection.[12] Models such as the Enthalpy Method, which uses conservation of bulk enthalpy to predict melting dynamics in thermodynamic equilibrium, suggest that the rise of magma is accompanied by a decrease in temperature and an increase in melting, porosity, and fluid velocity, such that melt fraction increases from 0% at a depth of 60 km to 20% near the surface.[2,13] These changes decrease magmatic density and drive further vertical movement due to buoyancy. Thus, magma generation below the MOR systems contributes to a net vertical movement towards the crust.

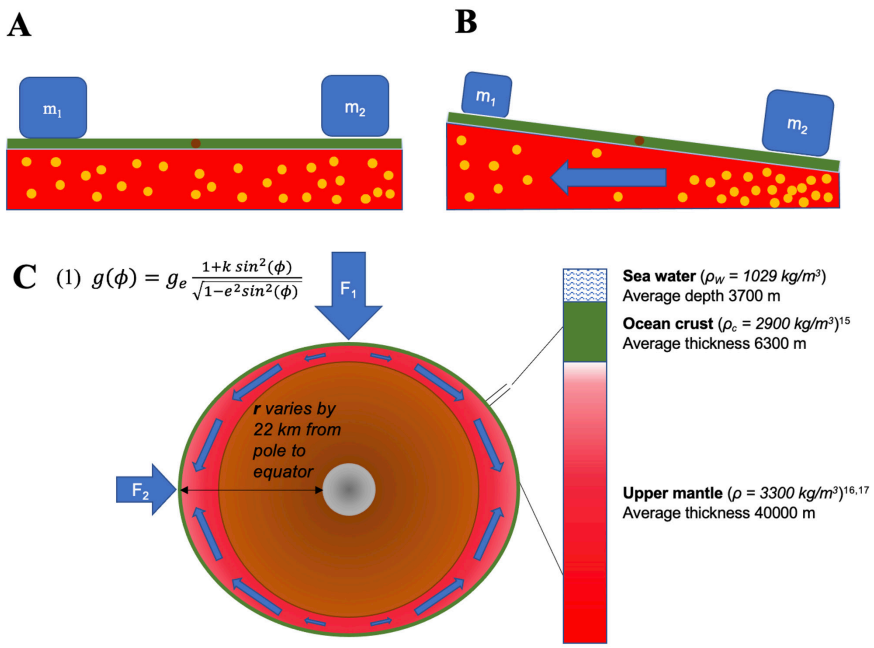
The observed crustal thickness of MOR systems indicates that magma must not only move upward from beneath the ridge axis but also laterally inward. Crustal thickness at MOR systems with spreading rates greater than 15 mm/a is approximately 6-7 km.[3,4] If magma was only generated below the ridge systems, the crustal thickness would be thinner as there is not enough melt to generate a crust with the indicated thickness. Therefore, there must also be a horizontal component to magma migration.[13] The combination of vertical and horizontal magma movement creates a triangular melt regime below the ridge (Figure 1). Magma being produced over 50 km away on either side of the ridge requires a high degree of focusing toward the axis, which is provided by lateral pressure gradients.[2,3,14] The magma directly below the ridge axis rises vertically, not interfering with the lithospheric plates. However, the melt that rises beneath the flanks of the melt triangle may encounter the cooler lithosphere. Since the solid lithosphere is an impermeable layer, pooling of magma may occur at the contact between the asthenosphere and lithosphere, forming a highly porous zone about 100 meters thick by increasing the

melt fraction at the top of the asthenosphere.[13] As magma continues to accumulate beneath the solidus, the permeability of the high-porosity layer increases, allowing buoyancy to drive magma along the solidus boundary. The solidus boundary slopes away from the axis due to increasing lithospheric thickness away from the ridge.[13] Buoyancy focuses magma migration toward the region of thinner crust, and, thus, toward the ridge axis.[3] In summary, decompression melting is thought to be the primary magma-producing component under MOR systems. After magma is generated, buoyancy drives its vertical movement upward while the slope of the rigid asthenosphere-lithosphere boundary focuses magma horizontally within the triangular melt region.

Expanding upon the traditional 2D model where magma flows directly upward or latitudinally in the MAR systems, we propose that longitudinal pressure gradients may also induce an axial component to magma flow. Thus, upwelling occurs in a 3D triangular prism both upward and, to a lesser extent, along the ridge axis either toward or away from the equator (Figure 2C). We proposed this model since Coriolis forces resulting from axial flow along the MAR system may account for the asymmetry noted in our topography of right- and left-lateral transform faults. For comparison, Coriolis forces on a hurricane with a radius of 250 km and an internal pressure gradient of 0.4 millibars/km produce extremely high wind speeds associated with the pressure gradient force. It should be noted that the viscosity of magma is roughly 105 times that of air and the relevant pressure gradients are 15-fold lower in the asthenosphere, so the fluid velocity induced by Coriolis forces in the asthenosphere will be much lower than hurricane wind speeds.

A reasonable question to ask is whether or not the magma has a low enough viscosity to migrate due to Coriolis forces. Since viscosity is related to temperature and composition, magma movement is more likely in areas with warmer conditions. As the magma rises to shallower depths and cools, the viscosity increases, inhibiting lateral movement. The lateral flow of magma would also be dependent on the permeability and porosity generated by melting within the source rock, as well as the viscosity of magma produced. However, given the long time scales of tectonic migration, the effect of slow but persistent magma movement

Figure 2: Load calculation and pressure gradient. Lithostatic load variations may induce pressure gradients and magma flow in the upper mantle. A demonstrates the assumption of load equilibrium in the crust and mantle whereas B illustrates a more realistic picture of local load variations leading to magma flow in the underlying mantle from regions of high pressure to low pressure. C depicts a possible global variation in lithostatic load due to fluctuations in the gravitational field at the Earth's surface that arise from the ellipticity of the Earth. Shown also are the three layers – water column, mafic ocean crust, and upper mantle – whose weights were incorporated into the calculation of the total load at a depth of 50 km. Loads were calculated with the densities and average thicknesses indicated. Acceleration due to gravity values were determined from latitude based on the empirical equation shown in C sourced from the 1985 NIMA report.[18] The resulting global pressure gradient shows the potential for fluid flow from higher pressure at higher latitudes to lower pressure at lower latitudes given the same average column of weight-bearing material.



due to the Coriolis force could be visible in the orientation of fault segments.

Another question our study addresses regards the source of the pressure gradient leading to axial magma migration. One of our hypotheses was that variation in the gravitational field strength due to the equatorial bulge might create a pressure gradient from the poles toward the equator. As Earth spins on its axis, it bulges an additional 22 km at the equator and flattens near the poles, influencing the gravitational values in a predictable manner. The force of gravity experienced at sea level increases with increasing latitude. We explored the possible effect of the global variation in gravitational field strength, as well as more local variations in pressure, by calculating lithostatic load variations at 50 km below sea level. The National Imagery and Mapping Agency published the relationship between latitude (ϕ) and acceleration due to gravity as an equation as part of the World Geodetic System 1984 (equation 1 in Figure 2C).[18] This relationship calculates the acceleration of gravity at 0° latitude as 9.78032 m/s^2 (g_e) and 9.7932 m/s^2 at 30° S. The constant used for the ellipsoid shape of the earth (k) is (1.913185x10^{-3}) and e is the first eccentricity of the ellipsoid (6.69438x10^{-3}).[18] With the acceleration due to gravity determined at each point of interest ($g(\phi)$), the lithostatic load can be calculated as shown in Figure 2C.

(2) $P_{50} = g(\phi)(\rho_w d_w + \rho_c(d_c - d_w) + \rho_m(d_m - d_c))$

Lithostatic load is the pressure occurring at depth in response to the overlying load. It can be expressed as an equation (2) where the density (ρ in kg/m^3) is used along with the change in depth (d in m) for three different layers. The sum of these layers represents the lithostatic load as the pressure

exerted on the material at 50km depth. In a MOR setting, the layers to evaluate include the water column of the ocean, oceanic crust, and mantle material. Figure 2 illustrates the column with layers as well as the values used to determine the confining pressure associated with the lithostatic load to a depth of 50 km. It should be noted that vertical gravitational variation was not accounted for in this simplified model. If melt is present at this depth, the lithostatic load on that melt will produce a higher pressure where the acceleration due to gravity is higher.

Methods

Gridded bathymetry information was obtained from the General Bathymetric Chart of the Oceans (GEBCO) website in January 2021. The downloaded fields represent an information product based on interpolation through the application of mathematical algorithms using bathymetric data (15 arc-sec resolution). The GEBCO grid is in the public domain, and resulting fields can be placed into ArcGIS software for mapping. Boundary coordinates were entered at the following website https://download.gebco.net/, where ESRI-ASCII files were downloaded to cover the Mid-Atlantic Ridge between the equator and 30 degrees south latitude. (Note: The TID Grid data can be used to distinguish bathymetry data sources. Information about the GEBCO TID Grid can be found at: https://www.gebco.net/about_us/contributing_data/tid_grid.html). ESRI-ASCII files were converted to raster files using spatial analyst tools in ArcGIS to produce a layer representing the ocean-floor topography.

Once the layer was established, a sequential visible spectrum color ramp from white to red was employed to indicate the bathymetry depth. With a color ramp in place, the Hillshade raster tool was used to generate an additional raster file and displayed with 50% transparency above the GEBCO data raster to develop terrain visualization for the data. Maps of the study area were generated from 1.5 ° S to 30 ° S and between 8 ° W and 18 ° W with a UTM projection to preserve the geometry of the area mapped. Since the data information spans the boundary of UTM zones 28 and 29 South, a custom UTM zone was made with a central meridian of 13 ° W, which was centered on the data set. All other parameters of the custom UTM projection remained the same as the standard UTM southern zones. For an accurate representation of the data from the bathymetry rasters, all rasters must be set to use the projection and coordinate system for the area of interest. In this case, rasters were set to the custom UTM projection. Figure 3 shows the mapped topography of the ocean floor in the study area with connected ridge and transform segments identified.

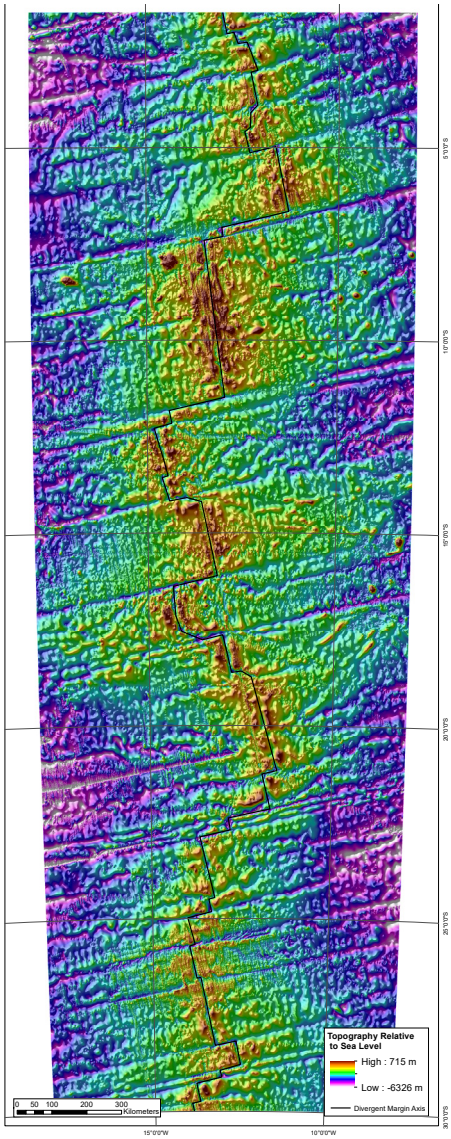
With the study area represented in a raster map form, the ridge axis and axial valley were identified and delineated. Hillshading and color ramping provided most of the visualization to identify these divergent boundaries. In areas where the ridge system is well-defined with tall ridges to the east and west of a lower rift valley, the ridge line is drawn between the ridges in the center of the lowest part of the valley. When the ridge line reaches a transform fault, the line is drawn along the transform fault until an orthogonal line can then continue along the rift valley. In areas where the rift valley is less defined, but an axis of divergence is apparent due to a partial rift valley north and south of a high region in the ridge topography, the line is drawn to connect directly between the apparent lower areas of the rift valley. An example of this is seen in the divergent margin south of the Ascension Fracture Zone.

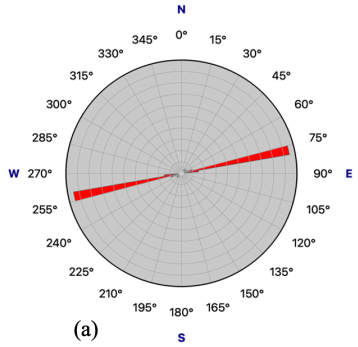
Forty topographic cross-sections were also used to verify the placement of major faults that define the divergent boundary. In other areas of the divergent margin, occasionally, the lowest part of the rift valley appeared to not conform to a strict path with orthogonal changes in direction and rather appeared to have a diagonal direction containing many transform faults between transform faulting boundaries and the typical orientation of the divergent margin. In these areas, the line was drawn to best conform to the lowest area of the rift valley and may take on an occasional diagonal path that is not orthogonal to the normal faulting direction and not oriented with the typical transform faulting direction. A more detailed analysis, using a higher resolution bathymetry data set than is currently publicly available, could result in subdividing these diagonally drawn sections into a set of multiple transform faulting regions.

Results

Connected ridge and transform segments delineate the divergent plate boundary in the study area as a result of topographic analysis and provide the basis for structural analysis associated with tectonic forces. A total of 26 ridge segments, 26 transform segments, and three oblique connecting fault lines were identified in this study. Identified transform segments found in the study area are plotted in Figure 4. The predominant direction of the major

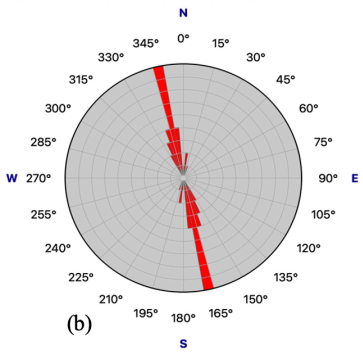
Figure 3: Southern Mid-Atlantic Ridge topography. Map of ocean floor topography based on GEBCO products focused on the Mid-Atlantic Ridge system extending from the equator to 30° S. Color raster exhibits red for shallow elevations associated with the ridge system and magenta to white for very deep locations along with hillshading. Structural lineations of ridge and transform segments are outlined in black to highlight the continuum of the divergent plate margin.





Azimuth	Number of Transforms
40-45	1
50-55	1
70-75	2
75-80	19
80-85	3

Table 1



Azimuth	Number of Ridges
150-155	2
155-160	3
160-165	4
165-170	9
170-175	4
175-180	0
180-185	1
185-190	2
190-195	0
195-200	1

Table 2

Figure 4: Structural azimuths of the southern MAR system. In reference to the Mid-Atlantic Ridge (1.5-30°), (a) plots the azimuths of 26 of the transforms indicated in Table 1, (b) plots the azimuths of the 26 ridges indicated in Table 2.

southern transform faulting is between 75° and 80° (73% of the azimuths). Additional analysis indicates that 69% of the transform faults exhibit a right-lateral, strike-slip movement. Furthermore, of the 19 transforms that extend beyond the ridge zone longitudinally, 16 show right-lateral movement, and 18 have azimuths between 75° and 80°. Analysis of the ridge segments shows an orthogonal relationship to the transform faults with azimuths between 165° and 170°.

Comparable depths at different latitudes exert differential lithostatic loads producing a pressure gradient toward decreasing latitudes for an equivalent depth. The pressure gradient calculated by Equation 2 showed a change in lithostatic load of 2.1 MPa over a distance of 30° latitude, 6.36 millibars per kilometer. A simplified model of magma movement in MOR systems suggests that the difference in gravity may induce an overall flow from higher pressures at higher latitudes to lower pressures in equatorial regions. However, to understand the significance of these calculated variables, a linear flow velocity was calculated using constants specified in earlier studies.

$$(3)\quad u = -\frac{k_0}{\mu L}\Delta p$$

The predicted linear flow velocity of the magma moving northward is calculated using a rearrangement of Darcy's law and the standard equation for flow velocity (equation 3). This calculation assumes a controlled environment where only a few variables are considered. In this calculation, u is the flow velocity in m/s, μ is the dynamic viscosity (Pa-s), ϕ is the porosity (ϕ=0.02)[3], L is the length of the ridge (3.33 x 10^6 m for MAR 1.5-30° South), Δp is the pressure difference between the two depths, and k_0 is the permeability 10^{-9} m^2.[3,13] The calculated velocity of magma is 2.5x10^{-3} cm/yr, which is three orders of magnitude smaller than MOR systems' spreading rates.

$$(4)\quad f = 2\Omega \sin sin(\phi)$$

$$(5)\quad Ro = \frac{U}{Lf}$$

$$(6)\quad \frac{\Delta P}{L} = \frac{u\mu}{k_0\phi^2}$$

Using the Rossby number (Equation 5) to compare the importance of length vs. the calculated velocity of the magma flow through the system, and Darcy's law (Equation 6) to compute the fluid velocity induced in a viscous liquid by pressure gradients, we find that the pressure differential required to create magma movement in the decompression melting zone comparable to upwelling is on the order of 10 MPa/km. The calculated velocity of magma due to variation in the gravitational field strength at different latitudes is 2.5x10^{-3} cm/yr, which is three orders of magnitude smaller than MOR systems' spreading rates, but may contribute long-term over many millennia if it is not canceled out by other forces and is constant long term. While this exceeds the pressure gradients attributable to global variation in the gravitational field strength on the Earth's surface, it does not rule out local variations in lithostatic load which may lead to pressure gradients of the required strength to induce axial magma migration subject to Coriolis forces.

Interpretation and Conclusions

Model of Structural Deformation

Structural data collected from the GEBCO information supports the tensional stresses expected for a divergent margin with orthogonal fracture sets. Normal faults and tension fractures are the most common structural elements of MOR systems.[19] With an upwelling asthenosphere, the oceanic crust would experience tensional stress producing fracture sets at 90 degrees to one another. The starting orientation of the fracture set would be related to the stress field experienced nearly 80 Ma ago during the westward migration of the ridge system.[20] This would produce a stress field with σ_1 related to upwelling, σ_3 associated with the westward drift providing the tension, and σ_2 neutral, which would result in N-S and E-W conjugate sets of fractures.[21] Our conceptual model, shown in Figure 5, is initiated with a set of orthogonal fractures oriented with ridge segments striking N-S.

Although this study uses GIS to identify a path for these major faults, the path typically represents a set of parallel fractures visible in areas where the bathymetry is higher resolution. These fracture sets have been recognized in basalt flows exposed in Iceland with fault swarm areas of 5-10 km width and 40-80 km length[19] and are similar in size when considered within much of the

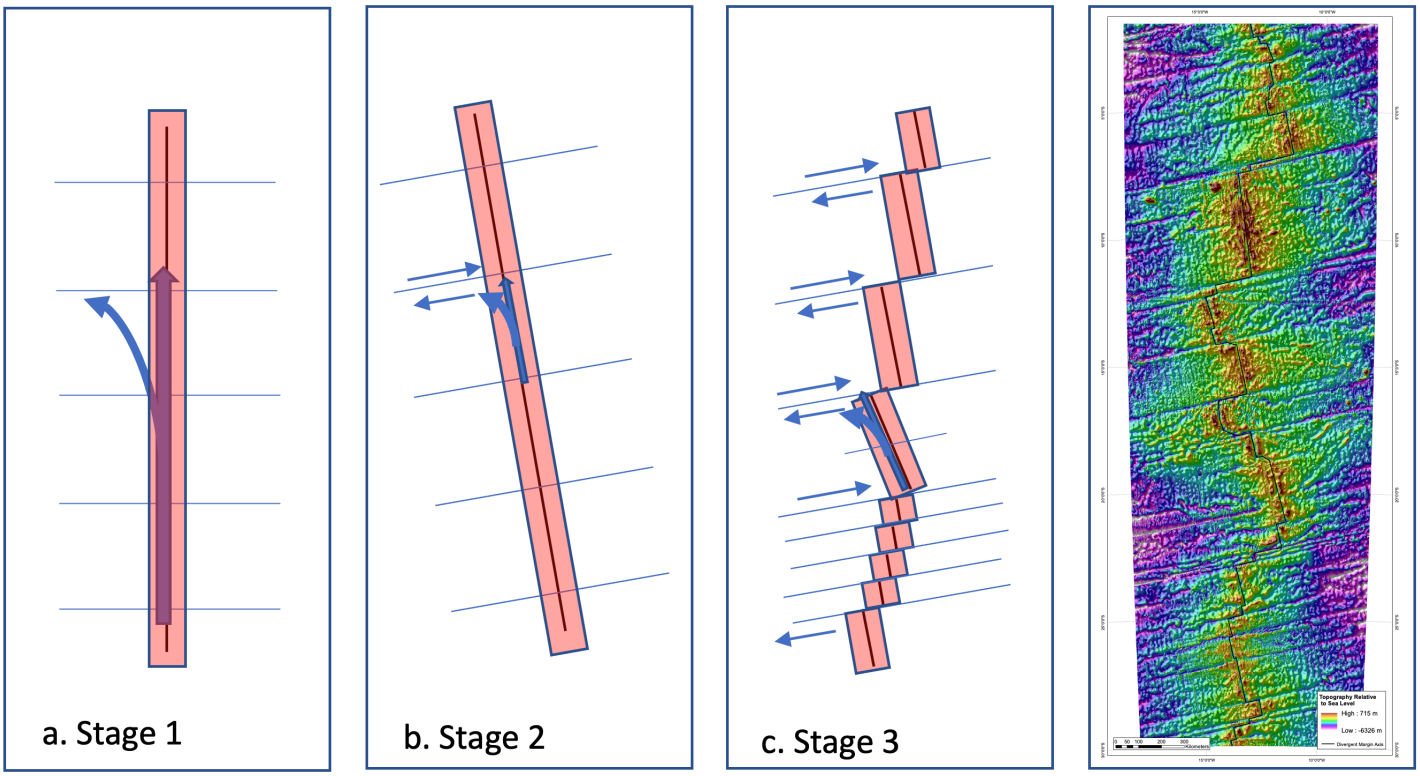


Figure 5: Conceptual model of tectonic development in the southern MAR system. Conceptual model of tectonic forces leading to the current orientation of the Southern Mid-Atlantic Ridge from 30°S latitude toward the equator. Stage 1 illustrates an idealized N-S trending ridge with tensional stresses producing divergence and orthogonal fracture sets. The larger vector shows a pressure gradient force toward lower latitudes associated with lithostatic load based on gravitational differences, while the smaller vector shows the Coriolis term of force. Stage 1 to Stage 2 illustrates a slight counterclockwise rotation of the system including major fracture sets. During Stage 2, shear stresses from the Coriolis force produce transform movement as shown by smaller right-lateral arrows, off-setting the ridge segments to develop Stage 3 as a segmented ridge. Ridge segments could also experience counterclockwise rotation resulting in some left-lateral, smaller-scale stress accommodation.

MAR within the study area. It is likely that the fracture sets start with a vertical opening but then develop into normal faults parallel to the ridge axis. Examples of this can be seen in Iceland, where nucleation of normal faults occurs on inclined fractures shifting to dip-slip movement at a depth of 0.5 km.[19] Brittle deformation associated with the ridge segments would be accommodated by normal faulting facilitating decompression, upwelling asthenosphere, and magma generation within the prism shown in Figure 1.

Though there may or may not be additional melt at depth, this study focuses on the decompression melt prism directly under the ridge system. As with the regional flow of air or water, these materials are subject to the Coriolis parameter of force induced by shearing associated with Earth rotation. This shearing causes a deflection to the left in the southern hemisphere, as shown by the smaller arrow in Stage 1 of Figure 5. At these transform faults, the Coriolis force could lead to the counterclockwise rotation we see evident in the southern hemisphere along the MAR system.[22] If the initial fracture orientation was N-S, rotation due to the Coriolis parameter of force is modeled to be approximately 10 degrees in a counterclockwise direction. Should the entire area rotate equally, the ridge will remain linear.

During Stage 2 of the conceptual model, the rotated transform faults are exposed to a greater shearing and begin to offset the ridge segments. If magma continues to travel to the north along the pressure gradient, it gets deflected to the left and shears the juncture between the ridge and transform, pulling the southern ridge segment to the west and resulting in an overall right-lateral transform fault movement. Data collected in this study shows that 69% of the transform segments exhibit this relative movement offsetting ridge segments with right-lateral transform faulting, meaning that the remaining transforms have left-lateral movement. In these cases, the left lateral movement could be related to brittle deformation above the magma prism as it rotates in a counterclockwise direction. As a result, we can conclude that between 1.5° and 30° south, ridge orientations and relationships are primarily controlled by the shearing at the ridge to transform junctures.

Magma migration interpretation

Considering the combined net movement of magma migration, further analysis of crustal thickness, faulting, and gravitational variance indicates that the Coriolis parameter (f in equation 4) may play a role in MOR system formation and evolution in conjunction with the aged rotation rate of the earth ($\Omega = 7.29 \times 10^{-5}$ Rad/s). The Coriolis effect is indicated by the Rossby number (Ro in equation 5), which is the ratio between the force of inertia and the Coriolis parameter induced over a specified distance.[23] The dynamic fluid mechanics of magma movement within the Earth's asthenosphere as expressed by the Coriolis parameter causes large-scale circulation of matter (e.g. air and water) to rotate clockwise in the northern hemisphere and counter-

clockwise in the southern hemisphere. If the prismatic magma source regions are affected by the Coriolis parameter, then a westward migration would be present at the equator as the clockwise and counterclockwise rotations come together. Recent research regarding subduction zones indicates a westward drift along the margins supporting large-scale motion that could be connected to the Coriolis parameter of force.[22,23,24] Geochemical assessment of magma movement in a MOR system supports this idea.[25] Additionally, a study surveying nine transverses over MOR systems reveals that heat flow asymmetry favors the westward side in the southern hemisphere.[26] This lateral movement would be governed by pressure differential, causing magma to migrate from higher latitudes to lower latitudes. Magma also has the potential to pool at depth, producing additional magmatic movement such as the northerly flow of magma under the ridge system between 7°30'S to 11°30'S of the Ascension Fracture Zone and the Bode Verde Fracture Zone indicated by isotopic studies.[27] Magma pooling and subsequent migration could introduce additional stresses and magma movements that may be affected by the Coriolis force.[20,28,29] Given that magmatic mass under the MAR may move toward the equator through a variety of mechanisms, stress can build along existing fault planes where ridge segments meet transform faults.

Conclusions

Topological analysis of faulting along the Mid-Atlantic Ridge provides evidence for rotation and westward drift, suggesting the influence of forces and flows that generate shear stress as important contributors to tectonic plate movement. The model presented suggests an additional latitudinal component of magma migration along mid-oceanic ridge systems. Based on the calculated gravitational forces and seafloor depths along the Mid-Atlantic Ridge system 0-30° south and the predicted pressure loads at a 50 km depth, a 2.1 MPa differential along the ridge system is estimated. If the viscosity of the melt fraction is low enough and magma can flow, the expected flow direction under the ridge would be toward lower latitudes. With flow, the magma migration would be subjected to shearing, possibly associated with the Coriolis parameter of force or westward drift, to induce stress on existing faults. This stress would manifest as right-lateral, strike-slip movement on existing transform faults, producing a model with similar geometry to the Southern Mid-Atlantic Ridge. Further research regarding magma movement and mega-scale tectonic faulting is required to understand the relationship more clearly between magma movement and mid-oceanic ridge development. Additional studies analyzing the relationship between fluid dynamics, rock porosity, and permeability, or comparing faulting stress dynamics along tectonic boundaries would provide more insight into the dynamics of these ridge systems.

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Unmasking the mystery of horror in the Scooby-Verse: how narrative and musical techniques in *Scooby Doo! Camp Scare* deviate from traditional structures

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Cartoons and animation have been a staple of entertainment for decades. Hanna-Barbera is one of many companies that pioneered the world of animated entertainment through memorable characters like Yogi Bear, Johnny Quest, Josie and the Pussycats, Tom & Jerry, and Fred Flintstone. Since their initial appearance in the late 1950s, Hanna-Barbera cartoons quickly gained popularity and are considered by many to be classics within the world of animated entertainment. In 1969, Scooby-Doo, one of Hanna-Barbera's most recognizable characters, made his debut in *Scooby Doo, Where Are You?* (1969), a television series that follows four teenage sleuths and their lovable talking dog, Scooby-Doo, as they solve mysteries and unmask "vile villains, ghastly ghouls, goony ghosts, spooky specters, and creepy creatures."[1] Fred, Daphne, Velma, Shaggy, and Scooby-Doo are the famous mystery solvers, commonly referred to as "the gang." With a charming cast of characters, spooky monsters, and a world of endless mysteries, Scooby-Doo has continued to captivate generations of fans since its debut.

With nearly six decades of Scooby-Doo content, Hanna-Barbera has remained relevant throughout multiple generations by adapting each installment to meet the interests of its audiences, while maintaining its original fan base. The impact of Scooby-Doo can be seen in different kinds of media, as multiple creators have utilized the famous cast of characters as inspiration to create their own stories about young mystery-solvers and animal sidekicks. Over time, Scooby-Doo stories have evolved and matured by showcasing changing technology and exploring various genres, exhibiting a reflection of current times and interests. Despite the hundreds of episodes and various films, there has been little research conducted on the narrative and musical techniques used by the franchise. Investigating the techniques used in each Scooby-Doo installment provides an opportunity to identify some elements of its long-lasting success and the creative changes that unite generations of viewers.

Scooby-Doo! Camp Scare (2010), commonly referred to as *Camp Scare*, debuted four decades after the first Scooby-Doo episode and combined multiple genres, including children's films, comedy, and horror, leading audiences to call it one of the scariest Scooby-Doo films.[2] Throughout this piece, the narrative and musical techniques used within *Scooby-Doo! Camp Scare* will be explored and analyzed to showcase how the filmmakers deviate from the traditional Scooby-Doo structure established in *Scooby-Doo, Where Are You* to emphasize the horror genre of the film.

The traditional narrative and musical structures of Scooby-Doo

Scooby-Doo, Where Are You? established a specific set of characteristics and a structure that has provided a basis for future installments of the Scooby-Doo franchise. Each Scooby-Doo episode or film can be classified as a children's ghost story. Sylvia Ann Grider, a researcher of folklore and ghost stories, explains that ghost stories for younger audiences are characteristically "highly formulaic," allowing them to be "frightening, but not too frightening."[3] This is exemplified through the family-friendly—but spooky—nature of most Scooby-Doo stories. The traditional Scooby-Doo narrative structure follows the three-act structure, originally popularized as a concept by Syd Field in his book *Screenplay: The Foundations of Screenwriting*.[4] Field's three-act structure consists of three parts: Act One, the Set-Up; Act Two, the Confrontation; Act Three, the Resolution. Act One is the portion of the film that establishes the story, characters,

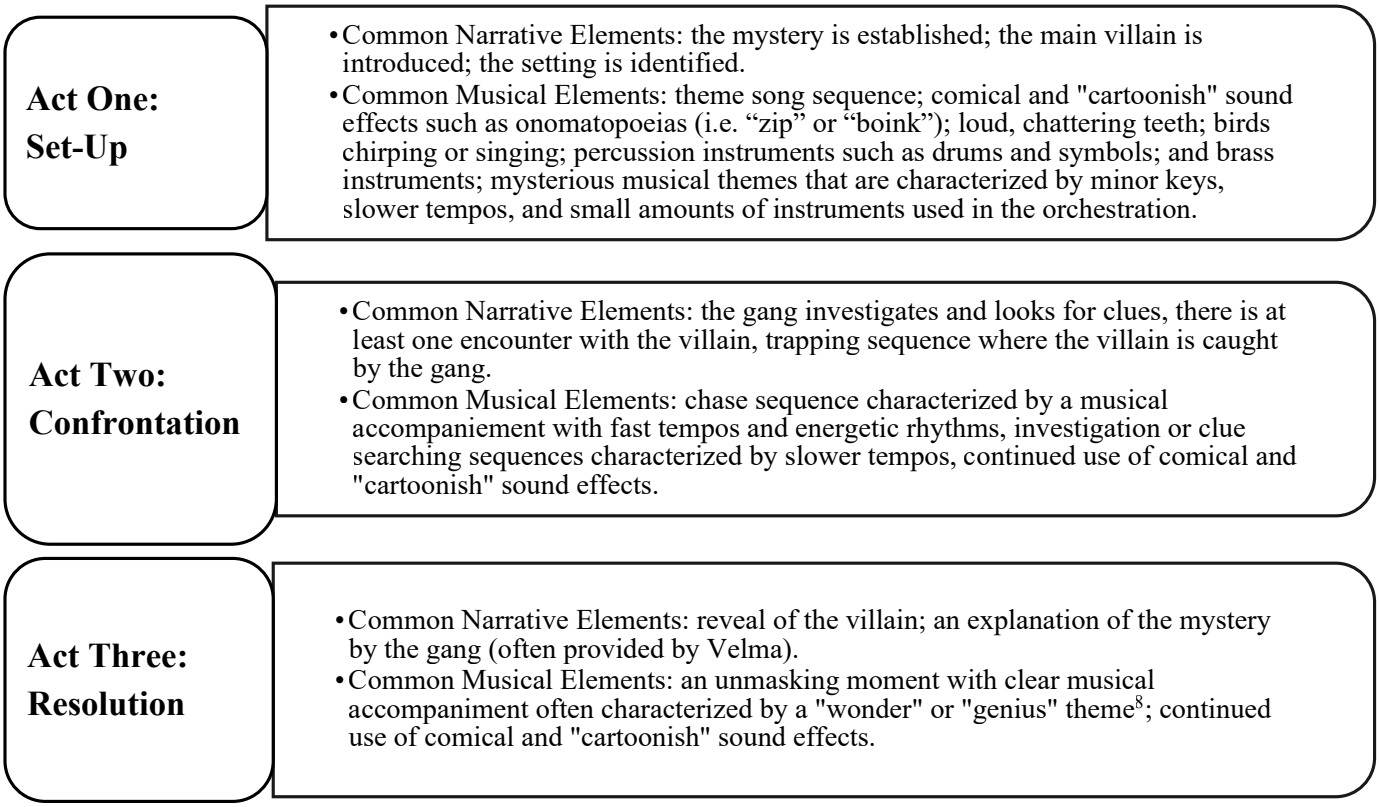

Figure 1: Scooby-Doo narrative and musical structures in each Act. Description of the narrative and musical structures found in each act of the traditional Scooby-Doo structure, which was established in Scooby-Doo, Where Are You? *(1969). Created by Melanie Matthews.*

and premise of the plot.[5] After the first act, the film continues to follow the characters as they are tasked with obstacles that inhibit their ability to achieve their goal, which is described as Act Two.[6] Act Three is defined by the actions and moments in the film that resolve the story.[7] This three-act structure is commonly used as a basis for screenplays, films, and television shows, including the stories within the Scooby-Verse, the cinematic and narrative universe of Scooby-Doo, as it is a simple and easily modified structure.

While the traditional Scooby-Doo structure follows Field’s three-act model, the sections change in length to be applicable to both feature films and TV episodes, as well as to appeal to different audiences. As described in Figure 1, Act One, the Set-Up of the Scooby-Doo structure, can be characterized through an introduction of the narrative, an establishment of the mystery, and a clearly identified setting. Act Two, the Confrontation, takes up the majority of time in the Scooby-Doo structure, as it consists of the gang investigating the mystery, searching for clues, encountering the villain, and creating an elaborate trap in which the villain is caught. Act Three, the Resolution, includes the unmasking of the villain and an explanation of the mystery. The unmasking scene is an iconic element of the series, accompanied by the villain’s lament that they “would have gotten away with it too if it weren’t for [those] meddling kids.” Utilizing the traditional structure creates stories that are easy for younger audiences to follow; however, to better appeal to maturing audiences, some Scooby-Doo installments alter the structure, creating more complicated plots to keep viewers engaged.

The narrative aspects of the Scooby-Doo structure are accompanied by many musical gestures that enhance the film. Jessica Green, a film music and English rhetoric researcher at Brigham Young University, explains that film music can “create the narrative and control the way that the audience interprets a film.”[9] The most common musical elements in Scooby-Doo narratives, as described in Figure 1, include percussion and brass instruments to accompany different moments and actions of characters. Often, there are energetic musical accompaniments with fast tempos heard during chase sequences and recurring musical themes that emphasize the conclusions made in the unmasking sequence. A mixture of non-diegetic (sources external to the film world) sounds and musical scoring with traditional Scooby-Doo sound effects create the musical gestures heard in the Scooby-Doo structure. Patrick Sullivan, a research fellow at the University of Rochester, explains that recognizable and comical sound effects in visual media often “sonically underscore” the action in a film or television episode.[10] In Scooby-Doo narratives, these sound effects establish a connection across the various episodes and films for maturing viewers who have followed decades of Scooby-Doo stories and aid in establishing the setting and tone of the film for younger audiences. The sound effects of traditional Scooby-Doo stories fall within a “cascade of zips, zaps, and whizzes” and comically exaggerated sounds such as creaky doors and crashes, which have been present in Scooby-Doo and Hanna-Barbera stories for over 50 years.[11] The Scooby-Doo franchise, as with many other cartoons, often uses a library of sound effects and music to help create a sense of familiarity for the audience. Similar to the narrative structure, each installment of the Scooby-Doo franchise uses these sonic and musical characteristics to establish a consistent story world that can be

altered to best fit the needs of each specific narrative.

Deviating from the traditional structure in *Scooby-Doo! Camp Scare*

As with any franchise, the world of Scooby-Doo has taken various approaches to differentiate each installment and maintain its relevance with audiences, often altering elements of the traditional structure such as the setting, ages of the Scooby-Doo characters, genres, types of villains, and the style of animation. For example, *A Pup Named Scooby-Doo* (1988) explores the lives of elementary-aged Fred, Daphne, Velma, Shaggy, and Scooby as they solve mysteries; *Scooby-Doo Adventures: The Mystery Map* (2013) utilizes puppetry rather than animation; and *Be Cool, Scooby-Doo!* (2015) uses an animation style that is drastically different from *Scooby-Doo, Where Are You?* (1969). There are also multiple installments that allude to the possibility of monsters being real, such as *Scooby-Doo on Zombie Island* (1998), *Scooby-Doo! and the Witch's Ghost* (1999), *Scooby-Doo! and the Goblin King* (2008), and in the episode titled "Scoobynatural" from the television show *Supernatural* (Season 13, Ep. 16, 2018) where the monster cannot be truly 'unmasked' as the monster is supernatural, which is a major deviation from the traditional structure that aims to create logical explanations to mysteries.[12]

Scooby-Doo! Camp Scare (2010) is an example of a film that deviates from the traditional narrative and musical structure of Scooby-Doo by showcasing musical and narrative characteristics taken from contrasting genres, like horror and comedy. *Scooby-Doo! Camp Scare* takes place in Camp Town, USA, which is home to two rival summer camps: Camp Big Moose and Camp Little Moose. Camp Big Moose is a modern summer camp with amenities such as a computer lab, scuba gear, and speed-

Figure 2: Camp Little Moose. Scooby-Doo and the gang enter Camp Little Moose in the Mystery Machine in Scooby-Doo! Camp Scare *(2010). Screen grab from DVD (00:09:32).*[13]

Figure 3: Narrative and msuical structures in Scooby-Doo! Camp Scare. *Description of the narrative and musical structures found in each act of* Scooby-Doo! Camp Scare *(2010). Created by Melanie Matthews.*

Act One: Set-Up	• Narrative Elements: the mystery is established with only one villain (The Woodsman) introduced; the setting is identified; presence of mutliple scary moments including a one-on-one encounter between a Camp Little Moose staff and The Woodsman and destruction of a boathouse. • Musical Elements: theme song sequence; horror sound effects including slamming doors with no apparent source, owl hoots, dark forests, and snapping twigs; first use of villain leitmotif accompanying the actions of The Woodsman; use of tempest and demonic musical topics to amplify the horror elements of scenes between the main characters and the villains.[14]
Act Two: Confrontation	• Narrative Elements: the gang investigates and looks for clues; there are two additional villains introduced (the Fishman and the Specter of Shadow Canyon); there are multiple encounters with the villains where the safety and wellbeing of the characters is put at risk; the first culprit reveals himself while all three villainous characters (The Woodsman, the Fishman, and the Specter of Shadow Canyon) remain unmasked; an additional minor mystery is introduced (a hidden treasure, the motivation for the villains' actions); the gang traps the Fishman, with the whereabouts of the other villains unknown. • Musical Elements: chase sequences accompanied by the tempest musical style[15]; investigation or clue searching; continued use of horror sound effects and semiotic signs; villain leitmotif is used frequently to signify presence or actions of all three villainous characters (The Woodsman, the Fishman, the Specter of Shadow Canyon).
Act Three: Resolution	• Narrative Elements: Unmasking of one villain (the Fishman), revealing The Woodsman, who is then unmasked again to reveal the actual 'man behind the rubber mask'; resolution of primary mystery through an explanation of the mystery by the gang (often provided by Velma); resolution of the additional mystery as the treasure is found. • Musical Elements: an unmasking moment with clear musical accompaniment often characterized by a "wonder" or "genius" theme utilizing woodwinds, repeated melodies, slow tempos, and dynamic swells.[16]

Figure 4: Reference to Friday the 13th. Scooby-Doo and Velma walking through Camp Little Moose. The interior wall of a cabin has a calendar with the number "13" in red marker—a visual reference to Friday the 13th (1980), which was a source of inspiration for the film. Screen grab from DVD (00:10:35).[17]

boats. Camp Little Moose, as seen in Figure 2, is a run-down, wooden summer camp with little to offer other than perhaps its classic nostalgia for viewers who attended similar summer camps in their childhood. The counselors at Camp Little Moose share ghost stories around the campfire, three of the most popular stories being the legends of the Woodsman, The Fishman, and The Specter of Shadow Canyon. Fred, a past camper of Camp Little Moose, returns with the gang as camp counselors for the summer. Upon their arrival, the gang discovers that the campfire legends have come to life and are terrorizing the camp. The Scooby-Doo gang decides to investigate and solve the mystery, leading to the discovery of a forgotten town and a hidden treasure. The villains are later unmasked and revealed to be Babyface Boretti, a gangster who was disguised as a camper at Camp Little Moose, and Ranger Knudsen, a law enforcement officer, who was planning to destroy the summer camp to retrieve the treasure. Figure 3 describes the variety of deviations from the expected Scooby-Verse narrative and musical structures that are found in *Camp Scare*. Each deviation allows the filmmakers to blend the contrasting genres of children's media and horror, emphasizing the scary elements of the film, while also including familiar characteristics of the comedy genre that have been present throughout generations of Scooby-Doo stories.

Structural deviations in *Scooby-Doo! Camp Scare*

The narrative of *Scooby-Doo! Camp Scare* borrows many techniques from the horror genre to establish the fear-inducing nature of the film. Horror films are often characterized by narrative components like unsettling locations, unknown figures, and violent crimes or scenes. Most Scooby-Doo narratives are not considered by viewers to be part of the horror genre, but *Scooby-Doo! Camp Scare* is one of the few exceptions and the filmmakers reinforce this notion with references to well-known horror films, as shown in Figure 4. The villains in conventional horror movies are not to be taken lightly, as many of them commit violent crimes. Often, Scooby-Doo narratives have only one distinct villain who is not especially violent, but *Scooby-Doo! Camp Scare* deviates from this by showcasing three different villainous characters: The Woodsman, The Fishman, and The Specter of Shadow Canyon. The villains of Scooby-Doo traditionally commit non-violent crimes, such as money laundering, fraud, or theft, to be age-appropriate for younger audiences; however, the villains of Camp Little Moose deviate from this expectation. The Woodsman, shown in Figure 5, is characteristic of villains from the subgenre of 'slasher' horror films, as he is an 'axe-wielding maniac' at a summer camp who creates dangerous situations for the campers in an attempt to scare them away and retrieve a treasure. The Woodsman is similar to Jason Voorhees, an 'axe-wielding maniac' villain

Figure 5: The Woodsman. The Woodsman, an "axe wielding maniac," surrounded by the burning ruins of a structure at Camp Little Moose. Screen grab from DVD (00:03:46).[18]

who murders multiple summer camp staff in *Friday the 13th*, a famous example of the slasher subgenre.[19] The Woodsman, however, differs from Jason Voorhees as he does not commit murder in *Scooby-Doo! Camp Scare*. In the title scene of the film, The Woodsman is depicted as being responsible for the violent explosion of a boathouse and is shown throwing his axe directly at the camera. The Fishman is representative of "monsters" from early horror films, such as *Creature from the Black Lagoon* (1954), and the Specter of Shadow Canyon is similar to the banshee villain commonly seen within the horror genre in films like *Cry of the Banshee* (1970) or *Darby O'Gill and the Little People* (1959). Between the three villains of *Scooby-Doo! Camp Scare,* multiple violent crimes are committed, including, but not limited to, attempted murder, assault with a deadly weapon, arson, and destruction of property.[20] Through the use of previously established characteristics of horror films, such as villains that commit violent crimes, the creators of Scooby-Doo! Camp Scare are then able to induce fear in viewers by highlighting the actions of the unknown or the supernatural while deviating from the expected structure of Scooby-Doo stories.

To reduce the fear created by villains, most children's ghost stories center around whimsical villains or characters, which Grider describes as zombies, "dancing skeletons," and "wandering souls."[21] Within fiction and reality, these characters make their narrative debuts in stories at events such as sleepovers, camps, or during Halloween. *Scooby-Doo! Camp Scare* introduces these character archetypes through campfire stories, but the film takes them to an extreme more commonly seen in horror films rather than children's ghost stories. The legends of the campfire monsters have a similar sense of whimsy as traditional children's ghost stories but are portrayed as much more violent and fear-inducing. The villains of *Scooby-Doo! Camp Scare*, The Woodsman, The Fishman, and The Specter of Shadow Canyon, are unlike the 'spooky monsters' in children's ghost stories because the actions they exhibit are intended to cause serious harm and damage and establish a legitimate fear in the characters and the audience by creating life-threatening, dangerous situations for the characters to navigate, which is consistent with conventional horror films. This is not commonly seen within Scooby-Doo films as the traditional structure is designed to debunk mysteries and scary topics for children and to minimize their fear.

Most Scooby-Doo narratives include a chase sequence where the gang is running from the villain, never appearing to be in extreme physical danger. This sequence is often musically accompanied by fast tempos and energetic rhythms as the characters run in and out of frame, confusing the villain and creating a comedic moment for viewers. *Camp Scare* alters this by creating intense chase sequences that put characters at risk of bodily harm. At (00:33:40) in the film, The Woodsman cuts the supports of a rope bridge, sending a character falling into a canyon, creating severe risk to her safety and wellbeing.[22] *Scooby-Doo! Camp Scare* does not minimize the fear, but rather builds on the suspense created earlier in the film by adding more villainous characters as the plot continues. At the beginning of the film, only The Woodsman is frightening the characters, while at the end, all three villains, The Woodsman, The Fishman, and The Specter of Shadow Canyon, are involved in the plot.

Acts one and two of the film follow the traditional structure, as they establish conflict while showcasing the journey of the characters. One of the most recognizable characteristics of the expected Scooby-Doo structure is the unmasking of the villain in the third act, which traditionally includes a scene where Fred, Daphne, Velma, Shaggy, and Scooby unmask the villain and provide an explanation of the mystery. In this dynamic, the 'good guys' or heroes of the story are shown as in control, while the villain is shown as powerless when their scheme fails. In *Scooby-Doo! Camp Scare*, this dynamic is reversed. Deacon, a camper at Camp Little Moose who was previously shown as being cautious and scared, reveals himself to be Babyface Boretti, the mastermind behind the villains, and traps the gang, which is a direct inversion of the traditional dynamic. Rather than the heroes trapping the villain in act three, the villain traps the heroes, showing the villain with the power. This leads to an additional conflict within act three when the second culprit is caught and revealed while the narrative returns to the traditional ending. In the penultimate scene, the gang unmasks the other culprit, revealing him to be Ranger Knudsen, who was previously shown in the film as a law enforcement officer. *Camp Scare* deviates from the traditional narrative structure of Scooby-Doo stories by revealing two villains, one who aligns with the 'man in a rubber mask' trope showcased in other narratives of the series, and another that was not concealed by a mask. Babyface Boretti is shown to exhibit intimidating behaviors and actions, like imprisoning the gang, even after he had been revealed, allowing the film to showcase a villain who does not hide their actions behind the image of a monster, but rather that of a child, magnifying the audience's fear as the villains are revealed to be characters that originally seemed trustworthy. In *Scooby-Doo! Camp Scare*, these narrative changes deviate from the traditional structure, playing the villains in an unexpected and powerful way, and establishing multiple conflicts that create more dangerous and scary situations for the characters.

Musical deviations in *Scooby-Doo! Camp Scare*

In addition to the narrative characteristics, the musical and sonic elements of *Scooby-Doo! Camp Scare* also deviate from the traditional structure, while still connecting the film to previous installments of the franchise. Robert J. Kral, the composer of *Scooby-Doo! Camp Scare*, has composed music for 20 Scooby-Doo videos and 40 episodes of Scooby-Doo! Mystery Incorporated (2010-2013), a Cartoon Network television series often watched by teenage viewers. In addition to his experience composing music for the Scooby-Verse, Kral is credited for his work on *The Haunting in Connecticut* (2009), a horror-drama feature film. In personal correspondence with the author, Kral explained that Tony Cervone and Spike Brandt, the producers of *Camp Scare*, "wanted a similar feel…to *Friday the 13th*."[23] As explained later, the use of *Friday the 13th* (1980) as inspiration for the film is evident in the horror characteristics presented and is shown through visual references, exemplified in Figure 4.

Many Scooby-Doo narratives use repeated sounds or pieces of music to establish a sense of familiarity within the audience. Kral recalled his experience with the "classic Scooby episodes of the 70s" and how he loved the familiar feeling he had when "certain cues" would return.[24] He utilizes this idea within *Camp Scare* through a "Mystery/Wrap-Up" theme, which first appeared in *Scooby-Doo, Abracadabra-Doo!* (2010) as a musical accompaniment for the wrap-up or

explanation of the mystery, which occurs at the end of many Scooby-Doo films. The "Mystery/Wrap-Up" theme, most notably heard at (1:05:00) in the film, utilizes woodwind instruments, slower tempos, and a repeating melody to act as a musical sign for viewers who have seen multiple other Scooby-Doo installments and heard this theme before.[25] *Scooby-Doo! Camp Scar*e also uses zany, comical, and groovy sound effects that are closely associated with past Scooby-Doo narratives to further establish a sense of familiarity of the Scooby-Verse for viewers. All Scooby-Doo narratives have comedic elements that are emphasized with sonic or musical gestures taken from the comedy genre, including onomatopoeias such as "zip" or "boink;" loud, chattering teeth to highlight fear experienced by characters; the sounds of birds chirping or singing after a character hits their head; percussion instruments such as drums and cymbals to accompany actions of characters, often heard when characters are running; and brass fanfares to highlight the accomplishments of characters. Many of these gestures and orchestration techniques are found within songs with 'funny' lyrics.[26] Kral explained that using a "fun pulse element" in more playful or funny scenes allowed him to draw on the comedy genre, which aligns with the expected musical style of the Scooby-Verse.[27] By utilizing the "Mystery/Wrap Up" theme, established sound effects, and comedic musical gestures, Kral creates a strong, familiar foundation for the film, which allows him to deviate from previously established expectations to highlight the horror genre of the film.

Music of the horror genre is often characterized by the Tempest and Demonic styles and musical gestures such as dissonant harmonies, varying tempos, and eerie, unsettling timbres that use high strings, low brass, ghostly voices, minor keys, and quickly changing and loud dynamics to build suspense.[28,29] *Scooby-Doo! Camp Scare* incorporates these gestures (Figure 3) in addition to the traditional comical and positive musical gestures of the Scooby-Doo universe (Figure 1) to blend the horror genre with children's media and create a sense of fear within the viewers by deviating from the expected structure and characteristics of Scooby-Doo installments, showcasing the supernatural aspects of the film.

The score of *Scooby-Doo! Camp Scare* consists mainly of composed music and three additional songs. Leitmotifs, recurring musical compositions or themes, and horror genre musical gestures are used to establish the scary, horror-based qualities of the film, and to enhance the horror-themed narrative. Kral explained how he scored the film as he would "a horror film, not at all thinking [of] a kids animation film," highlighting a conscious deviation from the traditional musical structure.[30] Rather than relying on common musical gestures of an animated children's film, like many Scooby-Doo narratives, Kral utilized horror-genre musical gestures to create the intensity heard in the score of *Scooby-Doo! Camp Scare.*

Throughout the film, Kral utilizes Tempest and Demonic musical styles—identified by Janice Dickensheets in 2012—to emphasize the supernatural aspects of the villains. In her exploration of the topical vocabulary of nineteenth-century art music, Dickensheets describes the Tempest Style as:

> Dating back at least to Vivaldi's *Four Seasons*, the musical evocation of wind, rain, thunder, and lightening continued to evolve into the nineteenth century, adopting several gestures to portray the powers of nature, which included the supernatural or the demonic…The Tempest Style is usually cast in a minor mode. Wind is represented in the frequent use of diminished chords and running eighth-note patterns that either undulate or change directions unexpectedly; trills in the timpani signify thunder, and lightning can be portrayed by a sudden, fully orchestrated chord…Other frequently used gestures include string tremolos (often in the lower register), agitation in the high strings to symbolize rain and wind, and chromatic passages to create an unsettled effect.[31]

This musical style is present in compositions throughout *Scooby-Doo! Camp Scare* but is especially evident during the first encounter with The Fishman in act two. The scene at (00:25:20–00:27:53) starts with Scooby-Doo scuba-diving in a lake, accompanied by violins, harp, and vibraphone playing in a high, narrow register with an approximate tempo of 50 beats per minute.[33] The Fishman then appears from the depths of the lake, grabbing Scooby-Doo and visually signifying the shift of the scene to a chase sequence with a Tempest Style accompaniment. The melody used in the composition outlines two sonorities: an E fully diminished seventh chord and a F# fully diminished seventh chord, which directly align with Dickensheets' description of the Tempest Style. The composition begins with the E fully diminished seventh chord sonority and later moves up a step to the F# fully diminished seventh chord sonority as the danger and intensity of the chase sequence increases. Throughout the scene, Scooby-Doo and the gang are attacked by The Fishman who breaks their canoes and later pushes them off a ledge of a dam, plummeting to the depths below. The composition utilizes moving sixteenth-note lines in the violins and high strings, trills in the flutes and piccolos, and newly added low brass,

Figure 6: The Fishman. The Fishman attack Velma and Trudy's canoe in Big Moose Lake. Screen grab from DVD (00:26:38).[32]

timpani, bass drum, and low strings, which provide power to the villain and emphasize the dangerous presence of The Fishman.

The composition maintains a consistent use of the Tempest Style and then transitions into the Demonic Style to support the increased intensity of the scene and supernatural nature of The Fishman. As described by Dickensheets,

> The Demonic Style often makes use of the minor mode, but a harshly wicked major key can also be employed in conjunction with frequent diminished chords. Rising scalar patterns in the low register (scored frequently for cello or double bass) are almost always found ascending in chromatic or altered scales, conjuring fantastic images of specters arising out of the deep. Such ascending lines are frequently followed by cackling passages of glissandi or agitated high strings and woodwinds, often outlining augmented or diminished chords. Low brass, trombones especially, are featured in a forced, almost overblown manner, playing open intervals that allude to Medieval settings.[34]

As Scooby-Doo and the gang flee from The Fishman underwater, Kral's score shifts from the Tempest Style to Demonic Style, exemplified through the use of loud dynamics (volume), trombone and low brass instruments playing in a loud, "overblown manner," rising scalar patterns in the low strings, and rising melodies outlining the fully diminished seventh chords in the trombones to amplify the "fantastic images of specters," specifically The Fishman, "arising out of the deep."[35] The combined gestures of the Demonic Style showcase the threatening and dangerous nature of The Fishman that seeks to terrify Scooby-Doo and the gang. By blending the Tempest and Demonic styles, which are commonly used in horror films, Kral is incorporating key elements of horror music into his score for *Scooby-Doo! Camp Scare*. These techniques and melodies continue to reappear in compositions throughout the film to accompany villainous moments, creating an overall blend of traditional Scooby-Doo or children's media music with that of the horror genre in the film's score.

The music in *Camp Scare* was intended to achieve a similar feeling to Harry Manfredini's score in *Friday the 13th* by creating a more intimate and controlled setting to develop certain musical outcomes, which aided in establishing fear in the viewers.[36] Kral explained his love for "using orchestral sounds" as they can be "big and powerful or small and intimate…and any mood at all can be conveyed."[37] Kral's orchestrations, featuring mainly string instruments, allowed the film to reference other horror scores and progressively increase the tension and anxiety that is occurring within scenes of the film. *Psycho* (1960) and Bernard Herrmann's iconic use of high-pitched, "sharp, dissonant stabs" are referenced multiple times throughout the film to establish a scary and ominous mood within scenes, most notably when The Woodsman raises his axe.[38] The stabbing sounds of the string instruments act as both a sound effect—as it is synchronized with an action seen on screen—and a musical gesture within the score of the film; viewers who are familiar with *Psycho* are bound to follow Kral's reference. Vincent Aragon, a film music theorist at California State University, Monterey Bay, argues that melodies that utilize string instruments and alternate between two specific notes are used in horror film orchestrations to show "that a monster is near even when that monster itself is hardly even visible," as heard in the musical gestures in the shark leitmotif in *Jaws* (1975).[39] These 'two-note' strings are used in the introductory scene of *Scooby-Doo! Camp Scare* to audibly allude to the villains within the scene. The "Villain" leitmotif within *Scooby-Doo! Camp Scare*, often heard in scenes with The Woodsman, acts as both a sound effect and a musical gesture to tell the audience that "the villain is there or something scary is about to happen."[40] Kral achieved this through "orchestral gestures and echo effects" to create a recognizable and distinct theme to assist the narrative in villainizing the Woodsman, the Fishman, and the Specter of Shadow Canyon.[41]

The spooky sound effects used in addition to this leitmotif assist in blending the genre of a children's film with horror by establishing the setting through sounds that already have an eerie connotation with many viewers. Throughout the film, horror sound effects such as slamming doors with no apparent source, owl hoots, and snapping twigs are used to amplify the suspense and fear experienced by the audience. When viewed from a semiotic perspective, these musical gestures and sound effects create specific reactions in viewers because of their prevalence in horror films like *Friday the 13th*, *Jaws*, and *Psycho*.[42] As supported by previous statements from Kral, the filmmakers intended these signs to be recognized as scary sounds by the audience (including children) because "they have heard such sounds accompany scary parts before."[43]

Scooby-Doo! Camp Scare also amplifies the audience's fear through visual gestures such as shadow figures, dark forests, and glowing eyes by drawing upon signs that signify a threat.[44] Each of these visual gestures can be seen throughout decades of Scooby-Doo narratives in addition to a variety of horror works. The shadow figures and dark forests create uncertainty as the viewers cannot be sure of what lies within the darkness. The glowing eyes can then expand upon the uncertainty by emphasizing a threatening feature of the creature that hides in the darkness, creating a sense of danger or fear for the viewer. By incorporating both the comically eccentric characteristics of Scooby-Doo features with horror-based sound effects, musical gestures, and indices, *Scooby-Doo! Camp Scare* deviates from the established expectations and seamlessly blend the two often contrasting genres of horror and children's animation.

Conclusion

The traditional structure of Scooby-Doo has provided a narrative, musical, and sonic basis for over 50 years. The Scooby-Doo franchise has made westerns, science fiction, puppetry shorts, comics, books, and live-action films. Each installment of the franchise uses characteristics of the original formula created by *Scooby-Doo, Where Are You?* to connect all the narratives in the Scooby-Verse. The three-act structure, bright music, zany sound effects, and memorable characters provide the perfect basis for an animated children's story, which is seen through the decades of Scooby-Doo success. Famous horror films like *Friday the 13th*, *Jaws*, and *Psycho* have influenced years of cinematic art, the world of Scooby-Doo being no exception. *Scooby-Doo! Camp Scare* embraces traditional characteristics of the Scooby-Verse while intermixing gestures and ideas from the horror genre to deviate from the original formula and enhance the film. Altering the narrative structure and increasing the severity of the villains allows

the film to branch into the horror genre by establishing a complicated plot with increased danger and potentially harmful situations that create more suspense and fear for the audience. The musical and sonic signs, leitmotifs, references to famous horror works, and musical gestures such as tempo, orchestration, and dynamics establish the horror aspects of the film, while remaining recognizable as a Scooby-Doo story.

While all Scooby-Doo installments are created to be appropriate for children, some films include more horror tropes to be of interest to both younger and more mature audiences, for example, children and their guardians. By including horror elements and allusions to famous works such as *Psycho* (1960) and *Friday the 13th* (1980), *Scooby-Doo! Camp Scare* appeals to older viewers that may have followed the franchise for multiple years or may be watching the film with younger viewers. Common Sense Media, a 501c(3) non-profit organization that provides media recommendations for families, educators and other individuals, has a community forum where viewers can rate *Scooby-Doo! Camp Scare* and state which age range(s) they feel are appropriate for viewing the film. Within the forum, multiple parental figures or guardians rank the film as unsuitable for young viewers due to the scary and intense nature of the villains; however, other viewers rate the overall film as suitable for young viewers with supervision as it does not include excessive gore, violence, or terror.[45] By using narratological, musical, and sonic conventions from the horror genre, Kral and the other filmmakers made *Scooby-Doo! Camp Scare* stand apart from its Scooby-Doo media counterparts by introducing younger audiences to the horror genre. Recognized as one of the scariest Scooby-Doo films by audience members and dedicated fans, *Scooby-Doo! Camp Scare* is a successful example of how a storytelling franchise can alter characteristics such as genres, character archetypes, and musical gestures to create and maintain interest in an audience comprised of various generations.

Acknowledgments:
This piece would not have been possible without the support of Dan Obluda, Ph.D. who introduced me to the world of film music and encouraged me to continue developing my writing. Robert J. Kral, the composer of Scooby-Doo! Camp Scare*, created the music behind multiple episodes and films that have strengthened my love for Scooby-Doo stories. I am grateful for the time he took to answer my questions. The feedback and suggestions from the anonymous reviewers were vital for improving my work. I would also like to extend my thanks to my family—Cindy, Tim, Emilie, and Sophie—who have encouraged my love of Scooby-Doo stories and my academic journey.*

Appendix

Personal Communication Between Kral and Author: April 30th, 2023

1. Did you take inspiration from other movies or composers?

For CAMP SCARE, Directors Tony Cervone and Spike Brandt expressed they wanted a similar feel in some scenes to Friday the 13th. As such there's an echo effect on the Woodsman villain and an overall vibe of the intimately smaller orchestra sound used by Harry Manfredini in the first Friday film. Score wise though apart from that I scored the scary scenes as I would a horror film, not at all thinking a kids animation film. We wanted to get the spooky scary factory really happening!

2. How did you direct or shape the musical gestures (timbre, dynamics, instrument choice, etc...) you used to fit the theme of the film (i.e. Summer camp) and the genres of horror/comedy?

Many of the orchestral gesture type sounds and orchestral effects are from my own recordings of an orchestra I hired, wrote the gestures and orchestrated them and recorded them for further sampling and manipulation on my studio keyboard. This gave it a really organic orchestral vibe and I could get the swells, gestures and fx [sic] just how I wanted by adjusting speeds and pitches on the keyboard. The original sounds is composed and orchestrated for these types of scores in mind and so they were originally designed for this genre already. The summer camp vibes mostly come from the songs by Andy Sturmer, who usually writes and produces the songs for these Scooby films and he's so awesome at it! Other scenes we have a light summer camp feel approach from my score for comedy or a fun pulse element for the boats on the lake etc.

3. What elements of music do you feel make the most effective conduit for communicating emotions or ideas to the audience?

What I love about using orchestral sounds is that the orchestra is so versatile. Big and powerful or small and intimate. And any mood at all can be conveyed. My key interest and passion in film scoring has always been to provide the audience with an emotional experience. Music can do this for a story in such an immediate way even more than the story telling and acting itself. Once you hear the music come in, you instantly feel something! This has always fascinated me and was my key inspiration to pursuing film composing: guiding and providing the audience with the emotion, even an emotion that the visuals and dialog may not be providing at all, the unspoken or the subconscious behind a scene.

4. How do you use leitmotifs within the score and was there one that was harder to write or was more useful? Do you have a favorite leitmotif from Camp Scare?

My favorites in Camp Scare are for the villain, some orchestral gestures and echo effects to provide the signature sound so you know the villain is there or something scary is about to happen. There are others more light hearted, for example Scooby & Shaggy have a type of theme or cue that is actually used in several of my Scooby film scores. In my first Scooby project, Abracadabra-Doo!, a mystery type theme was developed for the wrap up/ explanation of the mystery of that film that I have brought back in all my Scooby projects and I live [sic] that we've done that to give some unity to many of these projects. I recall in the classic Scooby episodes of the 70s loving that familiarity of some of the music when certain cues "come back in".

5. Was there any struggle or creative problem solving you had to do in order to mix the two very different genres ("kids' films" and horror/monster) in one musical score?

Really no problem at all. As mentioned the actual songs are by Andy Sturmer, and often the score will need to lead into his songs so once I know the key he's in I can build into it. It's always seemed to work flawlessly and without issue. In terms of my score, I enjoy composing in different styles, "feels" and so on, so it's a joy to change even

quickly if needed within a scene.

6. How much time did you have to write the score?

About 6 weeks if I recall correctly. Usually full length films do have only about 5 weeks to score, record, mix and deliver which is quite intense usually!

7. Did the director give you any expectations or did you have a lot of creative freedom?

A lot of creative freedom although Friday the 13th was mentioned as a starting point as mentioned. The directors and I watch the movie together carefully and discuss where music should be, and what style and mood, in the "spotting session". Each cue is mapped out this way prett [sic] much to the exact frame it will start and stop, and any changes in feel and mood, hit points (stings) etc that are really important. Whilst these are discussed together beforehand, I have a lot of freedom otherwise. As I finish each cue and I send the directors a QuickTime file of the music synced to that scene, so they can give any comments or changes as necessary. Fortunately there are rarely any changes, maybe some minor adjustments and I can re-record adapting to any requests. By the time I wrote the last cue they've usually approved the rest of the score, so working this way there's no big surprises on workload or requirements at the last minute!

8. What was the hardest piece within the film to compose and why?

I honestly don't recall a hard one... although the long canoe chase scene near the end was fairly challenging. There is usually one or two cues of each project that for some reason prove to be a bigger challenge than the others, and it's not necessarily predictable at all until I get to that scene and find "oh this is the tricky one!". I e [sic] learned now to expect it and factor in more time for it. The freedom to pretty much wrote whatever I liked though from Tony Cervone on our projects (and most other directors I've worked with too) really makes things easy in terms of not feeling "hard" except sometimes the deadlines can be challenging to meet simply due to time.

9. How did you originally become involved in composing music for Scooby-Doo movies and why do you enjoy it?

I was originally hired by Tony Cervone and Spike Brandt at Warner Bros Animation back in 2003 when they chose me to score for Duck Dodgers ("in the 24th and 1/2 Century!"). They were fans of my work on the TV series Angel and called me in to see if I was interested! We got along so great right off the bat, Duck Dodgers was an extremely fun and hilarious show to work on. Years later they started developing Scooby-Doo features and brought me in for Abracadabra-Doo! I was so thrilled to be working in this classic set of characters that I'd thoroughly enjoyed as a kid watching Scooby on Saturday mornings! From there I was hired to do more Scooby films, and Scooby-Doo! Mystery Incorporated TV series. I was able to keep my "wrap up" theme music where each mystery is solved for all of the Scooby films and episodes I've scored, even with different directors. I've really loved that I can bring in a now familiar theme and vibe for audiences that may have been watching for years and years. I was also hired by other Directors and producers at WB for many DC super hero projects since Superman Doomsday in 2007. Similarly I've kept using and further developing my Superman and Batman themes for well over a decade now. I'm happy to compose new themes, but also thrilled that for my movies over this period of time, audiences can be familiar with these themes.

10. Out of all the films you have scored, which is your favorite and why?

I have so many favorites for particular reasons. Here's some!

- Superman Doomsday was my first super hero film and I got the job based off of a VERY emotional big cue [sic] chosen for the audition. I was so thrilled to get it, because of the emotional goals really working for the director, and such a hugely established character such as Superman! I was just so thrilled to write a new Superman theme that the director and as I read YouTube comments the audiences really love. (Tricky because we wanted it to be TOTALLY different from John Williams amazing Superman theme).
- Abracadabra-Doo! Because it was my first Scooby-Doo! project and I just love working for Tony and Spike so much.
- The Haunting in Connecticut as it's my first cinematic feature for Hollywood, and produced one of my favorite vids "Prayer for the Innocent", being so heartbreaking and emotional for the music.
- Injustice, could well be my favorite score overall. I got to use and develop further my Batman AND Superman themes, especially Superman, and this score has a lot of heartfelt emotions needed for the story, I just truly love how it turned out!

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T Cell Differentiation

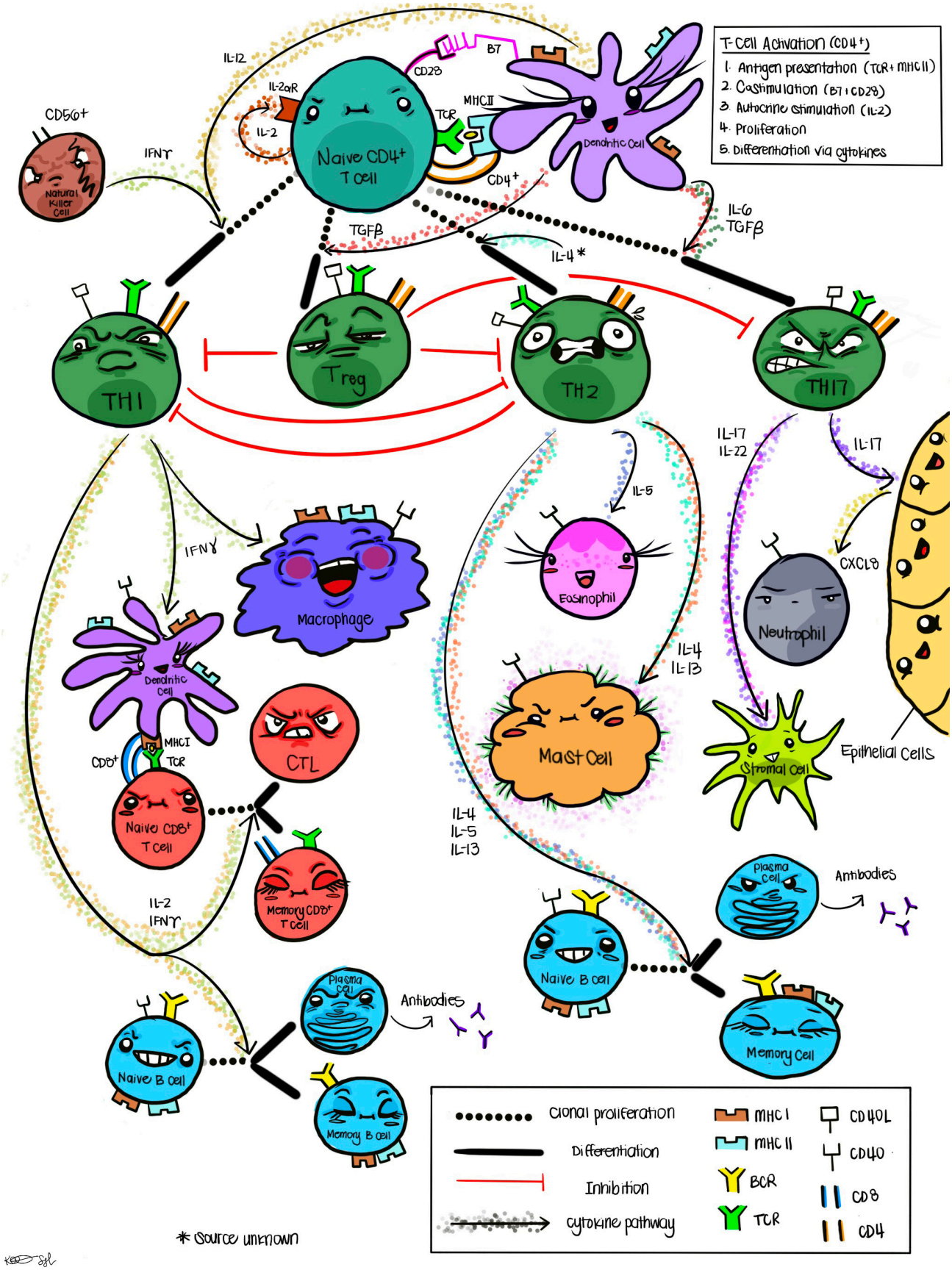
By Kassandra Alonso
Colorado State University

Artist's Statement

Drawing cartoons has allowed me to give colorful life to complex biological processes. This immunology diagram illustrates the steps of how "naive" T cells are activated and differentiate into specialized T cells. Once I was able to see the body as a communal system - with cells having individual personalities and jobs to maintain homeostasis in the body - I fell in love with immunology. Dendritic cells don't fight, they act as secretaries that rush around the "office" (different lymph nodes), to spread the news of the antigen they've encountered in the wild. I hope this diagram serves other students of science and medicine, cheers.

This digital art medium was created using the drawing software Procreate. It was made using a digital tablet and stylus in 11/2022.

Acknowledgments: Jennifer McLean, Ph.D., reviewed immunological content. Stacey Lee assisted with software and labeling design.


T-Cell Activation (CD4+)
1. Antigen presentation (TCR+MHCII)
2. Costimulation (B7+CD28)
3. Autocrine stimulation (IL-2)
4. Proliferation
5. Differentiation via cytokines
CD56+
Natural Killer Cell
IFNγ
IL-12
IL-2αR
IL-2
Naive CD4+ T cell
CD28
B7
MHCII
TCR
CD4+
Dendritic Cell
IL-6
TGFβ
TGFβ
IL-4*
TH1
Treg
TH2
TH17
IL-17
IL-22
IL-17
IL-5
IFNγ
Macrophage
Eosinophil
CXCL8
Neutrophil
Epithelial Cells
Dendritic Cell
MHCI
CD8+
TCR
CTL
Naive CD8+ T cell
Memory CD8+ T cell
IL-4
IL-13
Mast Cell
Stromal Cell
IL-4
IL-5
IL-13
IL-2
IFNγ
Plasma Cell
Antibodies
Naive B cell
Memory Cell
Plasma Cell
Antibodies
Naive B cell
Memory B cell
*Source unknown
Clonal proliferation
Differentiation
Inhibition
cytokine pathway
MHC I
MHC II
BCR
TCR
CD40L
CD40
CD8
CD4

Social standards of imposition: Respectability and the Raj through the eyes of Governess Marjorie Ussher

By Erin Nelsen
St. Catherine University

Abstract

The British Empire possessed a long history of imposing ways of thinking, political and economic structures, and social standards on their territories. This imperialism also extended to standards of beauty and respectability in Hyderabad, the capital of the Hyderabad state. These standards can be traced from the archived letters that the British governess Marjorie Ussher wrote to her family from 1934 to 1940, during the final years of the Raj–British sovereignty in India. This thesis recognizes and reflects on Ussher's aesthetic depictions of various people and objects through a close reading of the letters. The research analyzes the letters for themes of race, gender, and apparel using a framework built on literary, historical, and aesthetic lenses. Ussher's first-hand account offers a unique glimpse into how culturally conditioned aesthetic judgments inform assessments of beauty and respectability in citizens' everyday lives during the Raj. This thesis then explores how Ussher promotes macro knowledge systems through the microformat of letter writing.

Introduction and Background

"I was very sad leaving Mrs. Mae. She is one of the most splendid people I know & seems to combine many virtues & qualities, very good looking – well dressed (in fact extremely so) very witty, clever & well read & the kindest most thoughtful person one could ever meet. She does the most beautiful needlework too."[1]

On a short trip to Bareilly, India, Marjorie Ussher, a white British governess in British India, reflects on her disappointment at leaving Mrs. Mae in a letter to her mother. Presumably, Mrs. Mae is another white British woman accompanying her husband in India. Since Mae is a common English name, the 'Mrs.' implies her marital status, and analysis shows that Ussher spends most of her work breaks surrounded by other European persons. While one could easily interpret this sentiment merely as sadness over separation from a close friend, the statement carries implications on concepts of respectability and beauty in the context of 20th-century British India.

This thesis delves into why and how Ussher performs macro imperial knowledge systems through her letters in the microformat of respectability and beauty. For example, in this quotation, Ussher praises Mrs. Mae's appearance, personality, manner, apparel, and performance of feminine duties, all of which likely rest on her internal feelings surrounding race and class. Sociologist Pierre Bourdieu sheds a theoretical light on the interconnections between taste and class

in his book, *Distinction: A Social Critique of the Judgement of Taste.* Bourdieu explains, "Objectively and subjectively aesthetic stances adopted in matters like cosmetics, clothing or home decoration are opportunities to experience or assert one's position in social space, as a rank to be upheld, or a distance to be kept."[2] Therefore, societal tastes, like those emphasized in Ussher's letters, are not based solely on a personal whim but instead reflect the preferences of the ruling class. Ussher's reflection on Mrs. Mae calls to attention questions about how imperial values and beliefs shaped concepts of respectability and beauty during the Raj, the period of British sovereignty in India. Throughout her time in India, Marjorie Ussher, a single white British governess from Ireland, reflects on her perception of respectability and beauty.

The following thesis evolved out of a mutual interest in sharing women's stories, history, and curiosity about the world. Throughout the researcher's undergraduate college experience, she worked as a Research Assistant for historian Rachel Neiwert, Ph.D. In this role, she found, transcribed, coded, and analyzed more than 520 letters in Marjorie Ussher's archival collection. Through a framework based on literature, history, and aesthetic disciplines and a close reading of these primary source documents, this thesis aims to deconstruct the concept of respectability, as understood by Marjorie Ussher in 1900s British India. These disciplines, discussed in detail in the historiography section, act as a lens for reading and interpreting Ussher's letters.

A Brief History of Ussher

On April 3, 1905, in British-controlled Northern Ireland, Marjorie Ussher was born to Eva Oliver Reed Ussher and James Ussher. Hostilities raged between Britain and Ireland throughout the twentieth century, mainly along religious lines.[3] Whereas Irish Protestants generally supported the union with Britain, viewing themselves as British, Catholics broadly endorsed nationalist views in favor of Irish independence.[4] As Northern Irish Protestants, the Ussher family viewed themselves as British and rejected their Irish identity in line with other Irish Protestants. This identification with British social standards and values influenced Ussher's understanding of respectability and how she frames herself throughout the letters.

Marjorie Ussher served as a governess to the children of a white British military family from 1934-1936 and later to the Indian royal family of Hyderabad from 1936-1943. In 1934, at the age of 29, Ussher sailed to India to begin work as a governess with the Stirling family in Chakrata, Ootacamund, and Jubbulpore, India. Ussher taught and trained the Stirling children in everything from reading, writing, and drawing as their governess. After working with this white British family for a few years, Ussher utilized her connection to Mrs. Tasker, another white British woman in the empire, to procure a more lucrative governess position with the Begum Sahiba Wali ud-Daula, an Indian royal ward of the Nizam of Hyderabad. Here, Ussher held nearly the same educational role as she did with the Stirlings, the main difference being the family's race. In a September 1936 letter to her family, Ussher introduces the Begum Sahiba's household. The family includes five children with two daughters, Ekbal and Vikar, and three sons, Fareed, Karder, and Asman.[5] The children's father receives no mention in the letters, suggesting that he is either out of the picture or deceased. Ussher started her position in Hyderabad, India, in the summer of 1936.

Ussher continued her position with Begum Sahiba until 1940, when she began to work with an auxiliary group during World War II. While working with Begum Sahiba, Ussher builds trust, causing Begum Sahiba to rely heavily on her for daily help around the home and with the children. However, Ussher also enjoys considerable downtime engaging in various social activities and vacations during her time with the family.

Historical Context

Before looking at the letters themselves, it is crucial to consider the context in which Ussher wrote them. Between the late 1500s and early 1700s, the British Empire ruled or administered various colonies, dominions, protectorates, and other territories.[6] In 1757, after Great Britain colonized India, India became one of the empire's most significant colonies.[7] During this time, Britain, operating through the East India Company, depended on India as one of its primary sources of raw materials. In 1885, Britain formed the Indian National Congress (INC) to increase governmental representation for educated Indians and foster political and civic discourse between them and the British.[8] In return for India's help with the World War I war effort, Britain passed the Government of India Act in 1919, which established a diarchy, dividing power between the British and Indian administrations.[9] Under the leadership of Mahatma Gandhi, a British educated Indian lawyer, the INC grew in popularity through efforts to eliminate caste, religious and ethnic divisions, and poverty. Though the party earned most of the votes during the first election in 1937, World War II's outset in 1939 halted these independence efforts.[10]

Meanwhile, some groups continued to advocate for the end of British rule. Mahatma Gandhi led one such effort in 1942 called the 'Quit India' movement, which sought a British withdrawal from India.[11] However, the movement lacked coordination, and the British ultimately arrested Gandhi and other leaders of the INC. Meanwhile, World War II highlighted difficulties in effectively ruling India and severely diminished British supplies. Attempting to remove themselves quickly, the British split India along religious lines through the 1947 Indian Independence Act, partitioning Pakistan for Muslims and India for Hindus, which resulted in waves of religious violence and displacing millions of people.[12]

Respectability and Ussher

During her time in and outside of Begum Sahiba's home, Ussher repeatedly interacts with the idea of respectability, creating a foundation for this research and the corresponding paper. For the purposes of this thesis, respectability is socially constructed, and it refers to "respectable character, reputation, or social status."[13] During the empire period, the British middle class pursued respectability "to maintain their status and self-respect against the lower-classes, and the aristocracy."[14] In Marjorie Ussher's perspective, many factors contribute to a person's respectability. Like other white British individuals, Ussher views respectability as correct, proper, and socially acceptable adherence to class, race, nationality, gender roles and identities, occupation, age, personality, and manners. Some examples include only marrying amongst people of certain classes and races, not spending too much alone time with married people of the opposite sex, and working in positions that demonstrate support for and pride in one's nation. However, this thesis lacks the space

to explore all these areas.

Marjorie Ussher aims to convey a level of respectability both personally and in her interpretation of others. Ussher's letters outline a strict definition of respectable beauty and aesthetics, which predominantly adheres to white British standards of respectability. These standards follow traditional gender roles and identities, behavior, dress, education, language, cleanliness, race, and class. While Ussher presents herself as a heterosexual woman, she recognizes the beauty of other women much more frequently than the beauty of men. This recognition could result from the more significant pressure placed on women's attractiveness than their male counterparts, queer identity, insecurity surrounding her appearance, the recipient's interests, or various other factors. Historical events, such as the World Wars and colonialism, shaped beauty standards due to access to goods, exposure to other cultures, and available print culture.[15] Ussher acts according to the white British public perception of what it means to be a likable, attractive, and a well-mannered woman in the 20th century British Empire to present herself as a respectable British woman to her social circle and family back in Ireland. Not being seen as respectable in her social circle may create barriers to obtaining or maintaining a job in India.

Similarly, if her family thought she was losing her respectability, they may suggest or even force her to return to Britain or Ireland. Therefore, by upholding British values of respectability at an individual level, Ussher gains economic opportunities and freedom while reinforcing macro-level colonial concepts of how women should act and be in society. Through the race, apparel, and gender themes, Ussher presents herself as a respectable woman, demonstrating how working-class citizens understand and promote the imperial message and British social standards in their everyday lives.

Historiography

The following section provides summaries of the historical works on the chosen lenses of analysis. It also illustrates this thesis's unique place in the current literature surrounding women's roles and respectability during the Raj. Marjorie Ussher provides a new understanding of how white British people in British India demonstrated their respectability through concepts of race, gender, and apparel. While literature surrounding British respectability during the empire period as an ideal exists, they do not focus on these three themes as factors.[16] This source set also differs from the sources used by other authors in that they come from a working-class woman living out her everyday life as opposed to coming from a wealthy person or noble. Taking Ussher's positionality as a white woman of considerable socioeconomic class into context, Ussher has a motive to promote British notions of respectability to maintain her family's British identity and, subsequently, white privilege. Through this self-promotion, it becomes clear that Ussher understands and advances the imperial message, demonstrating how deeply British social standards influence working-class people in the empire. The audience to which Ussher writes similarly presents an innovative argument for this thesis. Ussher writes almost entirely to her parents, allowing a mediated view of respectability related to race, gender, and apparel.

To better understand the performance of macro-knowledge systems in the micro-format of Ussher's letters, this thesis employs various lenses of analysis. These lenses include literary, historical, and aesthetic lenses. Author Lois Tyson argues for the interpretation of letters through both a literary and historical lens in her book *Critical theory today: A user-friendly guide*.[17] She explains that literary texts serve as "cultural artifacts that can tell us something about the interplay of discourses, the web of social meanings, operating in the time and place in which the text was written."[18] Tyson adds that "the literary text and the historical situation from which it emerged are equally important because text (the literary work) and context (the historical conditions that produced it) are mutually constitutive: they create each other."[19] Therefore, by reading Ussher's letters with both lenses, we, as the reader, gain a better understanding of the text itself and the context from which it arose. Similarly, using an aesthetic lens to analyze the letters contribute to the knowledge of Ussher and respectability in 1900s British India, which mainly relied on perceptions of beauty and dress. The following three subsections will describe these lenses in detail.

Literary Lens

The literary lens allows the reader to understand the thoughts and internal desires of the writer, manifested through the letters. Through various literary techniques, Ussher shapes her audience's knowledge of other people, her actions, and herself. In the book *Epistolarity: Approaches to a form* by writer Janet Altman, she follows the creation of the epistolary, or letter-novel, genre, emphasizing the importance of letters as literary objects.[20] Altman's work reasons that using letters as a narrative device allows the author to shape character types, develop thematic emphasis, and create a narrative self-consciousness, all of which are visible in Ussher's letters. First, Ussher forms the character types of those around her in her parents' eyes. By describing those she interacts with in ways that her parents would see as respectable or not, Ussher shapes their character in the eyes of her family. Following traditional tropes, this micro-action of perpetuating racial and gendered stereotypes reinforces persisting macro-knowledge structures. Ussher also creates thematic emphasis, intentionally or unintentionally, through the subjects she focuses on in her letters. Some such themes include physical appearance, dress, and the respectability of those surrounding Ussher. Further, Ussher develops a narrative self-consciousness through her musings on different decisions. This narrative form highlights societal values by drawing clear lines between right and wrong actions.

In her book, Altman also identifies significant characteristics of the genre of epistolary novels that apply to Ussher's letters. One such commonality Altman emphasizes is the idea of letters as epistolary mediation. Because letters link senders to receivers, they work as a bridge that brings the writer and receiver closer together.[21] This relationship is particularly true of Ussher, the writer of the letters, and her parents, the most common receivers of her correspondence. In reading Ussher's letters as a literary bridge between herself and her parents, the reader can understand what Ussher deems significant and how she attempts to communicate and narrativize respectability. According to historian David Gerber, accruing social respectability is typically an immigrant's first project.[22] Gerber expands that this project often serves as the motivating factor for uprooting and dramatically transforming one's life. Social respectability similarly serves as one of Ussher's first projects upon arriving in India. For the 12 years that Ussher lived in India, she wrote letters weekly to her family, primarily her mother

and father, living in Ireland. By considering the letters as both a form of literature and history, we gain a mediated testimony surrounding race, class, gender, and performance of imperial ideology.

Historical Lens

Meanwhile, the historical lens provides context for Ussher's background, the time, and the events surrounding the writing of the letters. Unlike the literary canon, the historical canon has always accepted letters as primary sources.[23] Since people began writing letters, they have formed networks, bridged distances, and strengthened relationships.[24] Literary historians have examined and appreciated their quality as historical sources. These sources contribute to our understanding of these far-off times and places, giving us a glimpse of people's everyday lives. Additionally, ordinary people, including women, can engage in letter writing, creating a more accessible means for people to contribute to the historical narrative. As historical sources, writing letters has become an essential form of sociocultural praxis and letters a powerful communication method.[25]

Historians analyzing the Raj hold differing opinions on women's role in empire-building. Some authors, such as Indrani Sen, view women during the Raj as providers of "companionship in the home" and the "'civilizing mission' beyond."[26] This sentiment suggests a certain level of agency, the ability to act independently and formulate one's own decisions, held by the women both in the home and as empire builders.[27] Sen further argues that women uphold racial and social hierarchies perpetuating colonial rule.[28] Maya Jasanoff similarly supports the idea of women as empire builders, explaining that thinking of them in these terms is a relatively new phenomenon.[29] Jasanoff asserts that previous literature presents the idea of an 'empire' as a masculine enterprise where women have little agency. Other authors, such as Swapna Banerjee, view women's role in the empire as shaped more by their domestic efforts. In his article, Banerjee discusses the new ideas of domesticity that arose under British rule in India, suggesting that domesticity spurs change and women's empowerment by giving them agency.[30] He then argues for greater participation by men and children in the domestic field to share the burden and the power. Ussher's letters support the idea of women as empire builders by maintaining a sense of British superiority through respectable actions and appearance. For example, during the war effort, some women changed their purchasing behaviors so that they could donate funds to the empire. In this way, Ussher distances her culture from that of the Indian people and, in some instances, imposes her beliefs of proper self-presentation both among white British people and Indian people in the empire.

Some of these empire-building roles involved leaving the metropole. According to Nupur Chaudhuri, women often went to India to satisfy their role as wives or in search of a husband.[31] However, marriage was not the only reason women left the metropole. Britain also sent women to its territories through the governess system to maintain its influence during this empire period. Governesses were women who lived with families, often middle or upper class, and taught the children. Young women from middle-class homes usually served in this type of role. These women educated both girls and boys, though families often sent boys to boarding schools once they were eight or could afford it.[32] Governesses served as a status symbol and a way to maintain children's British identity when they grew up in the empire far from the metropole. These women taught anything from reading and writing to the piano and foreign languages.

Race, color, and ethnicity also impacted an individual's status and became a common theme throughout Ussher's life and letters. Sociologist Howard Winant explains that at a fundamental level, the term 'race' symbolizes and indicates sociopolitical conflicts and interests regarding different types of human bodies.[33] Socially and historically, people have based concepts of race on human biological characteristics as a means of racial signification. However, no biological basis exists for differentiating people in terms of race, and sociohistorical categories are imprecise, if not wholly arbitrary.[34] Concepts of race arose along with the world political economy and continued to persist into twentieth-century British India and society today. Winant explains further that class-based race theories frame racial conflict to express class conflict.[35] This thinking suggests that intergroup competition and racial stratification were well-defined in the post-war world.[36]

Racial stratification arises between the British and Indians and the British and Irish- Britain's first colonial project. Ussher, along with other white British persons living in this context, held white and fair-skinned people in high regard in 1934-1940 India.[37] This way of thinking created a race-based understanding of respectability. The concept of race is socially constructed and includes both color and class formation. Anne McClintock explores this racialization of class differences in-depth, describing class identity "as a social invention written in the language of clothes and physical signs."[38] This description suggests that class primarily comes down to material possessions and appearance. McClintock elaborates on perceptions of race at the time, with white women perceived as clean, feminine, and elegant as opposed to non-white women viewed as filthy, masculine, and indecent in their clothing.[39]

In her performance of social etiquette, Ussher racializes those who do not follow the same standards. As seen through the letters, the concept of race is not fixed but constantly changing. For example, as an Irish woman, Ussher associates more with the British than the Irish. By doing so, Ussher can ensure that those she interacts with see her as white, which carries ideas of wealth and respectability. Colorism considers skin complexion while ignoring racial or ethnic group affiliation. The term refers to "the allocation of privilege and disadvantage according to the lightness or darkness of one's skin."[40] Under this theory, people with lighter skin generally possess more privilege than people with darker skin across ethnic and racial groups. Within Ussher's letters, we can see colorism in Ussher's reflections surrounding people's skin color, particularly Indian people. Ethnicity relates instead to one's association with a group of people with a common racial, national, linguistic, religious, cultural origin, or cultural background.[41] Ethnic ties also surface as a way people demonstrate respectability in Ussher's letters.

Aesthetic Lens

The aesthetic lens then allows for the inclusion of artistic components, appearances, and the thoughts and opinions of the author on the aesthetic. It is essential to understand the norms of pleasing self-presentation to understand how Ussher and other white British persons imposed proper self-presentation on those around them.

In their 2015 book, *The visible self: global perspectives on dress, culture, and society*, Joanne Bubolz Eicher, Sandra Lee Evenson, and Hazel A. Lutz explain aesthetics during the Raj. George Santayana describes beauty as a "pleasing sensory experience," expanding that, "Beauty is a value… it is an emotion, an affection of our volitional and appreciative nature. An object cannot be beautiful if it can give pleasure to nobody."[42] This statement suggests that beauty depends on the values present in the cultural and historical context in which it exists. Without creating pleasure, something cannot be said to be beautiful. Eicher, Evenson, and Lutz elaborate that standards of beauty are created by society in that there exists a desire to "conform to the expectations of others with whom [people] affiliate and yet display a desire to express their individuality as well."[43] Society members tow a fine line between fitting in with what is expected while maintaining some uniqueness. Therefore, society creates the ideal appearance, "As consensus develops about an ideal based on the values of members in the society, cultural ideals for pleasing appearance evolve."[44] This consensus developed in relation to race, gender, and apparel. Throughout Ussher's letters to her family, Ussher aims to adhere to the values and ideals of her perceived society, her family and friends back home, and white British people in the empire.

These macro-level values and ideals ultimately shape what individuals see at the micro-level as respectable. Sociologist Sri Devi Thakkilapati defines respectability as "a form of symbolic capital that is produced within the conjugal (heterosexual, nuclear) family."[45] This idea of British respectability confined largely to traditional structures persists in Ussher's letters. Ussher often describes respectability as it pertains to traditional British values such as gender roles and styles of acceptable dress. Historian Charles Reed expands on this concept of respectability, relating it to behavior, clothing, education, language, cleanliness, and social conservatism.[46] In reading the letters with this framework of 'symbolic capital,' we, as the reader, understand the factors motivating people's actions and why Ussher may choose to include or exclude certain information from her letters.

One topic Ussher made an intentional effort to include in her recollections was fashion. According to Professor of Fashion Arti Sandhu, balancing traditional Indian and Western dress served as a turning point in Indian fashion during British colonial rule.[47] While the Indian people Ussher interacts with present some desire for traditionally British characteristics and culture, such as light skin and governesses, some local cultural aspects remain. The saree, for example, a product of the 1850s Indian Parsees' and Chinese trade relations, stayed prevalent in the Indian culture even after the British brought in new clothing and styles, as seen through Ussher's letters.[48] Ussher and other British people in India even adopted some traditional Indian dress forms, such as the saree, suggesting that cultural exchange went in both directions. Tara Ghoshal Wallace's concept of British "mythmaking on [foreign] soil" further amplifies our understanding of this relationship.[49] Under this mythmaking, colonial spaces become mythical places characterized as otherworldly, bizarre, and romantic. The British reinforce these myths by adopting traditional and exotic styles of dress.

Method

The source material for this project includes more than 520 letters written weekly by governess Marjorie E. Ussher across a ten-year span. This analysis stems solely from the letters photographed by Rachel Neiwert, Ph.D. at the British Library in London, England. These letters, dated 1934-1943, were addressed predominantly to Ussher's parents, with the occasional letter to her brother or sister and clear instructions on whom to share them. The letters prove both beneficial and challenging to our understanding of history. As Marjorie Ussher wrote predominantly to her parents, her reflections are likely more tailored and mediated than if she were writing to a friend. This modification to her intended audience may have led Ussher to filter information or describe it in a way that would make her appear more respectable to her family. While this audience means that the readers do not have access to Ussher's unfiltered thoughts, it allows for a greater understanding of how Ussher wishes to portray herself to her family and, subsequently, what society deems respectable than the reader could otherwise access.

Furthermore, while Ussher's archived collection proved extensive, many more letters were not included because they were written to Ussher, written by Ussher to others, or not saved. These letters could be in a private collection, lost, or destroyed. The omission of these letters serves as a limitation. It remains unclear whether these are not included because the previous collection owners did not have them or whether someone intentionally omitted them to portray a specific image of Ussher. However, this collection also provides a historical perspective that otherwise would not exist. These letters expand the historical understanding of women's experience in the empire, the governess system, India during the Raj, and respectability in this context, among other topics.

In the researcher's first read-through of the letters, she noted every theme she saw in every message. She then read through the collected topics and pulled out the most common and salient ones. The researcher then reread the letters to ensure she had not missed anything in her first read-through. Initially, she focused on beauty and social standards. However, after outlining the paper and gathering the examples and available literature, the researcher discovered that respectability functioned at the core of these topics. With this new direction in mind, the researcher reread the letters a third time, noting how respectability influenced Ussher's actions and reflections to her parents and its frequency. She then separated all the instances of respectability into broad categories. Ultimately, the race, apparel, and gender themes emerged as most illustrative of promoting respectability to endorse British social standards and the Imperial message. Once the quotes tied to respectability were gathered, the researcher applied a historical, literary, and aesthetic lens to the documents. By doing so, she determined what was meaningful to highlight, such as the historical context that informed the example, the literary aspects present in the letters, and the importance of different fabrics and styles of clothing. As the following study does not include human or animal subjects, it did not require ethical approval by an approving body.

Race and Respectability

Throughout Ussher's letters, she frequently referenced people's race as a function of their and her respectability. Historian Peter Robb suggests that in the early twentieth century, whiteness connoted dominance- Europe-born, elite, and respectable.[50] The racial component of respectability in Ussher's letters holds that elite

and middle-class white Europeans outrank lower-class Europeans and non-white Indians. This ranking results from the perceived inferiority of native and low-class individuals present during the time.[51] By drawing lines between native and low-class inferiority, Robb emphasizes that the two concepts are intrinsically connected. This section will demonstrate how race influenced respectability through the eyes of Marjorie Ussher.

Ussher originates from Ireland and derives her understanding of race-related aesthetic standards from her Irish and, more broadly, British upbringing. English colonization and racialization of the Irish in 1611 complicated this identity.[52] As she grew up in Northern Ireland, Ussher's allegiance aligned with the British. During this time, Ireland waffled between staying with Britain and seeking to regain its independence.[53] Some Irish people recognized the poverty in Ireland and believed the British crown could protect their well-being. As one of these people, Ussher recognizes her Irish identity while simultaneously promoting British values and ideas.[54] Ussher embodies the tensions between the British and the Irish and, as a result, becomes more resolute in her practice of colorist superiority.

Elite European women treasured white skin during the late 19th and early 20th centuries.[55] In a 1938 letter to her mother, Ussher reflects upon her meeting with Susan Shounie, a staff member of Mahindra from county Wexford, Ireland. She explains that Shounie, "although very nice would not strike one as a S. of Ireland girl. She is a prim, precise little thing."[56] The first part of this statement suggests a blanket niceness of all girls from Southern Ireland. However, Shounie differs from others from this region in her primness and preciseness. Despite this different manner, Shounie's origins as a white woman and niceness cause Ussher to see her as a fine and respectable girl. Upon meeting another Irish woman in Ussher's 1939 letter to her parents describing Mary Mescall, it is apparent that the same standards continue to shape Ussher's understanding of beauty even five years after she initially arrived in British India. In this letter, Ussher states, "Mary is a most attractive girl from Tipperary – I like her immensely."[57] In this seemingly simple quote, the reader learns two things about Mescall: first, that she is attractive either physically, in behavior, or both. Second, she comes from Tipperary, a county in central Ireland. From these two simple things, her attractiveness and her race, presumably white, Ussher has determined her immense liking of this person.

Although Ussher returned to India to work for an Indian family, she holds a clear, preconceived, negative notion about the respectability of non-white persons. This understanding of respectability becomes visible in her musings on the beauty or lack thereof of people of other races. It is necessary to investigate the standards of respectability, whom Ussher interacted, and Ussher's racial comparisons to unpack this understanding, which likely represents the views of other white British persons living in this context.

Race-related aesthetic standards also dictate with whom Ussher chooses to spend her time. To present herself as a respectable British woman, Ussher defends her interactions with Begum Sahiba. In a 1936 letter to her parents, Ussher reasons, "there is absolutely no need for you to worry about – Begum Sahiba has got very advanced ideas and a very European outlook – indeed I believe she is looked on as being very exceptional for an Indian."[58] By explaining her parents' fear away, Ussher confirms her trepidation that associating with an Indian woman would hinder her respectability. Relating Begum Sahiba's thinking to European ideas and ways of thought suggests that Ussher will not revert to lesser intellectual integrity. However, she clarifies that Begum Sahiba is not as exceptional as Europeans with the addendum "for an Indian." Edward Said's book, *Orientalism*, aids our understanding of this power configuration. Said argues that in non-totalitarian societies, particular cultural forms always predominate, making specific ideas more influential than others.[59] During the British colonization of India, this power dichotomy splits the Orient, countries of Asia, and the Occident, western countries such as the United Kingdom. Within this dichotomy, "Indians were civilizationally, if not racially, inferior."[60] Western people, such as the British, further mentally designated Orientals as "backward, degenerate, uncivilized, and retarded."[61] Therefore, by reassuring her parents of Begum Sahiba's progressive ideas and European outlook, Ussher disassociates herself and Begum Sahiba, at least in part, from the inferior Indian culture. This act reinforces colonial power dynamics at the micro-level.

Ussher's taste for British aesthetic standards comes through her comparisons between British and Indian people. When writing to her parents in 1937, Ussher explains this English ideal, stating, "The [Indian] children are not nearly so attractive as ours. They are all fat & flabby looking & the Begum Sahiba is nothing like as refined as ours."[62] This quote suggests the appearance of fatness and flabbiness, which Ussher associates with the local Indian population, to be unattractive and unrespectable. Ussher also stresses the importance of being refined and sophisticated, even for children.

During the Raj, the British also socially constructed several racial categories, such as Anglo-Indian, to establish racial differences. Anglo-Indians fell between Indians and white persons in terms of respectability, though both groups effectively isolated them.[63] As a result, both the British and Indians married almost exclusively within their group, likely shaping Begum Sahiba's views toward her own children's marriage.[64] British ostracism made Anglo-Indians essentially endogamous, though it is argued that this was never entirely the whole case. This ostracization of biracial couples surfaces in a 1939 letter Ussher wrote to her parents. In this letter, Ussher comments on the soon-to-be wife of Sandy Parker, a previously married white man who works for the Imperial Bank. Ussher explains that Sandy Parker's "bride is an Anglo Indian – quite fair & English looking, but goodness knows what the children will be like!"[65] Ussher sets off this woman's race as an Anglo Indian with a dash (–), evidently leaving space for her parents to come to their conclusions on the respectability of Sandy Parker marrying a non-white person. However, she soon clarifies that this woman is "quite fair & English looking," making her more respectable despite her race. However, because of their mixed race, Sandy Parker's children will not automatically receive their parents' looks and manners, calling into question their children's future respectability.

While looking at some of Begum Sahiba's old photos as they prepare for Ekbal's wedding, Ussher contemplates the respectability surrounding mixed-race marriages. Ussher believes so intensely in the superiority of white British culture and aesthetic standards that she laments, "I honestly believe that if it were possible [Begum Sahiba] would change their colour so that they could all marry English people, but she is sensible enough to realize the folly of their doing so as Indians."[66] Whether

this reflects Begum Sahiba's thoughts on the situation remains unclear. Still, the assertion likely reflects her inclination towards other traditional English practices like hiring a British governess and believing marriage should come later in life. However, Ussher recognizes that it would be a mistake for Indians to marry British persons. The most likely interpretation of this statement is that Begum Sahiba is a realist and has seen the ostracization of other biracial Indian-English couples. This realism may drive Begum Sahiba to view a strictly Indian match as the most respectable and best possible outcome for her children.

The white, British aesthetic standard also applies to non-white persons in Ussher's mind. Ussher reinforces this British aesthetic standard when attending the wedding ceremony of Akeel Jung's daughter and Najuf Ali Khan. Ussher explains, "some of the younger girls were extraordinarily pretty. The members of one family were very remarkable because they had all blue eyes."[67] As blue eyes appear relatively infrequently among Indians and relatively frequently among Europeans, the remarkableness of this family exists mainly in their similarity to aesthetically pleasing European persons. In other cases, Ussher expresses little reasoning behind her disdain for certain groups of people. For example, Ussher displays an evident lack of respect for the Parsees, Persian Zoroastrian descendants who initially fled to India to avoid persecution by Muslims.[68] For instance, in a letter to her mother dated 1939, Ussher writes, "Indeed at the best of times Parsees are not at all good-looking – there are very few pretty women amongst them & I don't like the type of sarees they wear. At the Hindu wedding of the Dhobi's daughter – the women were much more attractive!"[69] Ussher's apparent dislike of Parsees may result from differences in physical characteristics from her British aesthetic standard or internalized bias picked up from other people's thoughts, feelings, and group discussions.

Ussher's reflections present a mediated understanding of the imperial message and British social standards surrounding race as a working-class citizen writing to her parents. Through her discussions of race, readers better understand racial standards of respectability. These standards fall primarily along the lines of being white and British. Ussher also discusses what does not meet the standard, namely non-white Indians, Parsees, and, in some cases, the Irish.

Apparel and Respectability

Marjorie Ussher's letters also frequently reference people's apparel as a factor of their respectability. British clothing signified a "racial superiority, modernity, refinement, masculinity and power over Indians," necessitating contemplation regarding clothing choices and self-presentation.[70] Ussher outlines a clear standard for clothing to adhere to, including specific types of clothing and colors, modern, not old-fashioned clothes, and displaying a level of wealth. However, as Edward Said points out, the Occident expresses "a certain *will* or *intention* to understand, in some cases to control, manipulate, even to incorporate, what is a manifestly different (or alternative and novel) world."[71] In this way, the British appropriate apparel from the Indian culture as part of their own. Along with increasing the wearer's respectability, wearing proper clothing increases the person's likability.

One way people demonstrated respectability and elite status was through expensive clothing choices signifying wealth. Ussher brags that her New Year's Day party outfit "was one of the smartest costumes in the room."[72] For her outfit, Ussher "chose a glorious shade of Bocara silk (1/per yd) & a pierette type of thing with an enormous white organdi ruff piped with green round [her] neck – Black silk scarf tied on [her] head & black shoes – white organdi ruffs piped with green on [her] wrists – the costume was cut very well & fitted perfectly – [her] legs were greatly admired."[73] Not only did she buy the fanciest of materials for her outfit, but she also had it perfectly made and fitted.

Respectable apparel choices further contribute to a person's likability, as viewed through Ussher's description of Mrs. Blake. Ussher explains that Mrs. Blake, a well-off white woman and the wife of one of the doctors at the O.C. hospital, "is a pretty very well dressed woman & I like her very much too."[74] Blake's attractiveness and apparel decisions contribute to her respectability and Ussher's desire to spend time with her. People could uphold respectability by adhering to this clear standard of apparel outlined in Ussher's letters, which includes clothing types, colors, styles, and cost. Ussher's itemization of various textiles and elaborate clothing demonstrates that she financially makes enough money to maintain an opulent lifestyle. The itemization also highlights that the people Ussher surrounds herself with are similarly well-off. With limited trade during the World Wars and a slowed global economy, this access to and ability to afford luxury apparel would have been particularly impressive and demanding of respect.

Apparel decisions also include hairstyles and accessories, acting as wearable art. Wearable art differentiates wearers by highlighting their individuality and increasing their visibility in the group.[75] Color also plays an essential role in respectable fashion. Reds and golds surfaced as a common thread of acceptable colors. On attending Vikar, Begum Saheba's youngest daughter, and Kadja's wedding, Ussher notes, "Vikar looked really beautiful in her strawberry coloured & gold clothes. She is tall & stately & carries herself very well."[76] These colors give Vikar an almost regal appearance. Other colors, such as plum, are not held in the same regard. While attending the Director General of the Police daughter's wedding, Ussher reflects on the bride's beauty before adding that "the Bridesmaids were the only failure - their dresses, plum colour, were most unbecoming and unattractive."[77] The dresses would have been much more successful if not for the color.

At another wedding, Ussher explains that "the M-in-law brushed & combed the girls' hair & taking a bottle from a yellow velvet tray poured oil on her head. She then took about six strands of hair on each side & bound each with gold & red thread. After this, she plaited the whole thing in one long plait tied with a gold ribbon at the end."[78] During the time, people would have viewed this hairstyle, bound and plaited with gold and velvet, as refined and opulent. *The Dictionary of Fashion History* describes velvet as "An imported silk fabric, from Spain, Italy or France, with a short dense pile, which could be cut or uncut, above a satin ground which might incorporate gold or silver threads."[79] As an imported fabric, people viewed velvet as a luxury item that the everyday person could not afford. The gold threads similarly would have suggested superiority and respectability. The use of oil would have elevated this braid even further, adding a shiny finish. The same wedding included extravagant showings of precious metals, such as gold and silver, and flowers. Ussher details that "the bride groom was wearing a gold shevani, gold dustar, white

pyjamas & gold shoes. King from his head over his shoulders were dozens of chains of flowers, white and pink, intertwined with gold & silver cords, his head seemed waited down with the weight of them all."[80] This elaborate display of wealth demonstrates the respectability of the wedding and those involved.

On the occasion of a different marriage, Ussher participates in these extravagant displays. To maintain acceptable standards, Ussher "wore [her] green Taffeta dress for the occasion & all [her] jewels as Begum Saheba wanted us to look our grandest!!!"[81] Wearing fine taffeta and jewels demonstrates Ussher's ability to afford more extravagant things due to her respectable social position. Taffeta is "a plain, glossy, silk fabric," often representing wealth.[82] Raw silk was an essential trade commodity from the eighteenth century onward. During the twentieth century, the British were one of its leading importers.[83] Between 1927 and 1930, the aggregate value of the world silk trade and production reached about 30% of the value of the cotton trade and 65% of the wool trade.[84] This high aggregate demand for silk suggests that the material was highly sought after and desired at the time, particularly in Britain.

In Ussher's view, wearing modern (instead of old-fashioned) clothes also plays into a person's respectability. To assure her parents that she is in line with current clothing trends, Ussher remarks, "I've just had the tailor in & handed him over all my dresses to shorten, they are looking old-fashioned!"[85] Here, Ussher demonstrates her desire to conform to the dress standards. The way she says, "I've just had the tailor in," suggests that this happens rather often and that they have an established working relationship. Further, Ussher emphasizes that she has 'all' of her dresses tailored, not just one or two, drawing attention to her considerable socioeconomic status. Mrs. Stirling also attempts to maintain a level of respectability through clothing choices. According to Ussher, "Mrs. Stirling has taken out 64 yds of material to have made up into frocks for herself and the children! She has some very pretty evening frocks."[86] Not only is that a large and likely expensive quantity of material to buy, but having clothing made from it for the entire family would not have been cheap. Evening frocks only add to this expense.

Ussher stresses looking clean and put together with specific types of clothing as another contributor to respectability. Writing to her parents, Ussher compares two women she spends time within India. She describes, "Mrs. Van & 'Birdie' are of course very different in appearance – the one so neat & tidy, the other in the most weird outfit."[87] While Mrs. Van receives praise for looking clean and put together, Birdie receives criticism for having a 'weird outfit' and being less neat and tidy than Mrs. Van. To conform to the current fashion and climate, Ussher describes her fashion choices to her mother. This description demonstrates the intentionality Ussher puts into her daily outfit choices as she explains, "for a few days I was wearing a woolen jumper etc. but have gone back into cotton frocks."[88] Woolen jumpers are wool sweaters worn during the colder weather, and cotton frocks are lightweight British dresses worn by women during warmer weather.[89,90] Ussher returned to the colder but more attractive cotton frocks to maintain appearances despite the chilly winter weather. This choice stresses the importance of fashion over utility. Ussher also emphasizes the importance of functionality in her clothing choices, explaining, "My navy slacks & shirt are a great blessing"[91] because of the ease of wearing them, unlike dresses. She clarifies, "there is a good ironing room where one can press dresses, etc., but one wants to be in there just as little as possible during the hot weather."[92] By opting for slacks that do not need ironing, Ussher minimizes the time she puts into her clothing while still looking fashionable.

Similarly, to demonstrate the respectability of her family by looking clean and put together, Begum Sahiba has clothing made for her son, Fareed. Before a parade, "Begum Saheba & [Ussher] had to rush into town, buy material & get the tailor to make a shevani for Fareed we got green and silver brocade and it looked lovely on him."[93] Brocade is a "fabric with a pattern of raised figures" of "silk interwoven with threads of gold and silver."[94] Through this fabric, the family demonstrated their wealth and respectability through clothing. The ability to afford such a material would have functioned as a barrier limiting access to this fabric to the highly affluent. This quote also displays the care-taking role women have with their male counterparts. Though having a mother help decide their child's clothing is relatively common, Begum Sahiba includes Ussher in the outfitting endeavor. Ussher's inclusion in this process suggests the importance of respectable dress, particularly from the white British perspective.

Society also values the thrown-together look, encompassing attractive clothing choices and little effort. For example, while attending a party hosted by several St. George's Grammar School staff members, Ussher explains to her parents, "my costume was really very attractive although made up of old odds & ends which I had in my trunk."[95] From the nineteenth century onwards, the word 'costume' refers to "the appearance, i.e., clothing, hairstyle and other decorations, which distinguished a particular class, nation or historic period."[96] Ussher boasts her outfit while attempting to underplay the effort she put into it with the phrasing of "old odds & ends." Setting and following trends also play into respectability. At the Fancy Dress Ball at the club, Ussher writes to her parents, "I wore the costume which I bought for last year's show. On that occasion, it was the only one of its kind in the room – for this year's dance it had been copied by three other people – quite obviously copied too!"[97] Here, Ussher draws attention to the fact that she wore the dress before it entered the cultural mainstream. This trendsetting reaffirms her taste in apparel and respectability. In certain situations, beauty even took precedence over function. While attending a wedding, she reflects on the style choices of the bride, remarking that "while she was away a number of chains of flowers were tied to her head & these hung down in front of her face covering it completely. (I wonder if she didn't suffocate!!!)."[98] To present a particular natural image, the bride rejected functionality and comfort in favor of fashion.

However, many of these clothes are anything but natural, taking exploitation and many hours of labor to create. The modern raw-silk trade reflects exploitation, unequal exchange, and imperialism between the Orient and Occident.[99] By highlighting Begum Sahiba's wearing of fine silk, Ussher emphasizes her association with people of refined fabric taste and respectable apparel choices associated with wealth and a civilized nature. This action further reinforces the importance of wealth to British social status. Leathers, hides, and animal skins also allow people to show their wealth and respectability through apparel.[100] In Ussher's

acknowledgment that Begum Sahiba wanted them to "look [their] grandest," it becomes apparent that surrounding herself with attractive-looking Europeans adds to Begum Sahiba's respectability amongst her peers. In a letter to her parents, Ussher boasts, "I am the proud possessor of a lovely brown crocodile handbag and shoes to match … The bag is beauty & will wear forever."[101] Her parents would have viewed objects such as these as exotic and expensive to those living in the United Kingdom, making the fact that she has both and that they match impressive and respectable. She then assures her parents of her purchase's attractiveness and quality, allowing them to last forever. Ussher also suggests her desire to send leathers back to her family. She tells her parents that she "would like to send [them] one of their lovely coloured suede belts but [is] so afraid it would be lost en route."[102] *The Dictionary of Fashion History* describes suede as "calfskin specially treated to produce a silky, slightly napped finish, this type of leather originated in Sweden."[103] People held suede textiles in high regard because of the time-consuming process of making suede and its ties to Europe. This sentiment suggests that the British elite would also have valued and sought leather goods.

Ussher, moreover, seems to differentiate locals' apparel standards from her British counterparts. Specifically, Ussher dislikes the appearance and dress of the Parsees. In a message to her mother, Ussher explains that "the official Parsee dress for men is most unattractive, they wear most unbecoming little brown hats & long white coats."[104] Ussher dislikes this style and makes her displeasure with Parsees' appearance known, adding, "Indeed at the best of times Parsees are not at all good-looking – there are very few pretty women amongst them & I don't like the type of sarees they wear."[105] However, this aversion to the garment does not transfer to all sarees as Ussher admires Ranee's, another Indian woman, saree on an Indian outing she accompanies. After praising Ranee for her attractiveness, English speaking ability, sensibility, and conversational ability, she compliments her outfit. Ussher writes, "She was dressed in a beautiful green sarai with a gold border round it. Her sister whom they hope to marry this year is very attractive in appearance – she looked simply charming in a blue & white sarai – the latter is really a most becoming graceful garment."[106] Unlike the Parsee's sarees, Ussher views Ranee and her sister's sarees as graceful and living up to Ussher's color specifications for respectability.

Ussher's mediated reflections portray how working-class citizens understood the imperial message and British social standards surrounding respectable apparel and aesthetics. Within her letters, Ussher stresses the importance of looking clean and put together but with minimal effort, modern and not old-fashioned, and adhering to specific colors, styles, and fabrics. However, the letters show that Ussher differentiates locals' apparel standards from those of her British counterparts. Additionally, some of the clothing choices demonstrate relationships of exploitation, unequal exchange, and imperialism between the British and Indian populations. The British upheld imperial social standards and messaging regarding respectability, wealth, and status through these deliberate apparel choices.

Gender and Respectability

Throughout her letters, Marjorie Ussher makes frequent, gender-divided references to people's manners and appearance as a function of respectability. Of the 91 mentions of people's looks in Ussher's letters, 68 (74.73%) reference women, and only 23 (25.27%) mention men. This increased awareness of women's beauty demonstrates the heightened standards placed on women's appearance and respectability in British India. Ussher feels these constraints, as made visible by her regular mentions of her own fashion choices and looks. This focus on women may also reflect the more significant amount of time Ussher spends with women due to prevalent gender expectations. These expectations dictate that white British women predominantly interact with other women and men only in the presence of others. These references display Ussher's desire to appear respectable in the eyes of her recipient, her family, and her British colleagues.

Ussher sets her standards of respectability and appearance in conjunction with her lived experience in Britain and the perceptions of other white British persons in India. This standard for women includes looking well-kept but not overly so and acting according to societal norms and expectations, among other things, as seen in Charles Reed's framework for respectability. Both qualities appear in Ussher's discussion of Mrs. Mae. On October 23, 1938, Ussher writes that Mrs. Mae "is one of the most splendid people I know & seems to combine many virtues & qualities, very good looking – well dressed (in fact extremely so) very witty, clever & well read & the kindest most thoughtful person one could ever meet."[107] Mrs. Mae conforms to Ussher's understanding of proper, well-kept appearance and style of dress. In her book *Imperial Leather*, Anne McClintock describes cleanliness as a distinguishing factor for class.

> Soap did not flourish when imperial ebullience was at its peak. It emerged commercially during an era of impending crisis and social calamity, serving to preserve, through fetish ritual, the uncertain boundaries of class, gender and race identity in a social order felt to be threatened by the fetid effluvia of the slums, the belching smoke of industry, social agitation, economic upheaval, imperial competition, and anticolonial resistance. Soap offered the promise of spiritual salvation and regeneration through commodity consumption, a regime of domestic hygiene that could restore the threatened potency of the imperial body politic.[108]

In this passage, McClintock draws clear boundaries between the clean, well-kept, civilized colonizers and the unclean and uncivilized colonized population. Soap represents a symbolic and literal cleansing intended to civilize and enlighten those who use it. Therefore, cleanliness imposes discipline, social order, and symbolic control of the body.

Ussher's concentration on her peers' well-kept and clean nature suggests her desire to associate with the clean and civilized British colonizers instead of the unclean and uncivilized Indian population. This way of thinking at the micro-level promotes views of British superiority. Similarly, Ussher bashes other women for being too put together. In a letter to her family on her initial trip to India, Ussher describes some of the other first-class passengers she interacts with on the boat. Ussher writes, "Needless to say the ladies in the party are *very* artificial looking."[109] This statement ties a negative connotation to looking 'artificial,' suggesting that it is crucial that women look put together but not to the point that it appears unnatu-

ral. This balance illustrates the British ideals of moderation and rationality regarding excess.[110] People could toe the line of proper moderation by avoiding excess indulgences in objects and appearance while still looking presentable.

Marjorie Ussher's letters also demonstrate the importance of maintaining a well-kept appearance, but not overly well-kept to upholding women's respectability. For example, regarding her beauty routine, Ussher explains to her parents, "One of my war economies now is to do my own hair & give the money instead to an aeroplane fund."[111] A war economy refers to an economy in which the government prioritizes the production of certain goods and services to support the war effort.[112] The British Empire had to find a feasible balance between "taxation, internal borrowing, and inflation" to finance World War II.[113] This economic model meant that available funds for armament hinged on the government's ability to impose taxes and the willingness of British subjects to accept sacrifices for their empire. Ussher's statement asserts several truths. First, Ussher typically has her hair done and will continue to do so, maintaining a well-kept appearance, and second, she cares so much about the war effort that she would sacrifice her beauty. Ussher's parents likely would have seen this as a respectable and potentially noble sacrifice upholding the imperial message.

British society also expected women to be entertaining, made visible by Ussher's description of Begum Sahiba. Some of the women even found ways to play this to their advantage. Ussher states, "all the men fall for her - she has got a very attractive manner and can be most amusing."[114] Based on her manner and personality, Begum Sahiba can win the hearts of men, likely a partial source of her power. When Ussher gets a new nursery ayah, a native nursemaid often employed by Europeans in India, she similarly judges her based on her adherence to a feminine standard. Ussher states, "My nursery ayah wasn't nearly as nice in appearance or manner as the dear old one."[115] This statement suggests an expected attractiveness and manners, even for local women and those in service roles. However, men do not have to adhere to the same standards as women. This dynamic surfaces in Ussher's description of Ekbal and her husband, who "seems to have no imagination at all & doesn't set about winning her in the right away."[116] As a man, Ekbal's husband can get away with not putting much effort into the relationship. Ussher elaborates, "I think he is a good man- reliable, steady but not attractive in manners or appearance."[117] Despite lacking manners and appearance, Ussher defends Ekbal's husband for being reliable and steady, which should be the bare minimum.

Marriage is another situation with strict gendered norms and expectations surrounding respectability. Society expected people to marry young but not too young and viewed divorce as taboo. These norms can be traced from Ussher's reflections about Ekbal, Begum Sahiba's oldest daughter. Ussher asserts her view of Ekbal as much too young for marriage, explaining that "the poor child is very upset about it and doesn't want to marry the man at all. He is 23 years older than she is – has been married before & divorced – most unattractive in appearance & manner."[118] Ussher points out Ekbal's suitors' age difference and previous marriage and divorce as factors against their being a suitable and respectable match. The man also falls short of Ussher's expectations surrounding appearance and manner.

After marriage, society also expected women to adhere to specific wifely duties. In a letter to her father, Ussher states, "I'm glad you like Mrs. Cranston - she will probably make him a very good wife."[119] Here, Ussher demonstrates her pleasure in her father liking Mrs. Cranston solely because of her ability to make a good wife, not on her individual merits. Innocence, charm, and purity are essential in one's wifely duties. In a letter to her parents about Vicar and Kadja, Ussher writes, "she is so innocent & quaint about it all & very much the 'blushing bride.'"[120] The phrase 'blushing bride' references a virgin or someone with limited sexual experience, making them anxious about their wedding night. Sexual purity would serve as another standard of respectability during the time. People also expected wives to maintain certain perceptions, as seen through Ussher's praises of Colonel Hill's wife as "pretty & charming."[121] These statements also include a possessive suggestion of women's attachment to men and in the eyes of society.

Maintaining a well-kept appearance holds less importance for men's respectability. When talking about the Bishop of Lucknow, a city in Northern India, Ussher states that he "is a delightful man. Very tall & good looking & thoroughly enjoyed playing badminton."[122] Though Ussher still places importance on the appearance of men, it surfaces more in terms of qualities that they cannot control, such as height.

While Ussher admires some men for their appearance, not having an attractive appearance does not present the same barriers for men as it does for women. For example, in her reflections on Neville, Ussher's brother, Ussher details, "He has good manners, appearance, charm & ability so wants all the scope he can get. He is completely wasted as a trooper," but "his intellect is stronger than his physique."[123] Even though Neville lacks an attractive figure, Ussher decides that his intelligence, decent appearance, personality, and skills make up for his fault. This comment reflects how personality and intelligence were only viewed as factors of worth and respectability for men, while appearance was most important for women- creating a double standard.

Ussher displays how working-class citizens understood the imperial message and British social standards surrounding gender in her mediated reflections. As demonstrated, Ussher set respectability and appearance standards based on her lived experience in the United Kingdom and the perceptions of other white British persons in India. These British Imperial standards differ regarding gender. For women, Ussher's letters display the importance of maintaining a modestly, well-kept appearance, but not overly well-kept, marriage, wifely duties, and manners. For men, respectability, personality, and intelligence hold more importance than maintaining a well-kept appearance. These mentions display Ussher's desire to appear respectable in the eyes of her family and her British colleagues through her practice of the imperial message and British social standards.

Conclusions and Future Study

Ussher presents herself as a respectable woman demonstrating how working-class citizens understand and promote the imperial message and British social standards in their daily lives through the themes of race, apparel, and gender. By employing history, literature, and aesthetic lenses, this thesis unpacked the concept of respectability as understood by Marjorie Ussher in 1900s British India.

Following traditional gender roles, identities, and white British standards, Marjorie Ussher's letters outline a strict definition of respectable beauty and aesthetics.

As discovered through a careful analysis of Ussher's letters, she strives to portray herself as respectable, both personally and in her interpretation of and interactions with others. Following the white British public perception of what it means to be a likable, attractive, and well-mannered woman in the 20th-century British Empire, Ussher successfully presents herself as a white, respectable British woman to her social circle and family in Ireland. Identification with the British aesthetic and economic norms stems from a desire to align with the more affluent upper-class British population versus the lower-class, more impoverished Irish community.

As seen through the letters, Ussher understands and practices the imperial message and British social standards for respectability related to race, apparel, and gender. In 1934-1940, India, Ussher, and other white British persons living in this context held white and fair-skinned people in high regard. This way of thinking created a race-based understanding of respectability. Ussher racializes those who do not follow the same standards in her performance of social etiquette. Apparel also factors into people's respectability in Ussher's letters. Aesthetic criteria specified in the correspondence include specific types of clothing and colors, modernity, cleanliness, and demonstrating a wealthy appearance. By adhering to these standards, the wearer can appear more respectable in the eyes of their peers. Finally, Ussher's letters make frequent gender-divided references to people's appearance and manners as a function of their respectability. Ussher's letters focus on women's beauty, indicating heightened standards for women's appearance and respectability in British India. As asserted, these standards for women include looking well-kept but not overly so and acting according to societal norms and expectations.

While Marjorie Ussher presents a critical perspective in the broader discussion of respectability and beauty in 1900s British India, it is essential to investigate how the understanding of these themes differs from people of other intersecting identities. An analysis of respectability and beauty in different places and times may also prove beneficial to understanding how values and norms shift over time and place. Other potential areas for research include an ecofeminist analysis of Ussher's time in India, for which the letters provide extensive support. A gendered analysis of social, societal, and occupational roles during the Raj, as seen through Ussher's letters, could also yield a fascinating study. Despite the extensive research conducted in this thesis, there will always be other questions, directions, and areas for further investigation.

Due to the limited inclusion of women in the historical field, particularly non-famous or non-wealthy persons, finding and telling their stories remains crucial. This necessity rings particularly true when, like with Ussher, knowledge of their story expands our awareness of working-class people's thoughts, actions, and motivating factors. As we can see through Ussher's reflections on and actions regarding respectability, such as her depiction of Mrs. Mae, ordinary people understood and disseminated the imperial message and British social standards in their daily lives. Therefore, Ussher promotes macro imperial knowledge systems through her letters in the microformat of respectability and beauty.

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Glorious Blasphemy: examining Soasig Chamaillard's French, Feminist Virgin Mary

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Abstract

Over the centuries, the Virgin Mary has been wholly claimed—in body, mind, and spirit—as an agent of Catholic dominion. The ethical ambiguity of Mary's relationship to the Catholic Church inspired French artist Soasig Chamaillard to create a burlesque series of statuettes that reintroduce Mary to contemporary society as a pop culture icon. Employing garish colors and whimsical forms, Chamaillard's miniatures simultaneously breach the marriage between Mary and the Church and fling Mary onto the French secular stage. The dual function of Chamaillard's works calls into question the Church's subjugation of Mary and of all women who are expected to emulate virginal qualities; because the Church extolls a biologically impossible version of feminine 'perfection,' it condemns women to a permanent state of inadequacy. Chamaillard overturns this dismal fate by producing a safe space in which to curate Marian liberation. In this space, Chamaillard facilitates the exploration of Mary's identities beyond those thrust upon her by the Church. The compositions that she produces dissolve Mary's responsibility to the Christ Child and celebrate the full scope of Mary's sexuality. This deliverance of Mary from a history of churchly hegemony to a seat of contemporary flexibility grants Mary the ability to act as a genuine model for female tenacity, autonomy, and gumption.

Introduction

An unequivocal emblem of righteousness, compassion, and salvation, the Virgin Mary (hereafter referred to as "Mary") is one of few who have successfully transcended not only geographical but also theological boundaries.* Her authority within social groups across the globe can be attributed to a profusion of factors, with each making Mary decidedly influential across spiritual and secular arenas alike. As a woman first and foremost, the influence that Mary so effectively wields is made special not despite, but *because* of its relation to her femininity. However, Mary's femininity-dependent fame is not without its cost. After generations of fastidious sculpting by male ecclesiastics, she has been pulled away from her selfhood and pushed toward the role of churchly token. In this assigned position, Mary is a larger-than-life queenly intercessor, designed to be

* The Marian figure has arisen across the globe in a variety of religious systems. However, this essay and its references to the "Church" refer to the Catholic Church as it exists in the Western hemisphere, particularly, France.

universally appealing, universally loved, and fundamentally immortal.

It follows that traditional art depicting this legendary woman is characterized by motifs that communicate her prestigious status in the Catholic Church.[1] Yet, the genre of Marian art has grown complicated amongst landscapes of increased secularism* and feminism†. In response, French artist Soasig Chamaillard has taken on the task of 'updating' Mary, in accordance with contemporary critiques of traditional Marian iconography. The French native repurposes thrifted statuettes of Mary by turning these once-churchly icons into lurid, action-figure-like sculptures.[2] With over 100 completed to date, Chamaillard's parodic miniatures effectively respond to a Catholic pattern of female obsequiousness; by confuting virginal motherhood *and* celebrating Marian sexuality, Chamaillard releases Mary from her patriarchal, religious trammels, granting her autonomy to embody and inspire female might as a quasi-secular feminist.

Faith and feminism

In order to fully understand Chamaillard's goal of Marian liberation, it is vital to first consider the national context under which she operates. The stalwart Catholicism that has come to be associated with France has existed from the time of Charlemagne (747–814 CE). With his coronation as Holy Roman Emperor in 800 CE, Charlemagne solidified a treaty of cooperation between France and the Church that has since remained largely undisturbed, though not entirely.[3] During the Enlightenment period of the 18th century, secular attitudes in France began to threaten the country's Catholic legacy. Finally concretized within France's Law of 1905, which abolished the Concordat of 1801‡, these laic philosophies made way for a seemingly militant version of French secularism.[4,5] Yet, France's continued cultural adherence to Catholic principles renders its secularism somewhat defective; the division between church and state that France claims is weakened by a social climate that endorses Catholic ideals as they pertain to familial structure, moral norms, and the teaching of history.[6,§] Alongside this passionate, albeit contentious, marriage between France and the Catholic Church, the country's second-wave feminism of the 1970s challenged the inner workings of French public society.[7,8,¶]

Dubbed the *Mouvement de Libération des Femmes* ("Women's Liberation Movement"), France's 20th century swell of theory and action was united by an overarching hunger for female autonomy from male-dominated spaces, both physical and symbolic.[9,10,**] In May of 1968, France witnessed a series of brief but dramatic protests during which French demonstrators, primarily students, called for a release from capitalist-consumer culture and an end to the colonialist mindset.[11] In the wake of this civil unrest, the number of women activists speaking and writing on the archaic role of women in the family and in public life exploded. By 1970, these new feminists were looking to overturn—rather than merely amend—the status quo.[12] To do so, they took on topics such as abortion, contraception, and the rights of married women.

Beyond France's feminist framework lies its long-standing reputation as world leader in sexual freedom. During the Renaissance period (15th–17th centuries), new forms of knowledge rippled outwards from Italy, including new ideas surrounding sex and procreation. France was one of many countries that was made to navigate the collision between these foreign notions and older, established beliefs, about the meaning of sex. By 1600, this reconciliation had turned France into what was widely recognized as the most sexually liberated nation in the Christian world.[13] What's more, France's sexually progressive landscape was supported by a series of French monarchs, stationed out of Versailles, who maintained indiscreet and abundant sexual lives.[14] In the 21st century, France's vibrant sexual culture is still alive and well. Written in 2009, Lucy Wadham's book, *The Secret Life of France*, states, "[t]here is a climate surrounding sex in [contemporary] France which lends itself to a more open enjoyment of the seductive game."[15] The openness of sex that Wadham

* Secularism in the context of this essay refers to the separation of religious influence from societal, cultural, and artistic domains, particularly in relation to the reinterpretation of traditionally sacred figures—in this case, the Virgin Mary. It emphasizes a departure from ecclesiastical authority, allowing for the reimagining of the 'holy,' apart from its original religious significance.

† Invoking the term "feminism" here carries with it an acknowledgment of a multifaceted and historically complex movement; carried along with the word is a rich and contentious legacy, shaped by many diverse waves. Within this written framework, feminist theory is applied to critically examine traditional gender roles and patriarchal constructs and to consider new ways to celebrate female identity and agency.

‡ The Concordat of 1801 was an agreement reached between Napoleon Bonaparte and clerical representatives of the Roman Catholic Church. The agreement resolved the schism that emerged between France and the Church during the French Revolution of 1789-99.

§ This dynamic is reflective of a broader Western European trend, where claims of secularism often coexist with underlying adherence to Christian-influenced systems and values. While stripped of overt religious language, these frameworks continue to shape cultural and societal norms across the continent.

¶ The organized participation of women in French politics can be traced to the start of the French Revolution in 1789. Even though women were seen as 'passive citizens,' they advocated for their rights by partaking in marches, supporting the civil effort, and even resorting to violence. In 1791, playwright Olympes de Gouges (1748–1793)… wrote the "Declaration of the Rights of Woman and the Female Citizen," modeled off of the 1789 "Declaration of the Rights of Man and of the [Male] Citizen." This landmark document argued that women are equal to men and are entitled to all the associated legal privileges. By 1848, France's provisional government, The French Second Republic (1848–1852), claimed to recognize universal suffrage, education, and employment. Yet the exclusion of women from this young social order did not go unnoticed. Parisian women in particular were highly active in their demands, focusing efforts on suffrage as well as on marital reforms. As France's first recognized wave of feminism, this period included great efforts for change. However, attempts to gain political and economic rights for women fractured alongside the demise of the French Second Republic. France's Third (1870–1940) and Fourth (1946–1958) republics continued to see advocacy from and for women, with women's suffrage granted in 1944. By the time of France's second-wave feminism under the Fifth Republic (1958–present), increased globalization added fodder to the debates surrounding women's rights. Continuing the centuries-long tradition of activism, France's second-wave feminism lasted roughly two decades.

** Founded in 1970, the MLF challenged French patriarchal oppression by advocating primarily for women's bodily autonomy. The MLF was composed of small groups and collectives brought together by a common goal and an attitude of action. Through their meetings, protests, and written work, these feminist activists brought lasting change to France. One example is the 1971 "Manifesto of the 343." This work criticized the French penal code that criminalized abortion, stating: "Just as we demand free access to contraception, we demand the freedom to have an abortion." Less than four years later, in January of 1975, the French government legalized abortion in the first trimester.

refers to has made intimacy a natural pursuit of pleasure rather than a shameful deed. This French sexual atmosphere, along with overlaying atmospheres of Catholicism and feminism, has been the foundation upon which Chamaillard has allied with Mary.

Reimagining Mary

A principal example of Chamaillard's jocose emulsion of faith, feminism, and the body is *Déchirement* ("Torn Apart"), a work that divorces Mary from her obligation to Christ and shuns the relationship between this mother and child (Figure 1). In *Déchirement*, a stark white Mary cradles the Christ Child, pressing her cheek to his in imitation of the Eleousa type (Virgin of Tenderness).[16,*] At once, a "fig. a" labeling at Mary's collarbone places her as superior to a derivative "fig. b" Christ and renders the pair 'anonymous.' Black dotted lines enclose Christ and a small illustration of scissors against Christ's left shin establishes him as an alien entity meant to be removed from its host.

While a mother-child relationship is generally mutualistic, Chamaillard portrays this one as anything but. As psychobiologist Helen Flanders Dunbar writes, "symbiosis of parent and child can exist only if first the parent and then the child becomes aware that they are essentially different creatures." If infant, child, adolescent, and adult are all fundamentally dissimilar, the lumping of one with another results in major dysfunction.[17] In line with Dunbar's thinking, *Déchirement* advises the necessary division of Mary and Christ. In *tearing* the pair apart, as the work's title bluntly declares, Mary's status as a mother is negated. As a result, she is raised to become more than just the body that bore Christ. The process of transforming one into two encourages viewers to acknowledge Mary's individuality outside of her churchly Marian perfection.

In lauding Marian perfection, the Church has constructed an unattainable version of femininity that prompts men to crave female obedience and defines women as intrinsically incomplete. Encapsulated in Mary's biologically impossible pregnancy, Marian perfection is paradoxical at its core. The Church has long proclaimed motherhood as a woman's highest destiny while concurrently extolling the very state of sexual 'purity' that renders women incapable of fulfilling that destiny. In doing so, it forces women to make a painful choice: either bear a child and forfeit virginity or remain a virgin and forsake motherhood. Yet not all is lost in the pursuit of perfection.

Figure 1: Soasig Chamaillard, Déchirement *("Torn Apart"), 2007, salvaged statue, plaster, acrylic paint, resin, 30 cm. Source: https://www.soasig-chamaillard.com/.*

While an ordinary woman cannot replicate Mary's virginal pregnancy, the same

* Eleousa, or, Virgin of Tenderness, is a representation type in which the Christ Child nestles against the Virgin's cheek. This positioning relates the intimacy between a mother and her son and alludes to the relationship between God and humanity as actualized in the Incarnation.

cannot be said for Mary's submissive character. Social theorist Simone de Beauvoir writes, "[f]or the first time in human history the mother [Mary] kneels before her son; she freely accepts her inferiority. This is the supreme masculine victory, consummated in the cult of the Virgin."[18] Not only does de Beauvoir call attention to the atypicality of this parent-child dynamic, but also, she points to the danger in it. Catholic women who attempt to follow in Mary's footsteps will find that the cost of their willing submission is their sense of self—be it physical, spiritual, or emotional.[19] When a woman's worth under the Church is tied to her subservience (be it to God, Christ, a father, a husband, or in Mary's case a son), she loses the ability to know herself utterly and intimately, as an individual. This platter of contradictions and dilemmas adds fuel to Chamaillard's goal of realizing Mary's selfhood outside of her Marian archetype.

Defined by timidity, contemplation, and subdued compassion, the Marian archetype appears in conventional Catholic art via indicators of Mary's youthfulness (e.g., smooth skin, cascading hair, and curving figure). In such art, the implication of sexual purity that exists alongside Mary's physical beauty produces a character that is illicitly appealing, akin to, as de Beauvoir is so apt to note, "the luster of a pearl on which the sun has never shone."[8] Indeed, it is ironic that Mary's alleged lack of sexual activity creates one who is so bursting with sexual promise. Because this traditional formula covertly objectifies Mary, Chamaillard's *overt* objectification of Mary is refreshingly satirical. Rather than thoughtlessly using Mary as an artistic aid, Chamaillard respectfully collaborates with the Marian statues she finds—statues that would otherwise have been discarded. In so doing, she saturates the forms with a kind of sovereign, new life. This new life simultaneously expands Mary's identity beyond her motherhood, as in *Déchirement*, and openly centers and celebrates Marian sexuality.

Notre Dame de la jouissance ("Our Coming Lady") unabashedly reveals Mary's erotic potential in a radically feminist portrayal of self-pleasure and full female embodiment (Figure 2). This work features a standing Mary, clothed in pale blue and white and crowned in gold, atop a surge of water ejected by a conch shell. Outside of the tangible composition, both the French and English titles signal *Notre Dame de la jouissance's* sexual overtones. The French *jouissance*, which loosely translates to "enjoyment," is utilized as a nod to 20th–century French feminist thinkers Hélène Cixous, Julia Kristeva, and Luce Irigaray. Women, they argue, must recognize and assert their corporeal "jouissance" to subvert phallocentric oppression.[20] For Mary, this means rediscovering and expressing the body that Catholic history has attempted to confiscate

Figure 2: Soasig Chamaillard, Notre Dame de la jouissance *("Our Coming Lady"), 2019, salvaged statue, plaster, conch, aluminum frame, acrylic paint, resin, gold leaf, 40 cm. Source: https://www.soasig-chamaillard.com/.*

Figure 2a: Soasig Chamaillard, Detail, Notre Dame de la jouissance *("Our Coming Lady"). Source: https://www.soasig-chamaillard.com/.*

from her. As a more playful approximation of this idea, the English title draws attention to Mary as she "comes" (i.e., emerges from the shell) *and* as she "comes," (i.e., orgasms). Consistent with the latter half of this cheeky double entendre, the shell is overtly vaginal in form. Marked by its soft pink interior, curvilinear edges, and glossy lacquer that imparts the illusion of moisture, the shell acts as an open proxy for Mary's genitalia. Thus, the fluid exploding from the shell can be understood as a symbol of female ejaculation. Rising from this discharge, Mary gazes downward in what would typically be a pose of humility. However, her serene expression is more proud than demure. After centuries of religious preoccupation with Mary's vagina as a source of life, it is liberating to recognize its merit as a source of pleasure. This liberation is made complete by the work's omission of a male presence.

Mary's solitude in *Notre Dame de la jouissance* challenges a Catholic male gaze that prioritizes the performance of women's bodies as they might serve men. Because the Church has historically regarded women as lesser, its matriarch must unfailingly hail masculine ambition and promote masculine agendas.[21] These requirements unfold within the Marian narrative: Mary is born as a result of *male*[*] (albeit divine) intervention[†] in order to birth a *male* child before being assumed into heaven to serve her male child in perpetuity.[22,23] Regrettably, this masculine control over Mary's physical, mental, and spiritual body is not an anomaly. Instead, it is an integral part of a larger pattern that confines women.

On the experience of being a woman,

* Although some theologists and practitioners of Catholicism conclude that the idea of 'God' transcends that of gender, God has historically been associated with a masculine, He/Him, identity. From the earliest editions of the Old Testament, God has been described by scholars and parishioners alike as ubiquitously male. This comes as no surprise considering the Old Testament arose out of the patriarchy of the ancient Near East. The New Testament similarly refers to a male God, in some versions even going so far as to include the Holy Spirit in this 'maleness,' via the masculine Greek word *Paraclete* ("Comforter"). Although the many stories found in both the Old and New Testaments were compiled from oral retellings that spanned geography, language, and time, God consistently emerges as a male character. Working now within the bounds of the English language, the association between God and masculinity makes Mary's story completely dependent on an intangible insemination by a divine man.

† Although excluded from the canonical Bible, apocryphal texts such as The Protoevangelium of James tell of Mary's miraculous birth to parents Anne and Joachim. Elderly and childless, Anne and Joachim long suffered societal shame and anguish over their inability to conceive. After fervent prayer, an angel appeared to each of them, promising that they would be blessed with a child who would eventually play a pivotal role in God's plan.

Hélène Cixous writes, "[women have] been turned away from [their] bodies, shamefully taught to ignore them, to strike them with that stupid sexual modesty."[25] What Cixous labels as "sexual modesty" is not merely a superficial adherence to codes of conduct or dress; rather, it is an entrenched construct that dictates a woman's understanding of her own body and desires. According to Cixous, women have been taught to disassociate from their bodies and internalize a sense of shame for their own sexuality. In solution to this detrimental estrangement between a woman and her body, Cixous rather succinctly declares, "your body is yours, take it."[25] And Mary *does*. By achieving sexual gratification independently, Mary reclaims her body as it exists for her and her alone. This is not only a victory for Mary, but also, a victory for all womankind; if Mary, the paragon of female virtue, can accept, and even flaunt, her sexual desires, so too can all women everywhere.

Of course, obtaining comfort with sexuality is easier said than done. An everyday woman raised under strict Catholic circumstances cannot effortlessly detach her self-worth from its assumed dependence on men. Chung Hyun Kyung is one author who has attempted to ease this challenge. In her 1990 book *Struggle to be the Sun Again: Introducing Asian Women's Theology*, Kyung explores one way in which women may reconcile a Churchly upbringing with sexual freedom:

> [Mary's] virginity lies in her true connectedness to her own self and to God. It is 'an inner attitude, not a psychological or external fact.' When a woman defines herself according to her own understanding of who she really is and what she is meant for in this universe (and not according to the rules and norms of the patriarchy), she is a virgin.[26]

In redefining virginity thusly, Kyung allows for the possibility that liberation can be accomplished without necessarily relinquishing a personal connection to the Church. Taking from Mary's story what reverberates and discarding the rest shifts attention away from the biologically impossible virgin motherhood and resettles it onto a '*relational* reality' in which 'virginity' is symbolic of life's fullness.

Still, a conversation on virginity is incomplete without the recognition of Mary's predecessor: Eve. In *Notre Dame de la jouissance*, a brilliantly hued snake winds between Mary's feet, accented by gold filigree that matches Mary's coronet. Unlike canonical depictions of Mary in which she is shown crushing the snake, and thus succeeding where Eve failed, Chamaillard's Mary is featured alongside the snake, in harmony with all its associated sin. This juncture between Mary's 'virtue' and Eve's 'wickedness' is relevant as a hermetic repudiation of the contradictory expectations placed on women. To return to de Beauvoir:

> Woman is at once Eve and the Virgin Mary. She is an idol, a servant, the source of life, a power of darkness; she is the elemental silence of truth, she is artifice, gossip and falsehood; she is man's prey, his downfall, she is everything that he is not and that he longs for.[18]

If women are biological reproductions of Eve, then they are, by nature, Mary's antithesis. And yet, they are still held to the same standards as Mary.[27] Therefore, the Virgin-Whore dichotomy positions women as lifelong victims, destined to internally struggle against Eve's sinful stain and externally struggle for Mary's sublime purity.[28,*] However, in reconciling Mary and Eve in *Notre Dame de la jouissance*, Chamaillard does away with the polarizing divide between the two women and encourages others to do the same.

Like *Notre Dame de la jouissance*, *S'embrasser* ("Kissing"), boldly embraces Mary's sexuality (Figure 3). In this work, two identical, rainbow-colored Marian busts are shown moments before they join in a tender kiss. The two veiled busts are bordered in the customary Virginal blue, which gives way to green, followed by yellow, orange, red, and finally a deep purple that is painted upon the lips of both Marys. Each paint color is applied in a diagonal fashion so as to offer the illusion of nested hearts, hearts that are made whole only when the two figures are united. In direct salute to the LGBTQIA+ community, the rainbow color palette here pays homage to all those who have or will be ostracized as a result of their sexual identity.

While often papered over, homosexuality is far from absent in the Church. In the 1986 book *Immodest Acts: The Life of a Lesbian Nun in Renaissance Italy*, historian Judith Brown chronicles the story of Mother Superior Benedetta Carlini and Sister Bartolomea Crivelli, two Italian nuns who became romantically involved during the early 17th century. The duality of their identities made their physical union deeply scandalous; as women *and* conventual authorities, Carlini and Crivelli's relationship transgressed social and ecclesiastical norms alike. In an Early Modern Europe that believed 'proper' sex to be centered around the phallus, intimacy between these two women was considered a threat to the 'natural' order of the world.[29] Responding to a history of homophobia and paranoia around sex, *S'embrasser* opens a door toward inclusion as a potential feature of the sacred.

Though *S'embrasser*'s colorway implies a degree of homoeroticism, it bears mentioning that the woman that Mary kisses in *S'embrasser* is but a clone of herself. In uniting one Mary with another, Chamaillard proposes an alternate interpretation: that of self-love. This act of self-embrace speaks to a profound form of acceptance. It is a reclamation of the body and the spirit, where Mary, in loving herself, challenges a churchly doctrine that positions women as the bearers of male desire rather than as autonomous subjects. According to this reading, liberation begins first and foremost, within. Regardless of how the work is understood, *S'embrasser* successfully creates space for those who wish to come to grips with their personal and religious identities.[30]

A final facet of Mary's sexuality is revealed in *Sainte Marianne*, a work that intertwines eroticism and patriotism (Figure 4). In *Sainte Marianne*, a bare-breasted Mary decked in a white dress with a cobalt sash stands atop a rose branch, in reference to the Marian title *Rosa Mystica* ("Mystical

* Important to note here is that the Virgin-Whore dichotomy is not bound to French-Catholic culture. Rather, expressions of Mary alongside her promiscuous alter (Eve) crop up across the Americas, Europe, Asia, and Africa. A 2019 study of the Virgin-Whore dichotomy and its relation to the patriarchies of Israel, the United States, and Germany provides quantitative evidence to support the global nature of this phenomenon. The report found that patriarchy supporting ideologies that endorse a Virgin-Whore complex negatively correlate with male sexual satisfaction and relationship satisfaction. This correlation supports the belief that the Virgin-Whore dichotomy limits women's sexual freedom and that it detracts from male fulfillment.

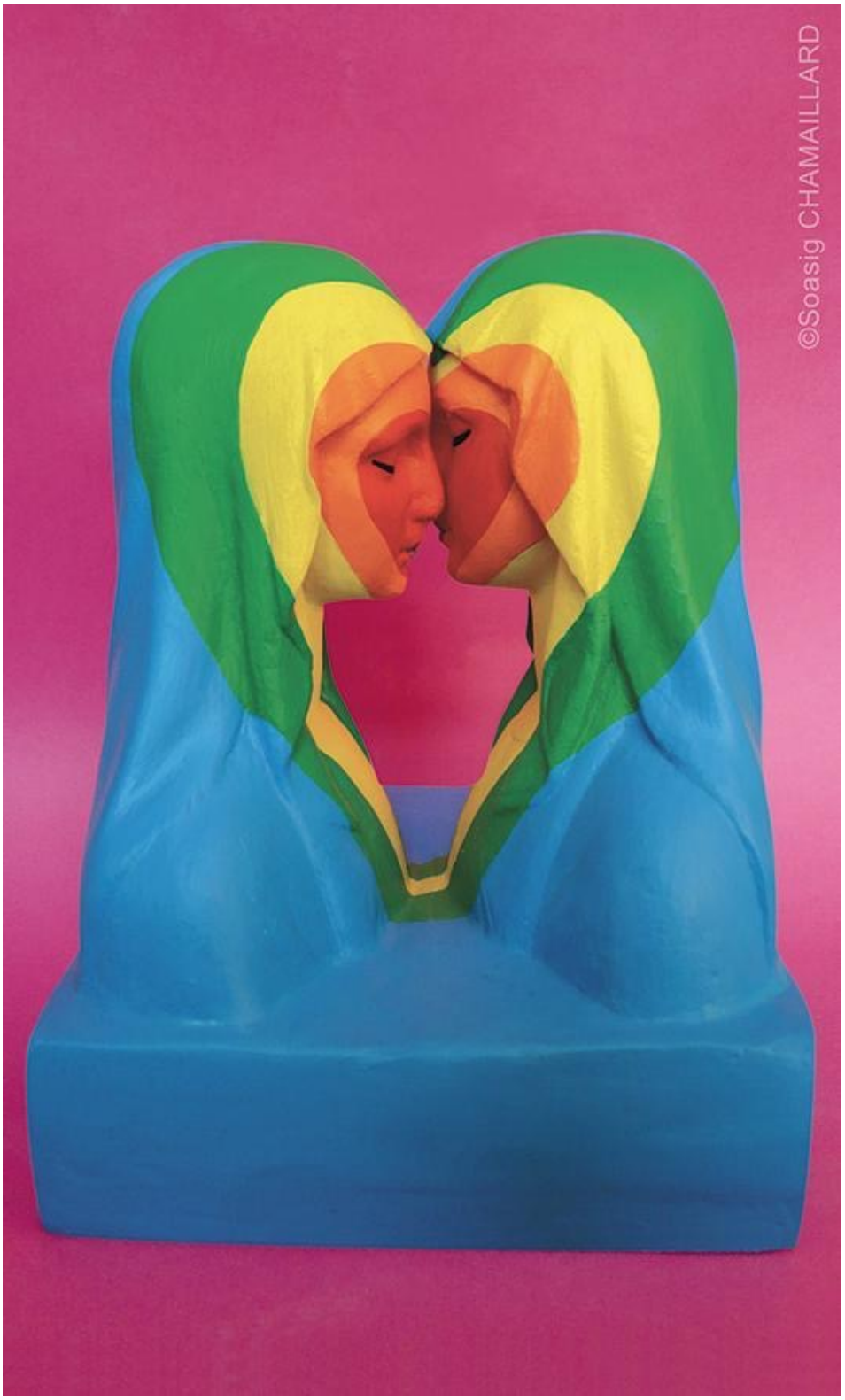

Figure 3: Soasig Chamaillard, S'embrasser *("Kissing"), 2007, salvaged statue, plaster, acrylic paint, 14 cm. Source: https://www.soasig-chamaillard.com/.*

Rose").[31,*] A cherry-red Phrygian cap covers her thick brown hair, and a silver rosary dangles from her right forearm. Emerging from smooth pale skin, shining blue eyes gaze toward the heavens with indifference, and hands join at the chest in prayer. Finally, glossy lips and painted fingernails and toenails modernize this Mary.

The Phrygian cap, also known as the liberty cap or bonnet rouge, was first employed as a symbol of freedom and resistance in France during the late 18th century.[32] The use of this symbol has arisen many times throughout French history and within French art, but perhaps most recognizably in Eugène Delacroix's 1830 painting, *Liberty Leading the People* (Figure 5). As a commemoration of the July 1830 revolution that deposed King Charles X, *Liberty Leading the People* depicts a triumphant allegory of Liberty in the form of Marianne, the national personification of the French Republic.[33] Though Delacroix's Marianne is posed more dynamically than Chamaillard's Mary, the similarities between the two works are incontrovertible. Most notably, the exposure of each figure's breast(s) equates the female body with notions of justice, perseverance, and democracy. Worth acknowledgment, however, is the fact that Chamaillard's Mary, as opposed to Delacroix's Marianne, is depicted with but a single breast showing, in line with Catholic tradition. The tradition of the bare-breasted Mary is presumably meant in ode to her motherhood. But too often, the revealing pose results in a rather seductive product; when a Marian image features a breast that is full, white, and punctuated by a nipple that faces the viewer in direct offering, lust is, for some, inevitable.[34]

Straddling the line between this traditional, if presumably accidental salacity, and a more deliberate eroticism, *Sainte Marianne* is uniquely restrained in its sexual tone. The rigidity of Mary's pose, of her gown, even of the roses at her feet, are suggestive of Mary's continued attachment to the Church—even within the context of Chamaillard's pseudo-secular art. After all, it is her rosary, the symbol of her own irreproachability and goodness, that grounds Mary's body, drawing the viewer's eye downward and providing a reminder that Mary still belongs to the Church.[35] *Sainte Marianne*'s fusion of religion, nationalism, and sex situates the work at the apex of Chamaillard's artistry. In toying with ideas of faith and freedom as

* Roses have been associated with Mary since as early as the 13th century. Saint Dominic, founder of the Dominican order and patron saint of astronomers and natural scientists, is credited with popularizing the Rosary of the Blessed Virgin Mary. The Rosary, which means "crown of roses," symbolizes the garlands of roses said to be worn in Heaven. Red roses in particular are traditionally emblematic of Mary's suffering. In an alleged apparition to Pierina Gilli in 1947, Mary referred to herself as a "mystical rose."

Figure 4: Soasig Chamaillard, Sainte Marianne*, 2012, salvaged statue, plaster, acrylic paint, resin, 43 cm. Source: https://www.soasig-chamaillard.com/.*

they present against the fabric of French (so-called) secularism and feminism, Chamaillard coaxes her viewers to question the ways in which Catholicism has infiltrated their own lives, the ways in which it has benefited them, the ways in which it has harmed them—and above all, the ways in which it has exploited its matriarch.

Conclusion

Many of Chamaillard's works, including *Sainte Marianne*, have been criticized for their flippant and audacious nature; even so, Chamaillard's dissection of the Marian figure remains essential. In a male-centric Church that discourages female expression, women have been forced to strive for a limited and unachievable model of behavior.[35] They are expected to emulate Mary's perfection and conceal their association with Eve, all while surreptitiously fornicating in order to fulfill their reproductive duty. The impossibility of these coexisting demands has ensured a history of female dependency and submission, a history that Chamaillard denounces. Whilst Mary can never exist as an altogether areligious icon, Chamaillard's daringly kitsch aesthetic is (mostly) effective in separating Mary from the Catholic standards she is habitually held to. Works such as *Déchirement*, *Notre Dame de la jouissance*, *S'embrasser*, and *Sainte Marianne* exhibit the ways in which Chamaillard mobilizes Mary in her promotion of those inalienable rights of all women. Though she is but one artist following but one path of Marian liberation, Chamaillard's works stand as an example of the respect that the Marian figure warrants. Her efforts have delivered Mary from a Catholic history of subjugation and birthed a feminist Virgin: A Virgin that can and should exist as an unyoked beacon of resilience and agency.

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Figure 5: Eugène Delacroix, Liberty Leading the People*, 1830, oil on canvas, 260 cm x 325 cm.*

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