

# ETHEL

An anatomical illustration of the human head and neck, focusing on the lymphatic system. The lymphatic vessels are depicted in a vibrant red color, forming a complex network that branches out from the head down to the upper chest. The background is a detailed blue-toned anatomical drawing of the underlying muscles, bones, and major blood vessels, providing a clear context for the lymphatic system's location and structure.

The ETHEL Undergraduate Research Journal  
Vol. 2, 2026



**The ETHEL Undergraduate Research Journal**  

---

*Vol. 2, 2026*



# Cover Art

## *Anatomical Illustrations of Our Time*

### **About the Cover Art**

'Anatomical Illustrations of Our Time' is a mixed medium painted illustration representing the relationship of arts and sciences throughout history and in current time. The piece uses researched historical methods of anatomical illustration in order to create a modern rendition of historical 18th-19th century lithograph anatomical illustration with modern materials. The work changes the context of typical anatomical illustrations and emphasises the creative influence behind the human artists who create scientific illustrations by creatively influencing an anatomically accurate depiction of the human throat and lungs with expressive medium application and color.

### **About the Artist**

Angelina Uy, also known as Blaise, is an Illustration student at UNC Charlotte who explores the visual appeals of intricate patterning, visual complexity, and vivid color. Working in a range of mediums, from digital work to gouache and oil paints, her work consistently uses intricacy and detail to create complex yet unified works for both fine arts and commercial purposes as a fine artist and illustrator. Her work creates narratives for the purpose of conversation and information. Ranging from works on femininity to scientific illustrations, Blaise uses her unique creative style to deepen the meaning of her work.

You can visit her website at  
[sites.google.com/view/angelina-blaise-uys-portfolio](https://sites.google.com/view/angelina-blaise-uys-portfolio)

# Letter from the Editors

It is our tremendous honor and pleasure to present to you the second volume of the *ETHEL Journal of Undergraduate Research* at The University of North Carolina at Charlotte. As *ETHEL* continues to develop its mission to provide a platform to all undergraduates across disciplines to showcase and broadcast their research, we are pleased to present four such publications in this year's journal. These papers represent the culmination of months of rigorous analysis, writing, and revision by the authors, our dedicated peer reviewers, and the *ETHEL* editorial board. For many of these student authors, the work published here serves as the defining capstone of their undergraduate experience, and we are proud to provide a forum to celebrate this achievement.

*ETHEL* is a student-run and student-edited journal that aims to highlight the tremendous work undertaken by undergraduates at UNC Charlotte and enable them to broadcast their findings, insights, and creations to the wider university community. Named after UNC Charlotte's founder, Bonnie Ethel Cone, *ETHEL* is also an acronym for the characteristics that comprise undergraduate research: Excellence, Transformation, Honor, Equity, and Leadership. This volume spans a diverse array of disciplines—from the biological sciences to sociology—supported by faculty mentors representing five different colleges and departments across the university.

We extend our deepest gratitude and congratulations to every student who submitted their work; without your contributions, this journal would not exist. We also thank our volunteer peer reviewers for their meticulous feedback, the Office of Undergraduate Research for fiercely promoting *ETHEL* across campus, and the faculty mentors who are instrumental in facilitating these brilliant research opportunities. Finally, we must recognize Dr. Eric Millard, the pioneering force behind a student-run research journal at UNC Charlotte and our faculty fellow for the past two years. Dr. Millard has guided *ETHEL* from its inception to this current release. His exceptional passion, devotion, and belief in undergraduate research have allowed this journal to blossom into the platform it is today.

We hope you enjoy the remarkable articles featured in this year's edition of *ETHEL*, and we thank you for your support of undergraduate research at UNC Charlotte.

Arnav Sareen  
Editor-in-Chief

Noor Chima  
Associate Editor-in-Chief



The *ETHEL* (Excellence, Transformation, Honor, Equity, Leadership) Journal of Undergraduate Research, is a dynamic, interdisciplinary platform that highlights student research, fosters innovation, upholds academic integrity, promotes inclusivity, and helps shape the next generation of leaders.

# Board

---

## Editorial Staff

### Editor-in-Chief

Arnav Sareen

### Associate Editor-in-Chief

Noor Chima

### Lead Designer

Rokia Sissoko

### Podcast Director

Ridhti Patel

### Social Media Coordinator

Alyssa Bissonnette

### Faculty Fellow

Dr. Eric Millard

---

## Associates

## Peer-Reviewers

Abhinav Biju  
Yazi Bulluck  
Emma Crawford  
Natalie Doerfler  
Lauren Feltz  
Alyssa Fowler  
Mehar Khanna  
Saanvi Kundu  
Stephanie Lewis  
Emma Miller  
Cory Nguyen  
Neha Panajkar  
Khushi Rathod  
Al Rego  
Ronnie Sahn  
Akshara Sisodiya  
Luis Tejada  
Rebecca Tirko

# Table of Contents

---

<b>07</b>	ADHD in the Global West: How Gender Influences Diagnosis Salma El-Houshy
<b>15</b>	Parameters that Define Resolution in Microscopy Ridhi Patel
<b>23</b>	Experience of a World Melded Through the Stripping of What's Rightfully Yours Sabrina Coffaro
<b>25</b>	To What Extent Can Herbal Interventions Reduce Benzodiazepine Reliance and Overmedication in Alcohol Withdrawal Syndrome (AWS)? Sydney McCoy
<b>35</b>	The Influence of Early Gendered Messages in the Household and Broader Society on Women's Financial Literacy and Investment Behaviors Later in Life Malimi Fernando & Gabriella Osorio

# ETHEL

The ETHEL Undergraduate Research Journal

---

*Vol. 2, 2026*



Learn more about ETHEL at  
**[etheljournal.com](http://etheljournal.com)**  
or @ETHELCharlotte on YouTube

Email us at  
[etheljournal@charlotte.edu](mailto:etheljournal@charlotte.edu)

# ADHD in the Global West: How Gender Influences Diagnosis

Salma El-Houshy

**Acknowledgements:** *I would like to express my deepest gratitude and appreciation for the support, time, and guidance I received from my friends, family, and my mentor, Dr. Rajwan Alshareefy, who have all seen my work at every stage, and encouraged me to pursue my research and improve it to the best possible quality. I would also like to sincerely thank Dr. Diane Zablotzky, for her time and assistance with revisions for this project, and for offering her continued reassurance and advice. Finally, I would like to thank the ETHEL board as well as peer reviewers for their tireless efforts in order to help me to put forward the best possible version of my paper.*

**Abstract:** A concerning phenomenon in the field of psychiatry has developed within the last 20 years: gender bias in diagnosis and treatment of neurodevelopmental disorders. Particularly, this trend can be seen in the diagnosis and treatment of attention deficit hyperactivity disorder—more commonly known as ADHD. Female patients are less likely to receive accurate and timely diagnosis and treatment of ADHD, which can present many obstacles and diminish quality of life. This paper examines the history of gender bias as it pertains to ADHD in the global West, how symptomology and presentation differ in male and female patients, and what the effects of delayed or inaccurate diagnoses can look like. This research also explores a solution as to how progress can be made to reduce gender bias and ensure that more female patients receive the diagnoses and treatments they need, while also looking into the challenges associated with implementing that solution.

**Research Advisor:** Dr. Rajwan Alshareefy, College of Humanities & Earth and Social Sciences

**Keywords:** Gender Bias, ADHD in Females, Gender Differences, ADHD Symptoms, Global West

## Introduction

The global West<sup>1</sup> has seen an alarming trend in the last two decades: female psychiatric patients are less likely to receive accurate and timely diagnoses of neurodevelopmental disorders than their male counterparts. There are several factors leading to this phenomenon, but gender biases are particularly prevalent. For instance, attention deficit hyperactivity disorder (ADHD) is one such condition whose rates of diagnosis are seeing significant effects due to these gender biases.

## Guiding Questions and Methodology

This paper intends to explore differences in gender as they pertain to ADHD diagnosis and treatment, with the results of this literature review identifying gender bias as a core factor for those disparities. Another key

element of this research is the discussion of possible solutions while also acknowledging the obstacles and limitations associated with the implementation of those solutions. This review asks: (1) How does gender bias disproportionately impact female patients' access to accurate, timely, and effective ADHD diagnosis and treatment as opposed to male patients? (2) How does ADHD present differently in female and male patients? (3) What can be done to fix this issue?

This review utilized international studies based primarily in the global West from the last ten to fifteen years, guided by key words and phrases like “gender bias,” “ADHD in females,” “gender differences,” “ADHD symptoms,” and more. Databases used include (but were not limited to) PubMed and the National Library of Medicine.

## Gender Bias and Its Consequences

What is gender bias? Gender bias can be defined as “favoritism toward one gender over another based on stereotyped beliefs about health, behavior, experiences, needs, and desires of men and women” (Barger et al., 2025). Gender bias in psychiatric diagnosis occurs when the gender of an individual skews their likelihood of receiving a particular diagnosis or the time at which they receive it. According to one study conducted in Wales, the ratio of male to female patients diagnosed with ADHD is 3.9 to 1 in clinical settings (Martin et al., 2024). In community or population-based samples, the ratio of males to females with ADHD is almost 2:1 (Martin, 2024). This indicates discrepancies between the clinical diagnosis rate and general likelihood of ADHD in men and women in everyday settings. Male patients have a higher likelihood of being diagnosed with ADHD in a clinical setting, so their presentation of symptoms and behavior is considered prototypical (the standard) for what the disorder looks like. “[B]oys are more likely to be referred, diagnosed, and treated for ADHD symptoms than girls” (Slobodin & Davidovitch, 2019).

The common misconception that ADHD is a “male” disorder often leads to less women and girls being diagnosed and treated. Findings by Platania et al. (2025) highlight that less than one-fourth of participants in the research that helped to define ADHD in the DSM-5 and ICD-11 were female. This lack of a diverse research sample reaffirms the damaging stereotype that ADHD does not affect females or affects them less. Furthermore, it reduces the body of research available to discern differences in presentation, which is imperative to accurately diagnose a disorder like ADHD. A 2013 study by Skogli et al. (2013) reveals that women and girls are also less likely to receive treatment for ADHD in comparison to men and boys with the same level of dysfunction. This creates a self-perpetuating cycle where ADHD is believed to impact the male demographic more, resulting in more diagnoses for men and boys. Female patients are diagnosed less, supporting the notion that ADHD more so affects male patients, causing the cycle to continue.

Gender bias in the field of psychiatry has caused many problems in a number of patients’ lives. Men and women have different symptoms of ADHD, including externalizing or internalizing behaviors and hyperactivity or inattention. Externalizing behaviors and hyperactivity tend to be more common in boys, while internalizing behaviors and inattention are more common in girls. As such, presentations of symptoms for ADHD and other neurodevelopmental disorders vary by gender among other factors. It is problematic to infer that the criteria for diagnosing one demographic of patients will yield accurate results for all patients. Furthermore, such biased practices can cause professionals to place more

weight on easily identifiable symptoms of ADHD in male patients and overlook important exclusionary factors that can prevent an unneeded diagnosis (Bruchmüller et al., 2012). They can also cause professionals to disregard symptoms that would encourage a specific ADHD diagnosis for female patients, rather than another disorder that may share some similar effects.

Gender bias might affect girls the most, but it can also affect boys seeking psychiatric help. A misdiagnosis or unnecessary diagnosis for disorders such as these can lead to a patient being prescribed medication they do not need, which may result in adverse effects on the individual’s behavior and experiences. On the other hand, not receiving a diagnosis for ADHD when one is needed can worsen a patient’s quality of life. Undiagnosed ADHD has been linked to higher rates of substance abuse, vehicular accidents, suicidal ideation, occupational struggles, unemployment, and divorce (French et al., 2023). More specifically, women whose ADHD goes untreated face higher risk of developing sleeping disorders and cardiovascular health issues, experiencing violence from an intimate partner, bullying, and are twice as likely to engage in self-harm (Murfit, 2025; Wilson, 2026). Almost 8 million people in the United States alone have ADHD, but only around 20 percent actually receive the care they need (Nobel, 2023). The remaining 80 percent are forced to reckon with the untreated effects of this condition, a struggle that is only further heightened in female patients. As such, it is necessary that gender biases are addressed and eliminated in the field of psychiatry.

## Background

To improve the accuracy of diagnoses, reviewing the methodology by which they are assessed will be crucial. “Understanding the role of gender in ADHD care has been historically hindered by methodological issues, such as involving relatively low numbers of girls in research samples, failing to control for possible gender effects, and relying solely on subjective scales which are often subjected to reporter’s bias” (Slobodin & Davidovitch, 2019).

A major factor in the issue of gender bias in ADHD diagnosis is the lack of female representation in research on neurodevelopmental disorders.

## Underrepresentation of Females in ADHD Research

A lack of representation and participation by female patients in research is one of the main factors that perpetuates misdiagnosis or lack of a diagnosis. As established earlier, male-centric criteria used to diagnose ADHD emerged due to a lack of female representation and the misguided assumption that male presentations of ADHD are “one-size fits all”. Misinformation or a lack of

information about female presentation of symptoms furthers the likelihood that professionals will rely on male centered research for diagnosis of the general population.

## **Gendered Symptom Presentation**

Within the disparities of symptom presentation, much can be said about the specific differences that continue to feed into a lack of diagnosis for many female patients. For one, male and female patients have different phenotypes for behavior. “In children diagnosed with ADHD, males are more likely to express hyperactivity than females, and females are more likely to show inattention as the predominant presentation; similar patterns have also been observed in adults” (Bölte et al., 2023). Thus, it can be attributed to this fact that female patients are commonly underdiagnosed or misdiagnosed, since they do not fit the prototypical presentation of ADHD symptoms associated with male patients (Barclay, et al., 2024).

Internalizing behaviors, such as being inattentive, forgetful, disorganized, or anxious, all disrupt an individual’s ability to focus. In contrast, externalizing behaviors like hyperactivity, impulsivity, or aggression cause outward disruption to the environment around an individual. Internalizing behaviors are more common in girls and are not as likely to cause problems in a school setting (Attoe and Climie, 2023). Less outward disruption means that less attention will be given to symptoms even though they may still cause dysfunction. For example, being inattentive will still result in the individual with ADHD having trouble focusing or absorbing information, but it does not interrupt classroom function nearly as much. This leads to less concern being raised, meaning less girls get referrals, diagnoses, or treatment (Slobodin & Davidovitch, 2019).

A 2023 literature review by Attoe and Climie highlights that women and girls face higher risk of social judgement and repercussions when they exhibit symptoms consistent with ADHD. Perhaps because of this, female patients have an increased likelihood of cultivating better ways to cover up their ADHD than their male counterparts. This results in more female patients avoiding or hiding the struggles associated with ADHD (Slobodin & Davidovitch, 2019). Women are also more likely to experience ADHD and a condition with overlapping symptoms such as depression, anxiety, or an eating disorder simultaneously,

making the root cause of symptoms harder to identify (Attoe & Climie, 2023; Quinn & Madhoo, 2014).

Another factor is how much research is being done on the variety of neurodevelopmental disorders. As found in a systematic literature review conducted in the United Kingdom, “most research focuses on autism, and to a lesser extent on ADHD and tic disorders, whereas research for other diagnoses is selective or absent” (Bölte et al., 2023). Not all neurodevelopmental disorders are examined with the same research backing. Though ADHD is researched more than some other conditions, it still does not have a lengthy body of research behind it. That lack of information can further the difficulty in diagnosing male and female patients alike as promptly as possible. Furthermore, female patients being diagnosed with the criteria developed from the currently available ADHD research can cause many issues. This is due to the ADHD research being almost exclusively done on male patients, despite it being known that women and men can (and usually do) experience ADHD differently.

## **Conclusion**

The solution to this ever-growing issue has two main aspects: raising awareness of differences in symptoms for male and female patients, and inclusion of female patients in research. These two steps will make a significant impact on the lives of patients with neurodevelopmental conditions. To aid in ensuring the timely and accurate diagnoses of individuals with neurodevelopmental disorders, especially ADHD, it is important to implement education efforts geared towards psychiatric professionals and prospective patients. To obtain the information needed to curb gender biases in the psychiatric field, more diverse demographics must be included in future research. Diverse research samples provide more data on how different demographics are impacted. If there are more samples of female participants, it becomes easier to understand how these biases impact their diagnoses, what their symptoms look like, and how they differ from male presentation. “Only by studying both males and females in both human studies as well as animal models and considering how sex interacts with gender norms and societal expectations to lead to diagnostic biases will we gain a complete picture of how neurodevelopmental disorders arise and grasp the full complexity of the etiology, symptomology and treatment strategies for these complex conditions” (Breach and Lenz, 2023).

This solution, while uncomplicated in concept, may be complicated to implement. As established by D’Mello et al. and Bolte et al. (2023), pleas made to integrate female subjects into neurodevelopmental research

have seldom been heard. The lack of inclusion stems from the historical myth that ADHD impacts men and boys much more than women and girls. Thus, it is imperative to first spread increased awareness on the issue. It is also imperative to display how impactful ADHD is on the greater population of not only neurodevelopmental patients, but also their families and the scientific community as a whole. In a 2023 US study, more than 15 percent of children and adolescents were found to have some form of a neurodevelopmental condition or developmental disability (Li et al., 2023). Furthering this assertion, according to the CDC, around 1 in 6 US children have a developmental disability (CDC, 2024). With this in mind, one can imagine the population of female patients in this group would be quite large. The likelihood of an adolescent having ADHD or a similar condition is fairly common, so it stands to reason that there are many prospective female patients who have not yet been able to obtain a diagnosis. Therefore, it is a disservice to the female youth population of not just the United States, but, as posited earlier, of the global West as a whole, to not take action on this issue.

## **Raising Awareness & Reducing Stigma**

One step that can be taken to spread awareness is to publicize and make information more readily available to the public. Through engaging in discourse in public and clinical settings about the discrepancies in research and diagnosis, the field of psychiatry can begin to dismantle the inaccuracies and biases that have plagued and continue to plague it. Engaging in discourse can look like discussions in academic circles about how to improve the research and diagnostic process. Discourse can also include speaking freely and openly about the subject in non-academic spaces, including social media or everyday conversation. Conversations around the topic in very public, easily accessible settings can help spread awareness on the issue as well as bring the conversation closer to home for women and girls. This will help female youth identify symptoms within themselves, leading to their pursuit of a diagnosis. More than 95 percent of young people cite limited knowledge of mental health conditions as a key factor in the avoidance of seeking treatment, according to a systemic review done on more than 50 studies by the journal for European Child and Adolescent Psychiatry (Radez et al., 2020).

Not only this, but dissolving stigma around mental health and research on it can create a more encouraging and inviting environment for researchers and subjects to work together and further study this

topic. This will ultimately contribute greatly to the body of knowledge surrounding the issue and eliminate stigma or discomfort surrounding the discussion of mental health diagnosis/ treatment. In fact, 92 percent of children and adolescents cite this negative stigma as a reason they avoid seeking treatment (Radez et al., 2020). If female patients can feel more secure in their understanding of symptoms and more comfortable seeking treatment, then they can begin the process of receiving the help they need. Additionally, when more female patients seek treatment, professionals will have a larger set of data to better understand how these conditions develop in female patients and what treatments are most compatible with them.

## **Increasing Female Participation in Research**

With awareness being spread, the focus shifts to how female patients can be integrated into more research. Methods like publicization of findings and knowledge on the issue can promote other studies, as well as inspire people to participate and engage in them. This publicization can be brought about in a number of ways, such as publishing findings in more general venues, such as news outlets or journalism articles. They can also be distributed in pamphlets in doctors' offices to encourage patient interaction with the information. This way, the research can be readily available to the general public, and anyone can spread awareness to female adolescents. The patients themselves will also be able to access the information independently. When academics and the general public engage in a mutual exchange of information, gaps in the collective understanding of the topic can begin to be filled.

While expanding the conversation is beneficial, it is not sufficient alone. There have been attempts made by female patients and their families to advocate for a better understanding of and more research on gender as it relates not only to ADHD diagnosis, but its treatment as well. However, not many studies have explored differences in access to and impact of intervention on women and men with neurodevelopmental conditions (Bölte et al., 2023). The scientific community must be willing to seek out female participants and conduct research on their presentations of symptoms. In order for this to happen, it is important to continue campaigning for more female patients to be included in research, putting pressure on professionals in the field to ensure equality and equity. One case of a successful campaign for the inclusion of female patients in ADHD research can be found in

the United States through the Duke Center for Girls & Women with ADHD. The initiative was founded in 2021 and remains one of the only specialized programs dedicated to furthering understanding of female ADHD manifestations. The center was established following a donation from an anonymous donor family. The project functions as a dedicated sector of Duke's ADHD program, with 30 years of research on the disorder (Hart, 2025).

The Center for ADHD in Girls & Women with ADHD is focused on putting women and girls at the forefront of ADHD research as well as providing educational resources and community for professionals and the public alike about ADHD in females. It also places an emphasis on supporting and uplifting current or prospective female patients with ADHD, including curating materials dedicated to navigating pregnancy with ADHD or information on how to initiate conversations with primary care providers about ADHD (Duke Center for Girls & Women with ADHD, 2024).

Efforts like this are vital and should be replicated. Furthermore, psychiatric professionals must be prepared to face biases and misinformation in the field head-on and make an active effort to amend them. Professionals can also be incentivized to partake in this research through the means of grants from large organizations like the NIH, WHO, and CDC. These organizations all emphasize the importance of research in fields that impact the well-being of the greater global population; a topic whose sentiment this issue embodies.

In a several year time frame, the goal is to have fully integrated female patients into research on ADHD. Another aim is to have significant increases in studies and bodies of work published on their presentations of symptoms and the methods of intervention most compatible with the female manifestation. Mental health impacts everyone, and all people should be entitled to timely and accurate aid and support. Furthermore, when more is known about female presentations of mental health symptoms (what they are and what they are not), the collective understanding of male mental health is deepened as well. It makes the similarities and differences between male and female patients clearer, along with what methods of treatment help which demographic.

## ***Limitations***

A solution to this issue cannot be discussed without also considering the limitations that may arise. For one, accessibility to information on this issue can pose difficulties in the pursuit of a remedy. Even if information is publicized

and readily available, it may not be accessible to certain demographics, such as those living in more rural areas. Moreover, it is not just the information that may present accessibility issues. The ability to participate in research may also be limited by distrust in the research setting and lack of time (Bixo et al., 2019).

Additionally, access to mental health intervention services may be restricted by these factors as well. Lower socio-economic status can also be tied to less insurance coverage as well as less quality in care and intervention (Gornik and Salgado, 2022). According to the Access Psychology Foundation, the high cost of treatment and limited options can impact the likelihood of seeking help. Moreover, “[o]verly narrow provider networks and high out-of-pocket costs are substantial barriers to individuals accessing mental health treatment” (National Alliance of Mental Illness, 2025). One barrier that must be broken to make mental health care accessible is making it more affordable. Providing prospective patients with services that are accessible, more varied to suit individual needs, and inexpensive is imperative to helping get more female patients involved and treated effectively.

In conclusion, while underrepresentation and bias play significant roles in diminished rates of diagnosis and treatment, a solution is possible. Despite barriers that may obstruct the implementation of solutions, it is not only possible to overcome them, but is also imperative. In short, solving the issue of gaps in ADHD research is beneficial not just to the underrepresented group, but to all parties involved. Neurodevelopmental conditions, including ADHD, are neither male nor female issues; they are human issues.

---

<sup>1</sup>The global West can be defined as the United States, Canada, the United Kingdom, and other regions of North America and Western Europe.

## References

- Access Psychology Foundation. (2025). Evidence-based mental health services. Access Psychology Foundation. <https://www.access-psychology.org/about-us/>
- Attoe, D. E., & Climie, E. A. (2023). Miss. diagnosis: A systematic review of ADHD in adult Women. *Journal of Attention Disorders*, 27(7), 645–657. <https://doi.org/10.1177/10870547231161533>
- Barclay, I., Kapil, S., Ford, T., John, A., Taylor, M.J., Thapar, A., Langley, K., & Martin, J. (2024). Investigating the reasons behind a later or missed diagnosis of attention-deficit/hyperactivity disorder in young people: A population cohort study. *JCPP Advances*. <https://doi.org/10.1002/jcv2.12301>
- Barger, S., Schaap, L. A., Castellini, G., Gianola, S., Innocenti, T., Ostelo, R., Tomaiuolo, R., Vidal-Itriago, A., & Rubinstein, S. (2025). Exploring the definitions of gender bias in healthcare literature: a scoping review protocol. *MethodsX*, 15, 103545. <https://doi.org/10.1016/j.mex.2025.103545>
- Bixo, L., Cunningham, J.L., Ekselius, L., Öster, C., & Ramklint, M. (2019). “Sick and tired”: Patients reported reasons for not participating in clinical psychiatric research. *Health Expectations*, 24(S1), 20–29. <https://doi.org/10.1111/hex.12977>
- Bölte, S., Neufeld, J., Marschik, P.B., Williams, Z.J., Gallagher, L., & Lai, M. (2023). Sex and gender in neurodevelopmental conditions. *Nature Reviews Neurology*, 19(3), 136–159. <https://doi.org/10.1038/s41582-023-00774-6>
- Breach, M.R., & Lenz, K.M. (2023). Sex differences in neurodevelopmental disorders: A key role for the immune system. *Current Topics in Behavioral Neurosciences*, 62, 165–206. [https://doi.org/10.1007/7854\\_2022\\_308](https://doi.org/10.1007/7854_2022_308)
- Bruchmüller, K., Margraf, J., & Schneider, S. (2012). Is ADHD diagnosed in accord with diagnostic criteria? Overdiagnosis and influence of client gender on diagnosis. *Journal of Consulting and Clinical Psychology*, 80(1), 128–138. <https://doi.org/10.1037/a0026582>
- Center for Disease Control. (2024). Developmental disabilities. Environmental Public Health Tracking <https://www.cdc.gov/environmental-health-tracking/php/data-research/developmental-disabilities.html>
- D’Mello, A.M., Frosch, I.R., Li, C.E., Cardinaux, A.L., & Gabrieli, J.D. (2022). Exclusion of females in autism research: Empirical evidence for a “leaky” recruitment-to-research pipeline. *Autism Research*, 15(10). <https://doi.org/10.1002/aur.2795>
- Duke Center for Girls & Women with ADHD. Duke Department of Psychiatry & Behavioral Sciences. (2024). Duke. <https://psychiatry.duke.edu/duke-center-girls-women-adhd>
- French, B., Daley, D., Groom, M., & Cassidy, S. (2023). Risks associated with undiagnosed ADHD and/or Autism: A mixed-method systematic review. *Journal of Attention Disorders*, 27(12). <https://doi.org/10.1177/10870547231176862>
- Gornik, A & Salgado, R. (2022). Health disparities and ADHD. *Attention Magazine*. <https://chadd.org/adhd-news/adhd-news-caregivers/healthcare-disparities-and-adhd/women>
- Hart, D. (2021). \$1M gift will establish ADHD center for girls and women. Giving to Duke Health. <https://giving.duke-health.org/why-give/inspirational-stories/meet-donors-like-you/gift-will-establish-adhd-center-girls-and-women>
- Li, Q., Li, Y., Zheng, J., Yan, X., Huang, J., Xu, Y., Zeng, X., Shen, T., Xing, X., Chen, Q., & Yang, W. (2023). Prevalence and trends of developmental disabilities among US children and adolescents aged 3 to 17 years, 2018–2021. *Scientific Reports*, 13(1), 17254. <https://doi.org/10.1038/s41598-023-44472-1>
- Martin J. Why are females less likely to be diagnosed with ADHD in childhood than males? *Lancet Psychiatry*. 2024 Apr;11(4):303-310. doi: 10.1016/S2215-0366(24)00010-5. Epub 2024 Feb 7. PMID: 38340761.
- Martin, J., Langley, K., Cooper, M., Rouquette, O.Y., John, A., Kapil S., Ford, T., & Thapar, A. (2024). Sex differences in attention-deficit hyperactivity disorder diagnosis and clinical care: a national study of population healthcare records in Wales. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 65(12). <https://doi.org/10.1111/jcpp.13987>
- Murfit, T. (2025). Untreated ADHD in female adults. Oxford CBT. <https://www.oxfordcbt.co.uk/untreated-adhd-in-female-adults/>
- National Alliance on Mental Illness. (2025). The Doctor is Out. NAMI. <https://www.nami.org/Support-Education/Publications-Reports/Public-Policy-Reports/The-Doctor-is-Out/>
- Nobel, D. (2023). ADHD symptoms are underdiagnosed in adults — And that has consequences. Mayo Clinic Press. <https://mcpres.mayoclinic.org/mental-health/adult-adhd-and-how-to-treat-it/>
- Oroian, B. A., Costandache, G., Popescu, E., Nechita, P., & Szalontay, A. (2024). The uncharted territory of female adult ADHD: A comprehensive review. *European Psychiatry*, 67(S1), S299–S300. <https://doi.org/10.1192/j.eurpsy.2024.624>
- Platania, N. M., Starreveld, D. E. J., Wynchank, D., Beekman, A. T. F., & Kooij, S. (2025). Bias by gender: exploring gender-based differences in the endorsement of ADHD symptoms and impairment among adult patients. *Frontiers in global women’s health*, 6, 1549028. <https://doi.org/10.3389/fgwh.2025.1549028>
- Quinn, P. O., & Madhoo, M. (2014). A review of attention-deficit/hyperactivity disorder in women and girls: uncovering this hidden diagnosis. *The primary care companion for CNS disorders*, 16(3), PCC.13r01596. <https://doi.org/10.4088/PCC.13r01596>
- Radez, J., Reardon, T., Creswell, C., Lawrence, P. J., Evdoka-Burton, G., & Waite, P. (2020). Why do children and adolescents (not) seek and access professional help for their mental health problems? A systematic review of quantitative and qualitative studies. *European Child & Adolescent Psychiatry*, 30(2), 183–211. <https://doi.org/10.1007/s00787-019-01469-4>

- Skogli, E. W., Teicher, M. H., Andersen, P. N., Hovik, K. T., & Øie, M. (2013). ADHD in girls and boys--gender differences in co-existing symptoms and executive function measures. *BMC psychiatry*, 13, 298. <https://doi.org/10.1186/1471-244X-13-298>
- Slobodin, O., & Davidovitch, M. (2019). Gender differences in objective and subjective measures of ADHD among clinic-referred children. *Frontiers in Human Neuroscience*, 13(441). <https://doi.org/10.3389/fnhum.2019.00441>
- Wilson, N. (2026). Why ADHD goes underdiagnosed in girls. *Nature*. <https://doi.org/10.1038/d41586-026-00098-7>
- Young, S., Adamo, N., Ásgeirsdóttir, B.B., Branney, P., Beckett, M., Colley, W., Cubbin, S., Deeley, Q., Farrag, E., Gudjonsson, G., Hill, P., Hollingdale, J., Kilic, O., Lloyd, T., Mason, P., Paliokosta, E., Perecherla, S., Sedgwick, J., Skirrow, C., & Tierney, K. (2020). Females with ADHD: An expert consensus statement taking a lifespan approach providing guidance for the identification and treatment of attention-deficit/ hyperactivity disorder in girls and women. *BMC Psychiatry*, 20(1), 404. <https://doi.org/10.1186/s12888-020-02707-9>

# About the Author



**Salma El-Houshy** is a first-year student majoring in Psychology, with plans to double-major in Biology and pursue a minor in Cognitive Science. Her research area focuses on the impacts of culture and societal structures on the ability of marginalized and underrepresented groups to receive mental health support and treatment, and how advocacy plays a crucial role in improving those services. Her research advisor is Dr. Rajwan Alshareefy from the College of Humanities & Earth and Social Sciences.

# Parameters that Define Resolution in Microscopy

Ridhti Patel

**Acknowledgments:** *We would like to thank Dr. Alain Burette from UNC Chapel Hill's Neuroscience Center for acting as the primary mentor for this research. This project would not have been possible without his guidance and support every step of the way. Additionally, we would also like to thank Dr. Philpot, PI of the Philpot Lab, without whom we would not have had access to the required facilities and materials to complete this study.*

**Abstract:** Microscopy, especially confocal microscopy, is an extremely powerful imaging tool for visualizing subcellular structure, but quantitative measurements in confocal images are prone to distortion depending on how the instrument is configured. This study investigates how two key acquisition parameters, the confocal pinhole size and the fluorophore emission wavelength, can affect the apparent feature diameter and, consequently, the effective resolution of images. Using P60 wild-type mouse brain tissue, stained for neurofilaments with SMI-31 primary antibodies, and multiple secondary antibodies (Alexa Fluor 488, 594, 647), as well as fluorescent beads, images were acquired on a Leica Stellaris 5 confocal microscope across a range of pinhole sizes and emission channels. The feature diameters were quantified from intensity profiles using ImageJ and summarized into graphs. Our findings aligned with the idea that as the pinhole size increased, the bead filament diameters also systematically increased. This is consistent with greater transmission of out-of-focus light and image blurring. Conversely, as the pinhole decreased, sharper but dimmer images were produced. Thus, illustrating the tradeoff between resolution and signal. Similarly, longer emission wavelengths were associated with larger measured filament diameters. Reflecting the fundamental link between wavelength and diffraction-limited resolution. Altogether, these findings demonstrate that both pinhole size and fluorophore wavelength significantly influence the measured structure size in confocal images, underscoring the need to optimize and standardize these parameters when performing quantitative morphometric analyses.

**Research Advisor:** Dr. Alain Burette, Department of Cell Biology and Physiology (UNC Chapel-Hill Neuroscience Center)

**Key words:** Resolution, Confocal Microscopy, Myelin, Pinhole Size, Frequency, Background

## Introduction

Microscopy is an important tool widely used to discover the makeup of cells and tissues. It allows for the visualization of minuscule biological structures, otherwise invisible to the naked human eye. Through this process, new discoveries are made by examining the fine details of the images leading to different therapies and solutions to various disorders and conditions. Among all types, confocal microscopy is the workhorse of microscopes [1]. The main purposes of a confocal microscope are optical sectioning for 3D representations of imaged samples and producing a point source of light and rejecting out-of-focus light, enabling deep tissue viewing with high resolution [5]. Confocal microscopy uses a pinhole to reject out-of-focus light, thereby sharpening the image [1]. To operate a confocal

microscope correctly, it is essential for the user to understand its inner workings, especially for quantitative analysis. For the best possible images, Two important factors affecting resolution are the pinhole size and emission wavelength [1]. Here we are studying how changing the pinhole size and emission wavelength affect image qualities.

To understand how to attain the best results when imaging, it is crucial to understand the physics behind the working confocal microscope and how an image is produced through its mechanics. We imaged with a microscope that had two laser options. There is a white light laser with up to five visible line lasers ranging from 485 nm to 685 nm and an ultraviolet laser with a wavelength of 405 nm [6]. From there, whichever laser is chosen is then filtered through what is known as an

acousto-optical tunable filter (AOTF) [6]. The white light laser is split into two beams going in opposite directions, and the UV laser beam only goes in one [6]. Then, if the white light laser is chosen, the beam path that goes in the same direction as the UV laser then goes through the acousto-optical beam splitter [6]. The purpose of the beam splitter is to separate the path of light that is being omitted from the white light laser and connect it to a visual medium such as a camera that is attached to the microscope [1,5,6]. Similarly, if the UV laser is selected, it has to pass through the UV laser incoupling, which also allows for the transfer of this beam of light into an electronic viewing camera device [1,6,9]. After that, the paths followed by the UV and white light lasers follow the same path. Next, they go through a tandem scanner. This consists of a three-mirror scanning base with an interchangeable motorized mechanism for the x-scanner [6]. With this setup, it is possible to use a FOV scanner to scan huge regions with a high scan resolution and a resonant scanner to scan very quickly, both within the same instrument [1,6,9]. Next, the beam passes through an HIVISR optics lens and into the scan field rotation system. It allows you to virtually rotate the field of view [1,6,9]. Next, it goes through the selected objective lens. Normally, these range from 4x, 10x, 40x, and 63x and 100x oil immersion lenses [6,8]. Due to the light being diffracted multiple times when using the high-magnification objective lenses, the oil is used due to its refractive index, which permits the objective to gather more light to create an image and prevent any air gaps and refraction-related light loss [8,18]. Lastly, this end of the beam reaches the eyepiece, where the tissue can be seen with the naked eye [6]. This is only possible, though, because of the way the other beam of the split white light laser goes. As previously mentioned, the white light laser is split into two and the other beam goes in the opposite direction. First, it goes through the square confocal pinhole and then the fluorophore disc [6]. After that, color is detected from the secondary antibodies in the tissue by the SP detection system after the beam passes through the prism-based dispersion reflector [1,6,9,16]. Confocal microscopes, like all microscopes, are subject to the limitations imposed by light diffraction. This can be seen through a value known as the numerical aperture [10,17]. The numerical aperture of a microscope objective is an indicator of how well it can collect light and distinguish minute details in a specimen when operating at a set distance [10,15,17]. Resolution is inextricably tied to both the wavelength of light

employed and the numerical aperture (NA) of the optical elements of a microscope, such as the objective lens [8,9,15,10]. Resolution in microscopy refers to a microscope's capacity to identify specific details in a specimen or sample. The smallest distance at which an observer or a microscope camera can still distinguish between two distinct points on a specimen [1,5]. In addition to the objective lens, in a confocal microscope, light also goes through a pinhole, a small hole that allows you to reject any out of focus light [1]. Light of a specific wavelength is shot through the pinhole to then illuminate the tissue and form a visual image that is captured by the camera [1,19]. Smaller slit width results in better resolution but lower illumination,— while large slit width results in better illumination but lower resolution [1,5,12]. The light wavelengths also play an important role. Frequency of light and resolution are directly correlated, with high frequency resulting in higher resolution and low frequency resulting in lower resolution [1,5,15]. Since frequency and wavelength are inversely related, this would mean that light with a larger wavelength would have lower resolution and light with a smaller wavelength would have higher resolution [1,5,15]. And lastly, the diameter of structures viewed would be inversely proportional to the resolution and amount of light gathered [1,5,13]. The practical implication is that when one is looking at very fine structures, such as neurofilaments, one needs to be careful with quantitative measurements, as the apparent object sizes will change with microscope parameters. Here we investigate how the size of the pinhole and the choice of fluorophores influence microscope quantification.

## Materials and Methods

### *Animal Tissue Preparation*

We used an adult P60 wild type mouse. We deeply anesthetized P60 mice with sodium pentobarbital (60mg/kg, i.p.) before transcardially perfusing them with heparinized saline (0.9% NaCl, 10 IU heparin/ml), immediately followed by phosphate-buffered 4% paraformaldehyde, pH 7.3, at a rate of 9ml/min. After delivering 50 ml of fixative, we decapitated mice, postfixed their heads overnight at 4°C, and rinsed and stored them in PBS at 4°C until ready to be used [10].

### *Immunohistochemistry*

We rinsed sections several times in phosphate buffered saline (PBS), then 50% methanol and PBS, and finally PBS for 1 hour at room temperature. Sections were incubated at 37°C for 2hrs in permeabilization solution

(0.2% TritonX-100, 2% glycine, 20% dimethylsulfoxide in PBS) followed by 1h in blocking solution (0.2% TritonX-100, 1% fetal bovine serum). Sections were then incubated overnight with IgG mouse anti-SMI-31 antibody (1:500) in antibody solution (0.2% Tween-20, 40mg/l heparin, 11% bovine serum albumin, 5% dimethylsulfoxide in PBS ). Next, the sections were washed in Tween X-100 (PBS-T) 3 times for 5 mins at room temperature and incubated in a mixture of Alexa Fluor Donkey Anti mouse (Alexa Fluor 488, 594 and 647 at 1:400;) in antibody solution overnight. Finally, we rinsed sections several times in PBS-T and then PBS before mounting the sections on gelatin covered slides and coverslipping with vectashield. The prepared slides were then stored at 4° C [10].

### Image Acquisition and Processing

Slides were imaged on the Leica Stellaris 5 Confocal Microscope.

### Tissue

The tissue was imaged on xyz scan mode, at 400 Hz scan speed, HC PL APO CS2 100x/1.40 OIL objective with 1.518 refraction index, and channel detectors SiPM (432nm-476nm), HyD (504nm-583nm), and SiPM (663nm-750nm).

### Beads

The beads were imaged in xyz scan mode at 400 Hz scan speed with an HC-PL APO CS2 100x/1.40 OIL objective and channel detector SiPM (496nm 739nm).

### Data Processing

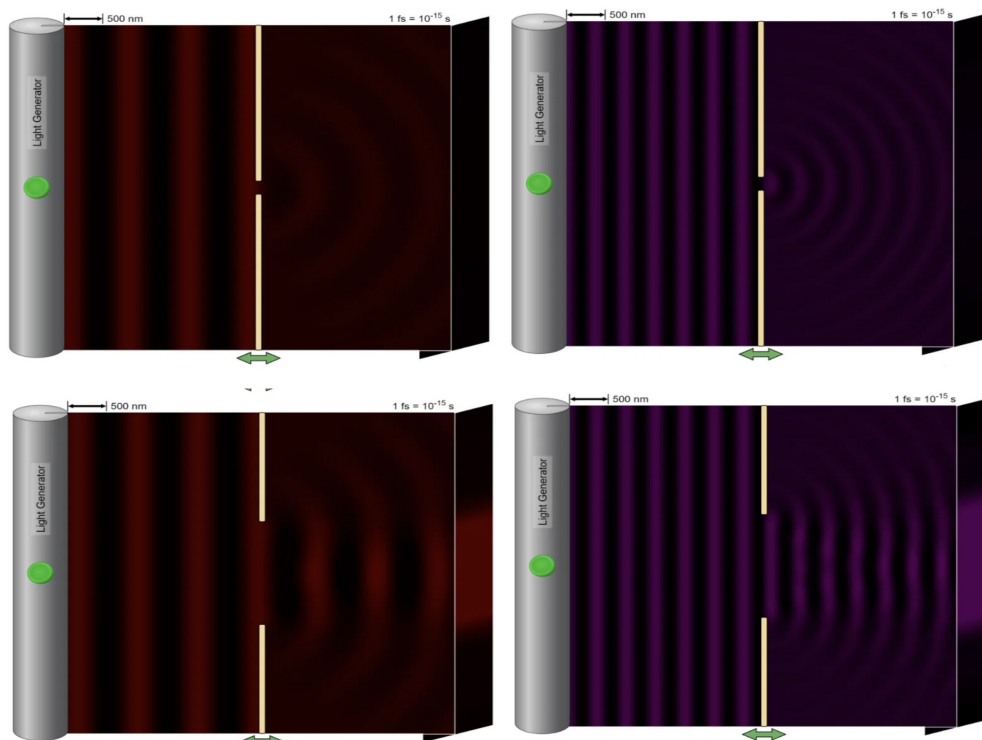
The data for graphs of diameter measured compared to wavelength and pinhole size was collected through the histogram feature of ImageJ software. Graphs were made in Microsoft Excel.

### Figure Production

We adjusted the pseudocolor images using a “fire” lookup table and measured the diameters of structures represented in images in microns. We also measured and recorded the diameters of microfilament structures multiple times for each image to view the average overall change. All images meant for direct comparison within figures underwent identical manipulations. All image editing was done with ImageJ software, and all figures were prepared using Corel Draw software.

## Results

The present study found that increasing pinhole size results in an increase in diameter. A smaller pinhole allows sharper imaging with more defined structures (**Figure 1**). A larger pinhole allows more light to pass through, resulting in greater illumination and elongation of structures (**Figure 2**).

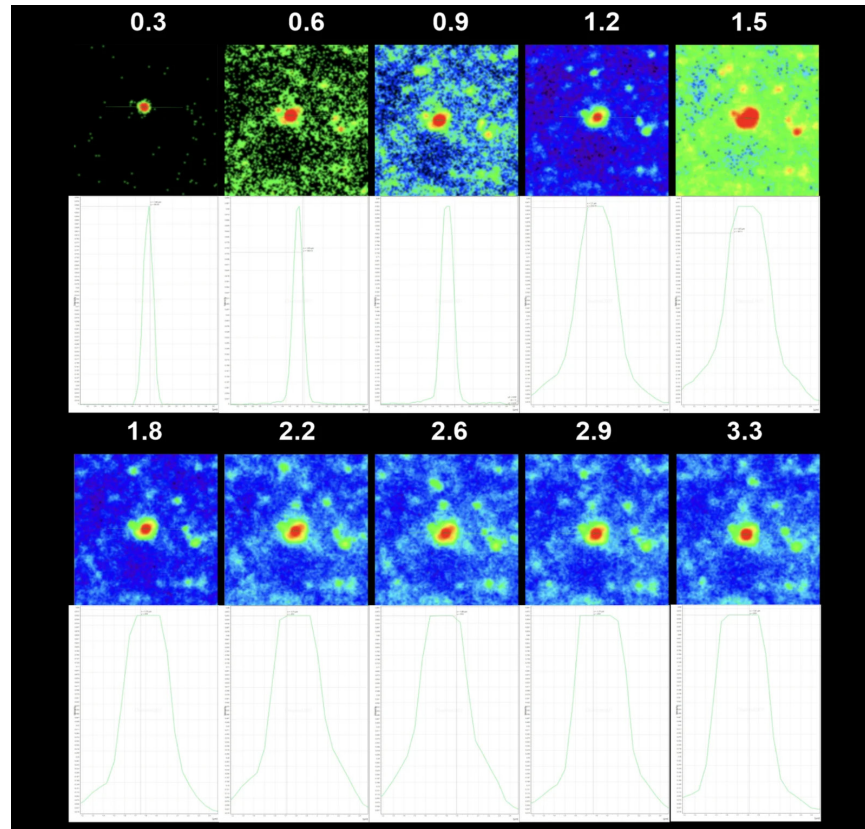


**Figure 1** - Laser light of the highest frequency (red) and lowest frequency (violet) is shot through the smallest pinhole size.(Figure created with Phet Interactive Simulations software.)

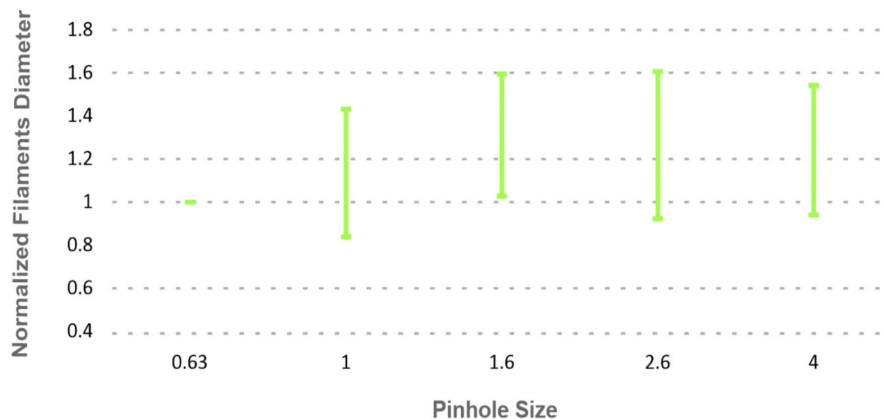
**Figure 2** - Laser light of the highest frequency (red) and lowest frequency (violet) is shot through the largest pinhole size.(Figure created with Phet Interactive Simulations software.)

The purpose of the pinhole is to eliminate any out-of-focus light. Imaging with a large pinhole would provide better light gathering of the section but would result in a loss of resolution due to unnecessary light passing through, suggesting a blurred image with an increase in diameter will be observed. To determine whether pinhole size and small feature diameter are directly related, we recorded diameter length across images collected of the same bead with ten different pinhole sizes (0.3, 0.6, 0.9, 1.2, 1.5, 1.8, 2.2, 2.6, 2.9, and 3.3 airy units [AU] ). We measured the diameter from one asymptotic tail to the other on the histogram. We subsequently verified

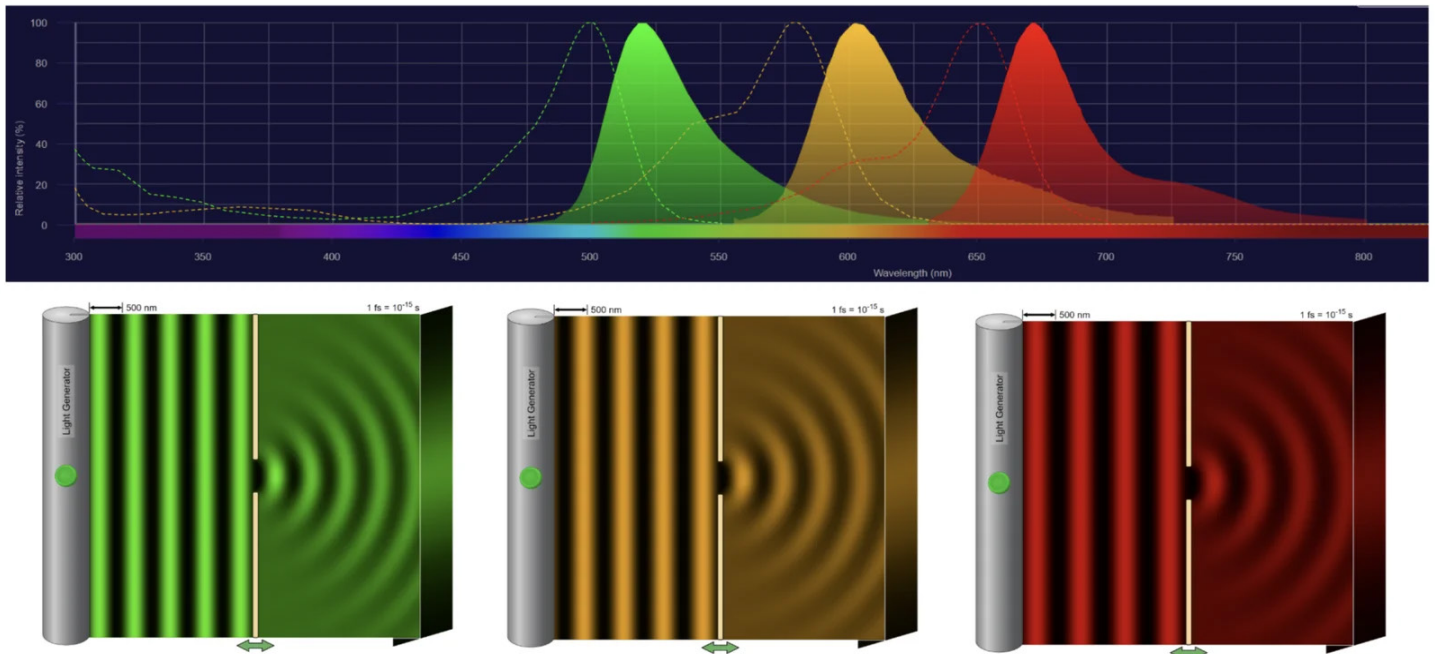
that as pinhole size increased, the diameter of the bead also increased, via blurring of the image from excess light (Figure 3). We imaged P60 WT mouse stained for IgG mouse anti-SMI-31 (neurofilament detector) and then imaged sections at five different pinhole sizes (0.63, 1, 1.6, 2.6, and 4). The graph shows an increasing trend between pinhole size and filament diameter (Figure 4). Increasing wavelength results in an increase in diameter. The findings show that when different light wavelengths are fired through a slit of the same width, structure diameters and wavelengths increase in a directly proportional manner (Figure 5).



**Figure 3** - A594 stained bead images and histograms of diameter at largest Z-stack slice. The top measurement values indicate the pinhole size and the horizontal displacement under histogram curve indicates the diameter.

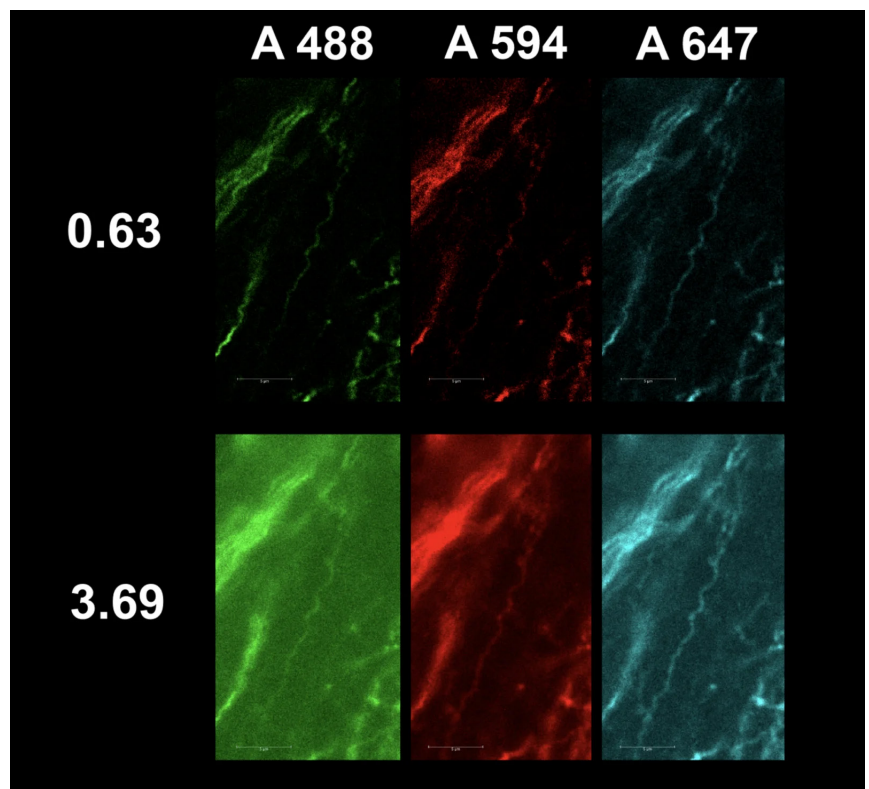


**Figure 4** - A graph of pinhole size and normalized filament diameter analysis.

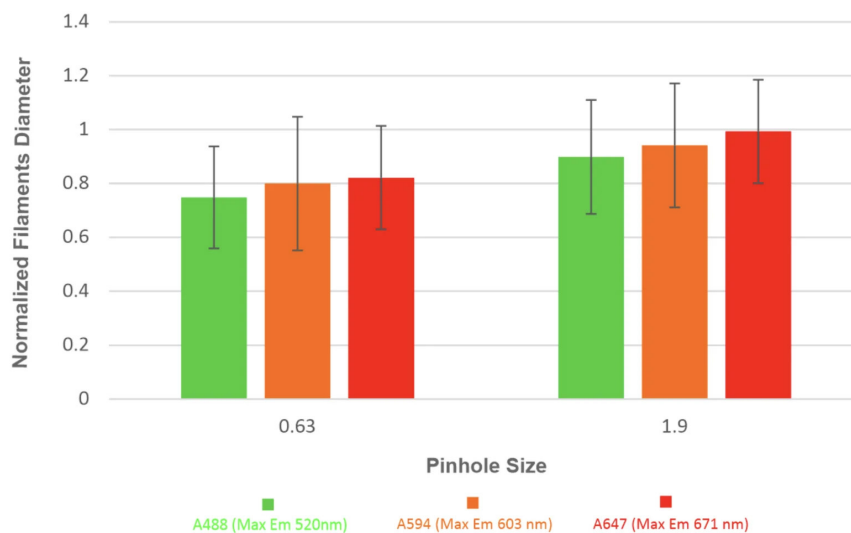


**Figure 5** - Top: Wavelength spectra of A488, A594, and A647 staining are shown, representing the wavelength at which light is shot (dotted peaks) and the wavelength at which it fluoresces (solid peaks). Bottom: Laser light of wavelengths A488, A594, and A647 is shot through a slit of the same width. (Figure created with Thermofisher Fluorescence Spectra Viewer software and Phet Interactive Simulations software.)

Results confirm that greater wavelength and pinhole decrease resolution and increase the diameters of filaments in images. It can also be seen that access light from a large pinhole creates excessive background noise on images making differentiation between filaments difficult. While a smaller pinhole provides better resolution, a lack of illumination causes images to appear dull and hard to view (**Figure 6**). We imaged P60 WT mice stained for IgG mouse anti-SMI-31 and secondary antibodies of DK IgG anti-mouse with Alexa Fluor 488, Alexa Fluor 594, and Alexa Fluor 647, and then imaged sections at pinhole sizes of 0.63 and 1.9, and discovered that as pinhole and wavelength increased, so did diameter (**Figure 7**).



**Figure 6** - We imaged P60 WT mouse stained for IgG mouse anti-SMI-31 and secondary antibodies of DK IgG anti-mouse with Alexa Fluor 488, Alexa Fluor 594, Alexa Fluor 647 and then imaged sections at pinhole sizes of 0.63 and 3.69.



**Figure 7** - A bar graph with standard error lines of pinhole size and normalized filament diameter of three different wavelengths (A488, A594, and A647).

## Discussion

### *Pinhole and Diameter Relation*

The present findings show a correlation between pinhole size and object diameter. My observations of increased diameter resulting from an enlarged pinhole are substantiated by figures 1, 2, 3, 4, 6, and 7. Since the pinhole's purpose is to block out-of-focus light, when it is larger, the extraneous light isn't being blocked as effectively, making the minuscule fine details of specimen tissue appear larger and out of focus [1,11]. Conversely, a pinhole that is very small will make filaments defined but lack of illumination of tissue provides for an image that is dark and lacks brightness [1,11]. It is important to note that there are downsides to having a pinhole that is either too large or too small. When imaging it is important to remember that although the pinhole is a unique feature that can assist in creating crisp images with defined details at a high resolution, overusing it can lead you to get the opposite result [12,13]. To achieve the best results, the size of the pinhole should be balanced so that there is enough illumination to clearly see the specimen but not so much that minuscule fine details are indistinguishable [12,13].

### *Wavelength and Diameter Relation*

Our results also show a correlation between wavelength and object diameter. Our observations of increased diameter due to a larger wavelength are supported by figures 1, 2, 5, 6, and 7. High frequency would cause the wave to oscillate faster, hitting and reflecting from small objects and the fine details of large objects more frequently [1,14]. The lateral resolution of the microscope is limited by diffraction and is commonly approximated by the Abbe/Rayleigh relation  $d = \lambda / (2NA)$  [20]. This convention outlines that the smallest resolvable distance between two

points gets smaller when the wavelength decreases or the numerical aperture increases [20]. In the practical applications that this paper aims to provide, this tells you that higher NA-optics and shorter wavelengths improve lateral resolution, but they cannot eliminate the fundamental blur that is caused by diffraction [20]. Thus, resolution is improved with shorter illumination wavelengths and larger numerical aperture, but features separated by less than this limit are unlikely to be distinguished as separate objects under conventional imaging conditions [20]. Since frequency and wavelength are inversely related, light of a higher wavelength would be longer and scatter more when it hits an object [1,14]. Like a large pinhole, this would also cause filament details to become undefined and appear blurry and larger [14]. To combat this issue and achieve optimal imaging results, the parameters derived from pinhole size must be applied [13,14]. The viewing wavelength cannot be easily changed because staining sections is time-consuming. Limiting yourself to a range of low-wavelength secondary antibodies is also impractical when multiple staining immunofluorescence is required [16]. In this situation, a slightly smaller pinhole with a larger wavelength is preferable to maximize the cancellation of resolution lost to blurring [1,15].

Knowledge of correct microscopy techniques is essential for ideal imaging results and that starts with understanding the fundamental systems of the instrument. With better grasp of how the main components of the confocal microscope work, users can achieve optimal results to aid in research. The quality of life for those affected is significantly improved by analyzing and quantifying data obtained from high-quality microscopy, which is then used to develop therapies and treatments for diseases.

## References

1. Elliott, A. D. (2019). Confocal microscopy: Principles and modern practices. *Current Protocols in Cytometry*, 92(1), e68. <https://doi.org/10.1002/cpcy.68>
2. United States Patent and Trademark Office. (n.d.). Petition documents (Artifact ID: NZWHEUqDP87XqN8eKGttoyOE3YLcpp\_agn9-P4cMJler964GEb\_\_t4c). [https://ptacts.uspto.gov/ptacts/public-informations/petitions/1541483/download-documents?artifactId=NZWHEUqDP87XqN8eKGttoyOE3YLcpp\\_agn9-P4cMJler964GEb\\_\\_t4c](https://ptacts.uspto.gov/ptacts/public-informations/petitions/1541483/download-documents?artifactId=NZWHEUqDP87XqN8eKGttoyOE3YLcpp_agn9-P4cMJler964GEb__t4c)
3. Wilson, T. (2011). Resolution and optical sectioning in the confocal microscope. *Journal of Microscopy*, 244(2), 113–121. <https://doi.org/10.1111/j.1365-2818.2011.03549.x>
4. McDonald-McGinn, D. M., Sullivan, K. E., Marino, B., Philip, N., Swillen, A., Vorstman, J. A. S., Zackai, E. H., Emanuel, B. S., Vermeesch, J. R., Morrow, B. E., Scambler, P. J., & Bassett, A. S. (2015). 22q11.2 deletion syndrome. *Nature Reviews Disease Primers*, 1, 15071. <https://doi.org/10.1038/nrdp.2015.71>
5. Cox, G., & Sheppard, C. J. R. (2004). Practical limits of resolution in confocal and non-linear microscopy. *Microscopy Research and Technique*, 63(1), 18–22. <https://doi.org/10.1002/jemt.20019>
6. Leica Microsystems. (2026). STELLARIS scan head poster. [https://downloads.leica-microsystems.com/STELLARIS/Poster/STELLARIS%20Scan%20Head\\_poster.pdf](https://downloads.leica-microsystems.com/STELLARIS/Poster/STELLARIS%20Scan%20Head_poster.pdf)
8. Otterstrom, J. (2022). How oil immersion objectives can improve your microscopy? IDEA Bio-Medical. <https://idea-bio.com/how-oil-immersion-objectives-can-improve-your-microscopy/>
9. Wilson, M., DeRose, J., & Greb, C. (2018). Microscope resolution: Concepts, factors and calculation. Leica Microsystems. <https://www.leica-microsystems.com/science-lab/life-science/microscope-resolution-concepts-factors-and-calculation/>
10. Abramowitz, M., & Davidson, M. W. (n.d.). Numerical aperture and resolution. Olympus Life Science. <https://www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/numaperture/>
11. Judson, M. C., Burette, A. C., Thaxton, C. L., Pribisko, A. L., Shen, M. D., Rumble, A. M., Del Cid, W. A., Paniagua, B., Styner, M., Weinberg, R. J., & Philpot, B. D. (2017). Decreased axon caliber underlies loss of fiber tract integrity, disproportional reductions in white matter volume, and microcephaly in Angelman syndrome model mice. *Journal of Neuroscience*, 37(31), 7347–7361. <https://doi.org/10.1523/JNEUROSCI.0037-17.2017>
12. Glazowski, C., & Rajadhyaksha, M. (2012). Optimal detection pinhole for lowering speckle noise while maintaining adequate optical sectioning in confocal reflectance microscopes. *Journal of Biomedical Optics*, 17(8), 085001. <https://doi.org/10.1117/1.JBO.17.8.085001>
13. Shihan, M. H., Novo, S. G., Le Marchand, S. J., Wang, Y., & Duncan, M. K. (2021). A simple method for quantitating confocal fluorescent images. *Biochemical and Biophysical Reports*, 25, 100916. <https://doi.org/10.1016/j.bbrep.2021.100916>
14. Waters, J. C. (2009). Accuracy and precision in quantitative fluorescence microscopy. *Journal of Cell Biology*, 185(7), 1135–1148. <https://doi.org/10.1083/jcb.200903097>
15. Li, Y., & Huang, F. (2024). A statistical resolution measure of fluorescence microscopy with finite photons. *Nature Communications*, 15(1), 3760. <https://doi.org/10.1038/s41467-024-48155-x>
16. Strasser, F., Offterdinger, M., Piestun, R., & Jesacher, A. (2019). Spectral image scanning microscopy. *Biomedical optics express*, 10(5), 2513–2527. <https://doi.org/10.1364/BOE.10.002513>
17. Piston D. W. (1998). Choosing objective lenses: the importance of numerical aperture and magnification in digital optical microscopy. *The Biological bulletin*, 195(1), 1–4. <https://doi.org/10.2307/1542768>
18. Sheppard, C. J., & Gu, M. (1991). Aberration compensation in confocal microscopy. *Applied optics*, 30(25), 3563–3568. <https://doi.org/10.1364/AO.30.003563>
19. Diaspro, A., Annunziata, S., & Robello, M. (2000). Single-pinhole confocal imaging of sub-resolution sparse objects using experimental point spread function and image restoration. *Microscopy research and technique*, 51(5), 464–468. [https://doi.org/10.1002/1097-0029\(20001201\)51:5<464::AID-JEMT9>3.0.CO;2-D](https://doi.org/10.1002/1097-0029(20001201)51:5<464::AID-JEMT9>3.0.CO;2-D)
20. Euan McLeod, Aydogan Ozcan, Nano-imaging enabled via self-assembly, *Nano Today*, Volume 9, Issue 5, 2014, Pages 560-573, ISSN 1748-0132, <https://doi.org/10.1016/j.nantod.2014.08.005>. (<https://www.sciencedirect.com/science/article/pii/S174801321400125X>)

# About the Author

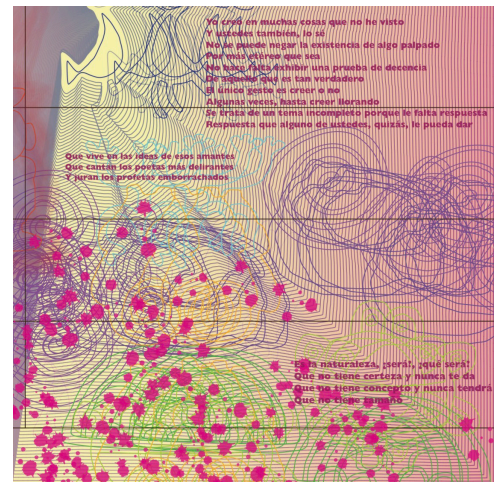
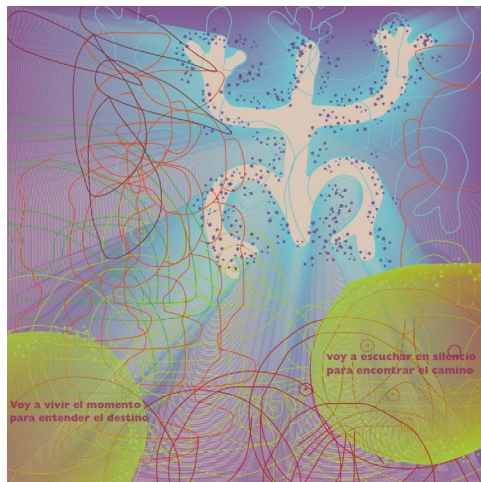
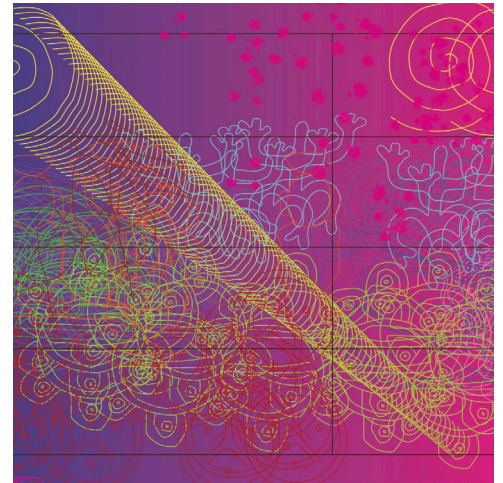


**Ridhti Patel** is a fourth-year Biology student concentrating in Cell and Molecular Biology and in the early-entry masters program. Her research area focuses on the Neuroscience and stem cell research to understand neural development and degeneration. Her research advisor is Dr. Alain Burette from the Department of Cell Biology and Physiology at the University of North Carolina at Chapel Hill Neuroscience Center.

## Creative Work Collection

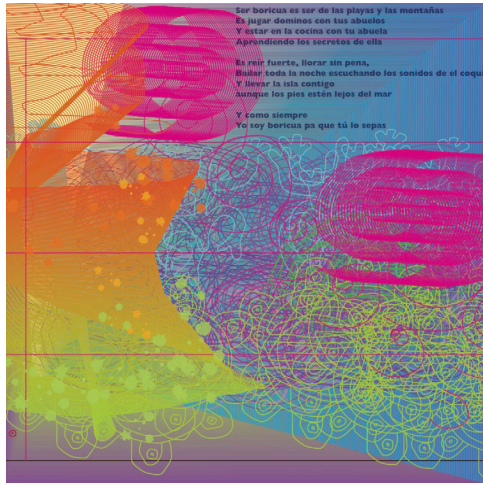
# Experience of a World Melded Through the Stripping of What's Rightfully Yours

**Sabrina Coffaro** is a Levine Scholar and an architecture major. She was born and raised in Venezuela and uses her lived experiences to uplift minority communities. This project was completed as part of her second-year architecture studio. Using the rhythms of Afro-Rican jazz, she created these drawings to represent sonic events in the lively music. Created digitally using Rhinoceros 3D, Adobe Illustrator, and Canva, she captures the essence of the Caño Martín Peña community in Puerto Rico and the music that binds them to their roots. You can find more of her work on Instagram @sabartarch.

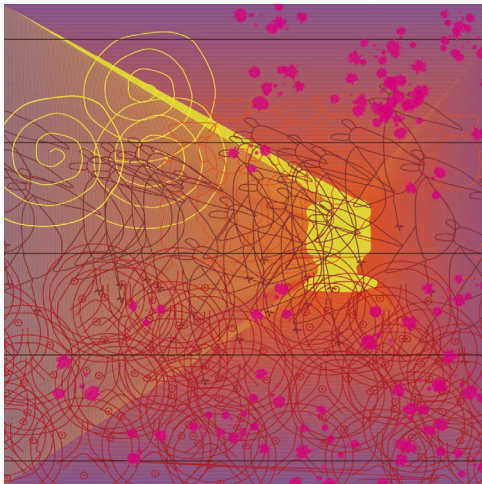
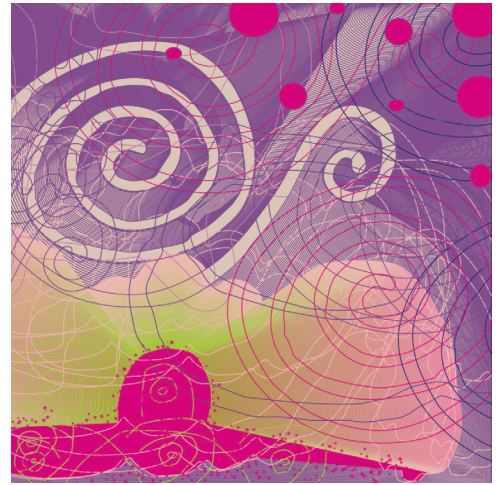




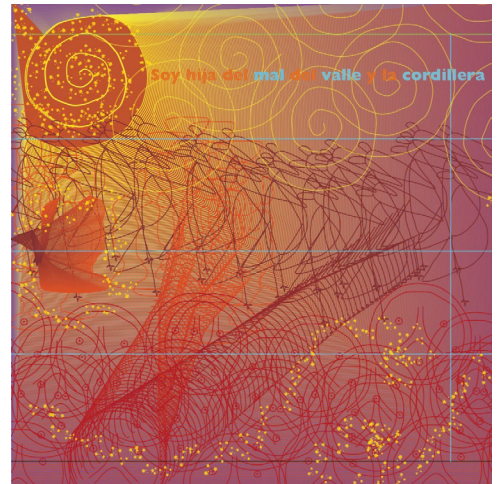
¡Ay Bendito!



Ser boricua es ser de las playas y las montañas  
Es jugar dominos con tus abuelos  
Y estar en la cocina con tu abuela  
Aprendiendo los secretos de ella  
Es reír fuerte, llorar sin pena,  
Bailar toda la noche escuchando los sonidos de el coque  
Y llevar la lata contigo  
Aunque los pies estén lejos del mar  
Y como siempre  
Yo soy boricua pa que tú lo sepas



Mientras uno está vivo  
Uno debe amar lo más que pueda



Soy hija del mal del valle de la cordillera

# To What Extent can Herbal Interventions Reduce Benzodiazepine Reliance and Overmedication in Alcohol Withdrawal Syndrome (AWS)?

Sydney McCoy

**Acknowledgements:** *I would like to thank my disciplinary honors mentor, Erika Montanaro, for her support throughout the development of this project. She not only guided me through the research and writing process but also encouraged me to submit this work despite my own initial self-doubt. I am especially grateful for her belief in my abilities and for inspiring me to take greater academic and professional risks moving forward.*

**Abstract:** Alcohol use disorder is a common condition that afflicts large populations within the United States. A subset of individuals who report alcohol use disorder develop alcohol withdrawal syndrome after abrupt cessation from alcohol, resulting in severe physiological consequences. Benzodiazepines are first-line treatments for instances of withdrawal; despite general efficacy, benzodiazepines pose large-scale concerns of dependency. The risks of benzodiazepine treatment present a need for an integrative treatment methodology. This literature review attempts to investigate solutions to benzodiazepine reliance, utilizing herbal interventions through neuropsychological and clinical psychology perspectives. Neuropsychology identifies withdrawal mechanisms, whilst clinical psychology addresses behavioral antecedents that vary in treatment. Integrative approaches aid in the evaluation of alternative treatments like Ashwagandha and Purple Passion Flower, revealing the adjunctive role of herbal interventions in clinical settings. Significant gaps within the literature give way to larger issues regarding benzodiazepine administration guidelines and the lack of integrative herbal interventions. The medical system's reliance on benzodiazepines may contribute to an increased risk of reliance among patients with alcohol withdrawal syndrome, and without reformation, this issue will persist.

**Research Advisor:** Dr. Erika Montanaro, College of Humanities & Earth and Social Sciences

**Keywords:** AWS, AUD, Ashwagandha, *Passiflora incarnata L.* Benzodiazepines, Purple Passion Flower, *Withania somnifera*

## Introduction

Alcohol is one of the most commonly utilized substances within the United States, with over 75 percent of individuals over the age of 12 reporting lifetime consumption (National Institute on Alcohol Abuse and Alcoholism, 2024). Those who report lifetime consumption struggle with Alcohol Use Disorder (AUD), often characterised by the problematic use of alcohol marked by physiological dependence, hazardous use, and failure to fulfil obligations (American Psychiatric Association, 2013). Those who experience negative effects of AUD seek remission through halting alcohol consumption to improve their quality of life (Cooper & Vernon, 2012).

Although abrupt discontinuation is associated with certain health benefits, complete cessation can lead to a subsequent condition known as Alcohol Withdrawal Syndrome (AWS). Shortly after the onset of AWS, mild to moderate symptoms like anxiety, tachycardia, and headache arise, with critical symptoms emerging 48 hours after the onset of alcohol cessation (Martin et al., 2018). Severe symptoms of AWS include alcohol hallucinations (visual and auditory) and seizures that require hospitalization for intensive care and supervision. These critical conditions affect large populations, as 50% of individuals with AUD experience AWS (Celik et al., 2024), with an

increasing number of hospitalizations emerging per year.

Given the widespread impact of AWS among those diagnosed with AUD, standards of care surrounding alcohol withdrawal follow strict guidelines. Treatment protocols encompass preliminary objectives to ensure individuals suffering from withdrawal have a safe, humane, and recovery-oriented detox. The first step to AWS treatment is identification and severity assessment of the Clinical Institute Withdrawal Assessment of Alcohol Scale Revised (CIWA-Ar) (Sullivan et al., 1989; see Appendix A). This scale provides a reliable way to assess the severity of alcohol withdrawal in patients through the examination of critical patient history, including previous history of severe withdrawal, hospitalizations for alcohol withdrawal, and duration of abstinence (Alvanzo et al., 2020). In this stage, individuals are ranked on a scale from mild to severe/complicated alcohol withdrawal severity. Individuals with varying levels of severity are then provided with corresponding levels of care.

Benzodiazepines are first-line treatments for AWS as they are positive allosteric modulators that enhance a given receptor's effects via binding to an alternate site on the receptor, distinct from the main agonist site (Hackos & Hanson, 2017). Benzodiazepines bind to the GABAA receptor in the brain to counteract severe symptoms of withdrawal by enhancing the inhibitory nature of the receptor. As a result, symptoms such as seizures and delirium (Martin et al., 2018) are minimized during AWS treatment. The depressive nature of benzodiazepines results in anxiolytic, hypnotic, anticonvulsant, and muscle-relaxing effects (Votaw et al., 2019), optimal for neutralizing severe withdrawal symptoms. Despite the effectiveness of benzodiazepines, concerns still arise with their use, as the psychoactive drug can create an issue of dependence in those who receive them as a crucial form of treatment. Notably, 30 percent of individuals with AUD report benzodiazepine misuse (McHugh et al., 2020). This cycle of adopting differing instances of dependence is often known as cross-addiction or sequential dependence, where one recovers from an addiction to develop a dependence on a secondary substance after initial treatment (Dowd et al., 2022). Thus, these findings have prompted the evaluation of benzodiazepine safety within clinical settings. In a broader context, these findings reflect patterns of Western or conventional medicinal approaches that prioritize pharmaceutical and procedural interventions (Yoshinaga et al., 2020). Although these approaches have been proven to be effective with substantial research, some interventions have been associated with risks of dependency and adverse physiological effects.

Instances of benzodiazepine reliance and misuse are not solely dependent on the patient, but rather the shared responsibility of regulatory healthcare guidelines and administration. A prime example of this interplay can be examined during the application of excessive loading procedures. Loading doses are high doses of a particular drug, often administered to elicit an immediate clinical response (Miniaci & Gupta, 2020), typically used in cases requiring anticonvulsant or severe pain management. This administration technique typically occurs under a front-loading regimen, entailing the administration of a loading dose at the beginning of treatment to compensate for a medication's long half-life, as longer half-lives delay when therapeutic effects take place. Although these procedures effectively manage delirium treatments, convulsions, and autonomic hyperactivity, it can also lead to an increased risk of reliance depending on the loading dose procedure utilized (Sujatha et al., 2017).

As different alternatives to benzodiazepines are being considered due to AWS, given their potential for adverse effects, the integration of herbal interventions may be a suitable alternative in reducing benzodiazepine dependence by enhancing therapeutic efficiency, hence reducing the amount of benzodiazepines needed during treatment and subsequently reducing benzodiazepine reliance. Herbal medications are often used adjunctively with other medications worldwide, although Western civilizations present with apprehension in adopting integrative approaches (Mohammad Hadi Nematollahi et al., 2022). Skepticism continues to follow herbal medication in westernized medicine; however, limited research has been conducted (Chen & Lader, 1990) and presented on the topic to justify the hesitation to use alternatives to benzodiazepines to treat AWS.

## **Perspective #1: Neuropsychology**

The physiological basis of withdrawal is primarily due to the disruption of homeostasis in the central nervous system (CNS) following subsequent detoxification. The CNS is the body's processing and control system, consisting of the brain and the spinal cord (Cleveland Clinic, 2023). This system acquires sensory information from the nerves and responds to this input via the transmission of electrical signals through the spinal cord.  $\gamma$ -Aminobutyric acid (GABA) and glutamate are important neurotransmitters that play opposing homeostatic roles in the CNS. GABA is a primary inhibitory neurotransmitter in the CNS that reduces neural hyperexcitability (Cleveland Clinic, 2022a), whilst glutamate is the most excitatory neurotransmitter in the brain that promotes transmission

by increasing the likelihood of action potential initiation (Cleveland Clinic, 2022b). Chronic alcohol indulgence tends to provoke a “tipping of the scales,” as GABA production and potency increase, while simultaneously suppressing glutamate. This indulgence leads to a state of inhibitory dominance or disinhibition characterized by a reduction of cognitive control and “inability to suppress impulsive behaviors” (Field et al., 2010). Chronic alcohol cessation can shift the body’s neurochemical composition from disinhibition to a state of hyperexcitability. This phenomenon is due to the body’s homeostatic rebound effect, causing glutamate overproduction to take place, compensating for long-term suppression of excitatory systems (Brousse et al., 2012). Hyperexcitability of the CNS can cause anxiety, agitation, and seizures, commonly seen in cases of AWS (Gilpin & Koob, 2024).

In serious cases of AWS, CNS hyperexcitability can lead to a life-threatening condition known as delirium tremens. Delirium tremens is a fatal form of AWS that is characterized by a set of symptoms including tremors, delirium, diaphoresis, seizures, hyperthermia, and tachycardia (Cleveland Clinic, 2023a). Preexisting mental health conditions increase the risk of delirium tremens development by enhancing one’s CNS excitability. Enhanced stress responses from preexisting conditions, coupled with neurochemical imbalances caused by alcohol withdrawal, can induce harmful levels of CNS hyperactivity. This level of hyperexcitability can result in a higher risk of delirium tremens development (Bramness et al., 2022). Delirium tremens can contribute to several complications during AWS treatment, including cardiovascular system distress, neurological dysfunction, and seizures (Mulkey & Olson, 2020). These complications increase mortality risks during AWS treatment, prompting the use of benzodiazepines to quickly decrease withdrawal severity and patient mortality rates.

In cases of AWS, benzodiazepines quickly diffuse through the blood-brain barrier to increase GABA production, decreasing the overexcitation of the CNS while maintaining a temporary balance between inhibitory and excitatory bodily systems. Acute use of benzodiazepines maintains a temporary balance between inhibitory and excitatory systems, although prolonged use can yield considerable health issues. According to Ritvo et al. (2023) in their meta-analysis of long-term benzodiazepine-induced neurological dysfunction, individuals who employed long-term benzodiazepine use experienced symptoms such as memory loss, nervousness, and anxiety even after a year-long discontinuation from the drug. Other physiological and psychological impacts of prolonged benzodiazepine

use would include Benzodiazepine-Induced Neurological Dysfunction (BIND), causing an increase in suicidality, akathisia or intense restlessness (American Association of Psychiatric Pharmacists, 2025), and other cognitive deficits similar to those seen in those with AUD.

The physiological consequences of benzodiazepines underscore the importance of an investigative search for a medication with lower risks of dependency with similar GABAergic effects. Herbal medications may be an avenue to pursue, as herbal substances have the potential to reduce dependence due to their synergistic nature (Ali et al., 2022). Being that AWS prompts GABA and glutamate dysregulations, herbs capable of temporarily reinstating homeostasis through manipulating the impacted pathways are an enticing alternative. *Passiflora incarnata* L., or “Purple Passionflower,” is a promising option, as it benefits those who need GABAergic treatments with no rebound, withdrawal, or dependence effects (Carminati et al., 2024). However, this treatment may not be strong enough to prevent critical neurological events like seizures and may limit its efficacy to instances of tapering. Similarly, Ashwagandha may be another alternate contender for benzodiazepine replacement or adjunct. In the study, Ruby et al. (2012), two groups of mice undergoing alcohol cessation were either given a (1 mg/kg) dose of diazepam (a subclass of benzodiazepine) or (500mg/kg) of Ashwagandha. The study found that (500mg/kg) of Ashwagandha demonstrates potential as a reliable alternative to benzodiazepines under conditions of withdrawal. Moreover, the key to finding an effective herbal alternative, adjunct, or tapering mechanism to benzodiazepines relies on an extract’s interaction with GABA or glutamate within the human brain. While many herbal medications have great sedative properties, they are not strong enough to decrease severe medical events as seen in AWS, limiting their efficacy to adjunctive means. *Passiflora incarnata* L. consists of GABAergic flavonoids such as chrysin, vitexin, and apigenin, which act as less potent positive allosteric modulators in comparison to benzodiazepines (Elsas et al., 2010). Although the herb exhibits similar inhibitory effects, its slower onset and lower potency may limit its use during severe and urgent cases of AWS. Similarly, Ashwagandha presents with similar barriers, as its GABAergic withanolides act as weak modulators to the GABA<sub>A</sub> receptor (Haque et al., 2021). Rather than acting as a direct agonist through strong positive allosteric mechanisms, Ashwagandha primarily acts as an adaptogen with mild sedative properties. The literature presented on the topic of benzodiazepines and herbal medicines is quite limited, as the broader scope of herbal medicine integra-

-tion remains a niche topic with large deficits. Further research regarding herbal medicine integration as a whole requires further expansion, especially within the realm of psychology and the physiological manifestations of mental diseases.

## **Perspective #2: Clinical Psychology**

AUD is often associated with many behavioral antecedents that affect AWS treatment. Specifically, the severity of AWS is often contingent upon concurrent addictive substance use, positive blood alcohol concentration during withdrawal, and co-occurring psychiatric disorders (Alvanzo et al., 2020). Being that alcohol acts as a common depressant of the CNS, varying behavioral factors can affect the effectiveness of particular treatment options within clinical settings (Alvanzo et al., 2020). Consequently, those who present with AUD and other mental health concerns during alcohol cessation are likely to experience psychiatric complications of delirium tremens (Alvanzo et al., 2020). These complications are often reduced by the use of benzodiazepines during severe withdrawal episodes, although it is important to weigh the positive and negative effects of benzodiazepine intervention, as there is a risk of developing secondary dependence. Those with complex cases of AWS require rapid CNS suppression, which herbal interventions may not be able to provide as a result of weaker GABAergic effects and slower medicinal onset. Although the use of herbal interventions may be inappropriate during acute AWS treatment, especially for those with complex cases, their use presents as being the most optimal once care shifts its focus to stabilization and dependence reduction (Haque et al., 2021). *Passiflora incarnata* L. and *Ashwagandha* both act as GABA modulators with anxiolytic effects. Utilization of these interventions during benzodiazepine tapering not only acts as a mild anticonvulsant but also as an anti-anxiety agent that cross-tolerates with alcohol to reduce residual CNS excitability (Wolf et al., 2020). The reduction of CNS excitability may also reduce psychological symptoms that present with AWS, including agitation, irritability, and dysphoric mood. The use of adjunctive herbal interventions during the tapering process can aid the management of psychological symptoms, promoting treatment adherence and optimal patient outcomes (Sarkhel et al., 2020).

Systematic guidelines and treatment plans for clinical providers are one of the primary methods to prevent benzodiazepine overuse in those with AUDs (Alvanzo et al., 2020), and current guidelines do not comprehensively address the negative consequences associated with

*benzodiazepine overuse. Severe CNS depression, following impaired cognition, hypotension, bradycardia, and paradoxical reactions like agitation and combativeness, are common symptoms of benzodiazepine overuse. These symptoms are often harder to treat, given that those who acquire secondary or “transfer addiction” are more likely to experience issues with treatment adherence, reduced quality of life, and pessimistic outcomes (Dennis & Scott, 2007).*

*Although benzodiazepines can be largely effective when utilized precisely, consistent monitoring and systematic guidelines must be followed to ensure those receiving treatment do not become dependent. Similarly, the distinction of benzodiazepine subclasses and appropriate dosing regimes is essential for this very reason. For example, long-acting benzodiazepines are often recommended over those that are shorter-acting due to their tapering ability that slowly weans the patient off of the medication (Alvanzo et al., 2020). Without the distinction between the two subclasses, individuals may be prescribed short-acting benzodiazepines such as lorazepam or oxazepam, which may wear off quickly, increasing the chances of subsequent addiction (Edinoff et al., 2021). Careful revision and application of new clinical guidelines can go a long way in preventing debilitating issues of sequential dependence in those struggling with AWS.*

## **Integration**

When both perspectives are examined in tandem, similar deficits regarding the integration of herbal medication in psychology are apparent. Holistic approaches are less frequently utilized and often superseded by pharmaceutical-grade medications (e.g., benzodiazepines) as symptoms become severe or life-threatening (Alvanzo et al., 2020). Furthermore, many clinicians prefer the prescription of medications like benzodiazepines due to stronger evidence of clinical effectiveness (Carminati et al., 2024), decreasing the chances of holistic applications and research.

Neuropsychological approaches have yet to discover a safe and effective integration of herbal care in Western medicine. Although adjunctive applications have been considered in cases of severe conditions, they are seldom employed due to a lack of research (Nematollahi et al., 2022). However, studies have shown that the adjunctive use of herbal extracts during treatment for AWS should be further explored, as these remedies can provide a less addictive alternative to benzodiazepines during AWS (Carminati et al., 2024). Comparatively, although clinical

psychology and neuropsychological approaches mildly advocate for the use of herbal interventions, the general effectiveness of pharmaceutical-grade medications is prioritized to avoid fatal outcomes (Mohammad Hadi Nematollahi et al., 2022).

Shifts towards integrative medicine require an integrative approach with an emphasis on clinical administration and physiological processes. Specific dosage regimens and suboptimal prescription guidelines may be the reason for benzodiazepine reliance (Alvanzo et al., 2020), presenting a demand for policy reformation within the healthcare system. An integrative approach should be utilized in reconstructing new administrative guidelines and providing alternative care for those experiencing AWS.

# Appendices

## Appendix A

Clinical Institute Withdrawal Assessment Of Alcohol Scale, Revised (CIWA-AR)

### CLINICAL INSTITUTE WITHDRAWAL ASSESSMENT OF ALCOHOL SCALE, REVISED (CIWA-AR)

Patient: \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_ (24 hour clock, midnight = 00:00)

Pulse or heart rate, taken for one minute: \_\_\_\_\_ Blood pressure: \_\_\_\_\_

**NAUSEA AND VOMITING** — Ask "Do you feel sick to your stomach? Have you vomited?" Observation.

- 0 no nausea and no vomiting
- 1 mild nausea with no vomiting
- 2
- 3
- 4 intermittent nausea with dry heaves
- 5
- 6
- 7 constant nausea, frequent dry heaves and vomiting

**TREMOR** — Arms extended and fingers spread apart. Observation.

- 0 no tremor
- 1 not visible, but can be felt fingertip to fingertip
- 2
- 3
- 4 moderate, with patient's arms extended
- 5
- 6
- 7 severe, even with arms not extended

**PAROXYSMAL SWEATS** — Observation.

- 0 no sweat visible
- 1 barely perceptible sweating, palms moist
- 2
- 3
- 4 beads of sweat obvious on forehead
- 5
- 6
- 7 drenching sweats

**ANXIETY** — Ask "Do you feel nervous?" Observation.

- 0 no anxiety, at ease
- 1 mild anxious
- 2
- 3
- 4 moderately anxious, or guarded, so anxiety is inferred
- 5
- 6
- 7 equivalent to acute panic states as seen in severe delirium or acute schizophrenic reactions

**AGITATION** — Observation.

- 0 normal activity
- 1 somewhat more than normal activity
- 2
- 3
- 4 moderately fidgety and restless
- 5
- 6
- 7 paces back and forth during most of the interview, or constantly thrashes about

**TACTILE DISTURBANCES** — Ask "Have you any itching, pins and needles sensations, any burning, any numbness, or do you feel bugs crawling on or under your skin?" Observation.

- 0 none
- 1 very mild itching, pins and needles, burning or numbness
- 2 mild itching, pins and needles, burning or numbness
- 3 moderate itching, pins and needles, burning or numbness
- 4 moderately severe hallucinations
- 5 severe hallucinations
- 6 extremely severe hallucinations
- 7 continuous hallucinations

**AUDITORY DISTURBANCES** — Ask "Are you more aware of sounds around you? Are they harsh? Do they frighten you? Are you hearing anything that is disturbing to you? Are you hearing things you know are not there?" Observation.

- 0 not present
- 1 very mild harshness or ability to frighten
- 2 mild harshness or ability to frighten
- 3 moderate harshness or ability to frighten
- 4 moderately severe hallucinations
- 5 severe hallucinations
- 6 extremely severe hallucinations
- 7 continuous hallucinations

**VISUAL DISTURBANCES** — Ask "Does the light appear to be too bright? Is its color different? Does it hurt your eyes? Are you seeing anything that is disturbing to you? Are you seeing things you know are not there?" Observation.

- 0 not present
- 1 very mild sensitivity
- 2 mild sensitivity
- 3 moderate sensitivity
- 4 moderately severe hallucinations
- 5 severe hallucinations
- 6 extremely severe hallucinations
- 7 continuous hallucinations

**HEADACHE, FULLNESS IN HEAD** — Ask "Does your head feel different? Does it feel like there is a band around your head?"

- Do not rate for dizziness or lightheadedness. Otherwise, rate severity.
- 0 no present
- 1 very mild
- 2 mild
- 3 moderate
- 4 moderately severe
- 5 severe
- 6 very severe
- 7 extremely severe

**ORIENTATION AND CLOUDING OF SENSORIUM** —

- Ask "What day is this? Where are you? Who am I?"
- 0 oriented and can do serial additions
- 1 cannot do serial additions or is uncertain about date
- 2 disoriented for date by no more than 2 calendar days
- 3 disoriented for date by more than 2 calendar days
- 4 disoriented for place/or person

The CIWA-Ar is not copyrighted and may be reproduced freely.  
Sullivan, J.T.; Sykora, K.; Schneiderman, J.; Naranjo, C.A.; and Sellers, E.M.  
Assessment of alcohol withdrawal: The revised Clinical Institute Withdrawal  
Assessment for Alcohol scale (CIWA-Ar). *British Journal of Addiction* 84:1353-1357, 1989.

Patients scoring less than 10 do not usually need additional medication for withdrawal.

Total CIWA-Ar Score \_\_\_\_\_

Rater's Initials \_\_\_\_\_

Maximum Possible Score 67

## References

- Airagnes, G., Ducoutumany, G., Laffy-Beaufils, B., Le Faou, A.-L., & Limosin, F. (2019). Alcohol withdrawal syndrome management: Is there anything new? *La Revue de Médecine Interne*, 40(6), 373–379. <https://doi.org/10.1016/j.revmed.2019.02.001>
- Ali, H., Ali, D., Almutairi, B. O., Kumar, G., Karga, G. A., Masi, C., & Sundramurthy, V. P. (2022). Synergistic Effect of Conventional Medicinal Herbs against Different Pharmacological Activity. *BioMed Research International*, 2022, 1–7. <https://doi.org/10.1155/2022/7337261>
- Alvanzo, A., Kleinschmidt, K., Kmiec, J., Kolodner, G., Marti, G., Murphy, W., Tirado, C., Waller, C., Nelson, L., Holt, S., Rastegar, D., Saitz, R., Weaver, M., Jarvis, M., Kotz, M., Novack, D., Pating, D., Pirard, S., Lindsay, D., & Williams, J. (2020). Physician Health Programs National Association of Addiction Treatment Providers National Association of Clinical Nurse Specialists National Commission on Correctional Health Care. [https://www.asam.org/docs/default-source/quality-science/the\\_asam\\_clinical\\_practice\\_guideline\\_on\\_alcohol-1.pdf](https://www.asam.org/docs/default-source/quality-science/the_asam_clinical_practice_guideline_on_alcohol-1.pdf)
- American Association of Psychiatric Pharmacists (AAPP). (2025). American Association of Psychiatric Pharmacists (AAPP). American Association of Psychiatric Pharmacists (AAPP). <https://aapp.org/ed/summit/2024/session/benzo>
- American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. *Diagnostic and Statistical Manual of Mental Disorders*, 5(5). <https://doi.org/10.1176/appi.books.9780890425596>
- Bramness, J. G., Pandey, S., Moe, J. S., Toft, H., Lien, L., & Bolstad, I. (2022). History of Delirium Tremens in AUD Patients in Treatment: Relationship to AUD Severity and Other Factors. *Substance Abuse and Rehabilitation*, Volume 13(13), 65–72. <https://doi.org/10.2147/sar.s361810>
- Brousse, G., Arnaud, B., Vorspan, F., Richard, D., Dissard, A., Dubois, M., Pic, D., Geneste, J., Xavier, L., Authier, N., Sapin, V., Llorca, P.-M., De Chazeron, I., Minet-Quinard, R., & Schmidt, J. (2012). Alteration of Glutamate/GABA Balance During Acute Alcohol Withdrawal in Emergency Department: A Prospective Analysis. *Alcohol and Alcoholism*, 47(5), 501–508. <https://doi.org/10.1093/alcalc/ags078>
- Brunner, E., Chen, C.-Y. A., Klein, T., Maust, D., Mazer-Amirshahi, M., Mecca, M., Najera, D., Ogbonna, C., Rajneesh, K. F., Roll, E., Sanders, A. E., Snodgrass, B., VandenBerg, A., Wright, T., Boyle, M., Devoto, A., Framnes-DeBoer, S., Kleykamp, B., Norrington, J., & Lindsay, D. (2025). Joint Clinical Practice Guideline on Benzodiazepine Tapering: Considerations When Risks Outweigh Benefits. *Journal of General Internal Medicine*. <https://doi.org/10.1007/s11606-025-09499-2>
- Carminati, M., Mattia Tondello, & Zanardi, R. (2024). *Passiflora incarnata* L., herba, in benzodiazepine tapering: long-term safety and efficacy in a real-world setting. *Frontiers in Psychiatry*, 15(1471083). <https://doi.org/10.3389/fpsy.2024.1471083>
- Celik, M., Gold, M. S., & Fuehrlein, B. (2024). A Narrative Review of Current and Emerging Trends in the Treatment of Alcohol Use Disorder. *Brain Sciences*, 14(3), 294. <https://doi.org/10.3390/brainsci14030294>
- Chen, Y., & Lader, M. (1990). Long-term benzodiazepine treatment: Is it ever justified? *Human Psychopharmacology: Clinical and Experimental*, 5(4), 301–312. <https://doi.org/10.1002/hup.470050403>
- Cleveland Clinic. (2022a, April 25). Gamma-Aminobutyric Acid (GABA). Cleveland Clinic. <https://my.clevelandclinic.org/health/articles/22857-gamma-aminobutyric-acid-gaba>
- Cleveland Clinic. (2022b, April 25). Glutamate: What it is & function. Cleveland Clinic; Cleveland Clinic. <https://my.clevelandclinic.org/health/articles/22839-glutamate>
- Cleveland Clinic. (2023a, June 5). Temperance movement: Lower alcohol use and avoid delirium tremens. Cleveland Clinic. <https://my.clevelandclinic.org/health/diseases/25052-delirium-tremens>
- Cleveland Clinic. (2023b, November 12). Central Nervous System: What Does It Do? Cleveland Clinic. <https://my.clevelandclinic.org/health/body/central-nervous-system-cns>
- Cooper, E., & Vernon, J. (2012). The effectiveness of pharmacological approaches in the treatment of alcohol withdrawal syndrome (AWS): a literature review. *Journal of Psychiatric and Mental Health Nursing*, 20(7), 601–612. <https://doi.org/10.1111/j.1365-2850.2012.01958.x>
- Dennis, M., & Scott, C. (2007). Managing Addiction as a Chronic Condition. *Addiction Science & Clinical Practice*, 4(1), 45–55. <https://doi.org/10.1151/ascp074145>
- Dowd, B., Hein, K., Diez, S. L., Prokofieva, M., Kannis-Dy-mand, L., & Stavropoulos, V. (2022). Cross-Addiction Risk Profile Associations with COVID-19 Anxiety: a Preliminary Exploratory Study. *International Journal of Mental Health and Addiction*, 22(106–129). <https://doi.org/10.1007/s11469-022-00862-6>
- Edinoff, A. N., Nix, C. A., Hollier, J., Sagera, C. E., Delacroix, B. M., Abubakar, T., Cornett, E. M., Kaye, A. M., & Kaye, A. D. (2021). Benzodiazepines: Uses, dangers, and clinical considerations. *Neurology International*, 13(4), 594–607. <https://doi.org/10.3390/neurolint13040059>
- Field, M., Wiers, R. W., Christiansen, P., Fillmore, M. T., & Verster, J. C. (2010). Acute Alcohol Effects on Inhibitory Control and Implicit Cognition: Implications for Loss of Control Over Drinking. *Alcoholism: Clinical and Experimental Research*, 34(8), no-no. <https://doi.org/10.1111/j.1530-0277.2010.01218.x>
- Gilpin, N. W., & Koob, G. F. (2024). Neurobiology of Alcohol Dependence: Focus on Motivational Mechanisms. *Alcohol Research & Health*, 31(3), 185. <https://pubmed.ncbi.nlm.nih.gov/articles/PMC2770186/>
- Haque, I. M., Mishra, A., Kalra, B. S., & Chawla, S. (2021). Role of Standardized Plant Extracts in Controlling Alcohol Withdrawal Syndrome—An Experimental Study. *Brain Sciences*, 11(7), 919. <https://doi.org/10.3390/brainsci11070919>

- International Society of Psychiatric Nurses. (2000). Assessment and Identification Management of Alcohol Withdrawal Syndrome (AWS) in the Acute Care Setting. <https://www.ispn-psych.org/assets/docs/10-00-aws.pdf>
- K. Sujatha, T. Arundathi, Rubina, S., B. Ramana, & Nagarajan, G. (2017). DRUG DELIVERY METHODS RANKING ADDICTION POTENTIAL. Semantic Scholar. <https://www.semanticscholar.org/paper/DRUG-DELIVERY-METHODS-RANKING-ADDICTION-POTENTIAL-Sujatha-Arundathi/d1764879d5f85a448f04186eef-cdcbd9d3320d63>
- Kang, M., & Ghassemzadeh, S. (2020). Benzodiazepine Toxicity. PubMed; StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK482238/>
- Khanna, D., Sethi, G., Ahn, K., Pandey, M., Kunnumakkara, A., Sung, B., Aggarwal, A., & Aggarwal, B. (2007). Natural products as a gold mine for arthritis treatment. *Current Opinion in Pharmacology*, 7(3), 344–351. <https://doi.org/10.1016/j.coph.2007.03.002>
- Kisling, L. A., & Stiegmann, R. A. (2024, February 26). Alternative medicine. PubMed; StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK538520/>
- Little, H., Donoghue, K., & Drummond, C. (2022). Prolonged benzodiazepine levels following withdrawal in alcohol dependence. *Journal of Studies on Alcohol and Drugs*, 84(1). <https://doi.org/10.15288/jsad.21-00432>
- Mahesh Kumar Harit, Narendra Mundhe, Sanjay Tamoli, Pawar, V., Vedvati Bhapkar, Ganesh Kolhe, Swapnali Mahadik, Kulkarni, A., & Agarwal, A. (2024). Randomized, Double-Blind, Placebo-Controlled, Clinical Study of *Passiflora incarnata* in Participants With Stress and Sleep Problems. *Curēus*, 16(3). <https://doi.org/10.7759/curēus.56530>
- Martin, C. S., Vergés, A., Langenbucher, J. W., Littlefield, A., Chung, T., Clark, D. B., & Sher, K. J. (2018). Algorithm Analysis of the DSM-5 Alcohol Withdrawal Symptom. *Alcoholism: Clinical and Experimental Research*, 42(6), 1073–1083. <https://doi.org/10.1111/acer.13633>
- McHugh, R. K., Votaw, V. R., Taghian, N. R., Griffin, M. L., & Weiss, R. D. (2020). Benzodiazepine misuse in adults with alcohol use disorder: Prevalence, motives and patterns of use. *Journal of Substance Abuse Treatment*, 117(10), 108061. <https://doi.org/10.1016/j.jsat.2020.108061>
- Miniaci, A., & Gupta, V. (2020). Loading Dose. PubMed; StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK557418/>
- Mohammad Hadi Nematollahi, Mohammad Ali Ahmadianmoghadam, Mehrnaz Mehrabani, Masoud Moghadari, Adel Ghorani-Azam, & Mehrzad Mehrbani. (2022). Herbal therapy in opioid withdrawal syndrome: A systematic review of randomized clinical trials. *PubMed*, 14(2), 152–163. <https://doi.org/10.22122/ahj.2022.195961.1247>
- Mulkey, M. A., & Olson, D. M. (2020). Delirium Tremens in the Older Adult. *Journal of Neuroscience Nursing*, 52(6), 316–321. <https://doi.org/10.1097/jnn.0000000000000543>
- National Institute on Alcohol Abuse and Alcoholism. (2024a, February 27). Alcohol Use Disorder: From Risk to Diagnosis to Recovery | National Institute on Alcohol Abuse and Alcoholism (NIAAA). [www.niaaa.nih.gov/health-professionals-communities/core-resource-on-alcohol/alcohol-use-disorder-risk-diagnosis-recovery](https://www.niaaa.nih.gov/health-professionals-communities/core-resource-on-alcohol/alcohol-use-disorder-risk-diagnosis-recovery)
- National Institute on Alcohol Abuse and Alcoholism. (2024b, September). Alcohol use disorder (AUD) in the United States: Age groups and demographic characteristics. [www.niaaa.nih.gov/alcohols-effects-health/alcohol-topics/alcohol-facts-and-statistics/alcohol-use-disorder-aud-united-states-age-groups-and-demographic-characteristics](https://www.niaaa.nih.gov/alcohols-effects-health/alcohol-topics/alcohol-facts-and-statistics/alcohol-use-disorder-aud-united-states-age-groups-and-demographic-characteristics)
- Newman, R. K., Stobart, M. A., & Gomez, A. E. (2024). Alcohol Withdrawal Syndrome. *Nih.gov; StatPearls Publishing*. <https://www.ncbi.nlm.nih.gov/books/NBK441882/>
- Peschel, W. (2016). Quality Control of Traditional Cannabis Tinctures: Pattern, Markers, and Stability. *Scientia Pharmaceutica*, 84(3), 567–584. <https://doi.org/10.3390/scipharm84030567>
- Ritvo, A., Foster, D. E., Huff, C., Finlayson, R., Silvernail, B., & Martin, P. R. (2023). Long-term consequences of benzodiazepine-induced neurological dysfunction: A survey. *PLOS ONE*, 18(6), e0285584–e0285584. <https://doi.org/10.1371/journal.pone.0285584>
- Ruby, B., Benson, M., Kumar, E., Sudha, S., & Wilking, J. (2012). Evaluation of Ashwagandha in alcohol withdrawal syndrome. *Asian Pacific Journal of Tropical Disease*, 2, S856–S860. [https://doi.org/10.1016/s2222-1808\(12\)60279-5](https://doi.org/10.1016/s2222-1808(12)60279-5)
- Sachdeva, A., Choudhary, M., & Chandra, M. (2020). Alcohol Withdrawal Syndrome: Benzodiazepines and Beyond. *JOURNAL of CLINICAL and DIAGNOSTIC RESEARCH*, 9(9). <https://doi.org/10.7860/jcdr/2015/13407.6538>
- Sarkhel, S., Singh, O., & Arora, M. (2020). Clinical Practice Guidelines for Psychoeducation in Psychiatric Disorders General Principles of Psychoeducation. *Indian Journal of Psychiatry*, 62(8). [https://doi.org/10.4103/psychiatry.indianjpsychiatry\\_780\\_19](https://doi.org/10.4103/psychiatry.indianjpsychiatry_780_19)
- Shoja, M., Mehri, S., Amin, B., Askari, V. R., & Hosseinzadeh, H. (2018). The Prophylactic and Therapeutic Effects of Saffron Extract and Crocin on Ethanol Withdrawal Syndrome in Mice. *Journal of Pharmacopuncture*, 21(4), 277–283. <https://doi.org/10.3831/kpi.2018.21.031>
- Steel, T. L., Malte, C. A., Bradley, K. A., & Hawkins, E. J. (2022). Benzodiazepine Treatment and Hospital Course of Medical Inpatients With Alcohol Withdrawal Syndrome in the Veterans Health Administration. *Mayo Clinic Proceedings: Innovations, Quality & Outcomes*, 6(2), 126–136. <https://doi.org/10.1016/j.mayocpiqo.2021.11.010>
- Sullivan, J. T., Sykora, K., Schneiderman, J., Naranjo, C. A., & Sellers, E. M. (1989). Assessment of Alcohol Withdrawal: the revised clinical institute withdrawal assessment for alcohol scale (CIWA-Ar). *Addiction*, 84(11), 1353–1357. <https://doi.org/10.1111/j.1360-0443.1989.tb00737.x>

- Szilvia Czigle, Nagy, M., Přemysl Mladěnka, & Jaroslav Tóth. (2023). Pharmacokinetic and pharmacodynamic herb-drug interactions—part I. Herbal medicines of the central nervous system. *PeerJ*, 11(15), e16149–e16149. <https://doi.org/10.7717/peerj.16149>
- Tang, S. W., Tang, W. H., & Leonard, B. E. (2017). Herbal medicine for psychiatric disorders: Psychopharmacology and neuroscience-based nomenclature. *The World Journal of Biological Psychiatry*, 20(8), 586–604. <https://doi.org/10.1080/15622975.2017.1346279>
- Tidwell, W. P., Thomas, T. L., Pouliot, J. D., Canonico, A. E., & Webber, A. J. (2018). Treatment of Alcohol Withdrawal Syndrome: Phenobarbital vs CIWA-Ar Protocol. *American Journal of Critical Care*, 27(6), 454–460. <https://doi.org/10.4037/ajcc2018745>
- UF Health. (2025). Benzodiazepine Dependence - UF Health. [ufhealth.org. https://ufhealth.org/conditions-and-treatments/benzodiazepine-dependence](https://ufhealth.org/conditions-and-treatments/benzodiazepine-dependence)
- Valenzuela, C. F. (1997). Alcohol and neurotransmitter interactions. *Alcohol Health and Research World*, 21(2), 144. <https://pubmed.ncbi.nlm.nih.gov/articles/PMC6826822/>
- Votaw, V. R., Geyer, R., Rieselbach, M. M., & McHugh, R. K. (2019). The epidemiology of benzodiazepine misuse: A systematic review. *Drug and Alcohol Dependence*, 200(114), 95–114. <http://doi.org/10.1016/j.drugalcdep.2019.02.033>
- Wolf, C., Curry, A., Nacht, J., & Simpson, S. A. (2020). Management of alcohol withdrawal in the emergency department: Current perspectives. *Open Access Emergency Medicine*, Volume 12(1), 53–65. <https://doi.org/10.2147/oaem.s235288>
- World Health Organization. (2012). Prevention. [www.who.int. https://www.who.int/teams/mental-health-and-substance-use/treatment-care/mental-health-gap-action-programme/evidence-centre/alcohol-use-disorders/management-of-alcohol-withdrawal](https://www.who.int/teams/mental-health-and-substance-use/treatment-care/mental-health-gap-action-programme/evidence-centre/alcohol-use-disorders/management-of-alcohol-withdrawal)
- Xu, J., Mercury, J., Zhang, Z., & Xu, F. (2008). Psychological, social and behavioural factors that influence drug efficacy: a noteworthy research subject in clinical pharmacology. *British Journal of Clinical Pharmacology*, 66(6), 901–902. <https://doi.org/10.1111/j.1365-2125.2008.03300.x>
- Yoshinaga, R., Maki, T., Goto, Y., Inoue, H., Yano, H., & Tahara, E. (2020). Discontinuation or reduction in benzodiazepine use by treatment with the traditional herbal medicine Hangekobokuto, case reports. *Journal of General and Family Medicine*, 21(4), 143–145. <https://doi.org/10.1002/jgf2.313>

# About the Author



**Sydney McCoy** is a fourth-year Psychology student. Her research area focuses on the extent to which herbal interventions can improve patient outcomes, with a focus on those with psychiatric and neurological comorbidities. Her research advisor is Dr. Erika Montanaro from the College of Humanities & Earth and Social Sciences.

# The Influence of Early Gendered Messages in the Household and Broader Society on Women's Financial Literacy and Investment Behaviors Later in Life

Malimi Fernando & Gabriella Osorio

**Abstract:** There is a financial gender gap, specifically in investing, that can be traced back to differences in financial literacy and the effects of early socialization. Early socialization refers to household and societal messages that shape children's beliefs, confidence, and behavior. This literature review synthesizes evidence linking early gendered socialization to later financial literacy differences and investment behavior. The review examines early socialization, specifically the development of internalized sexism through influences such as parental roles, societal norms, linguistic structures, and exposure to benevolent sexism and explores gender differences in adults' financial attitudes, literacy, and behavior. These areas are connected through the potential influence of internalized sexism on confidence and self-competency. The reviewed studies suggest that early gendered messages and unequal exposure to financial education contribute to women's lower investment participation compared to men, as well as their confidence and risk tolerance in investing, reinforcing the financial gender gap observed in adulthood. The implications of this research are to increase awareness of how early gendered messaging shapes women's financial confidence and investment participation across their lifespan, while also highlighting the importance of representation shifts and informing future financial literacy education policy and intervention efforts.

**Research Advisors:** Dr. Melinda Adnot, Honors College; Dr. Jennifer Ames Stuart, Department of Marketing; Dr. Stephanie Bradley, Department of Sociology; Dr. Gene Lai, Department of Finance

**Keywords:** Gendered socialization, Linguistic relativity theory, Benevolent sexism, Internalized sexism, Financial literacy, Investment behaviors, Risk, Confidence

## Introduction

Extant research finds that early socialization may shape women's financial literacy and investment behaviors including participation in financial markets, asset allocation choices, risk tolerance, and engagement with financial advice later in life. This review evaluates how the development of internalized sexism through exposure to gender-verbiage and expectations in society can greatly influence these behaviors. There is a lack of research on the direct connection between early socialization and financial behaviors later in life; however, this review aims to draw a connection for further research. Sexism is defined as behaviors, beliefs, or attitudes that support the unequal status of women and men (Swim & Campbell, 2001). While sexism can operate at institutional,

interpersonal, and internalized levels (Bearman & Amrhein, 2014; Cudd & Jones, 2005) this review focuses intensely on internalized sexism. Internalized sexism refers to a form of internalized oppression, whether it is a specific value, belief, rule, or behavior, and sustaining it as a characteristic of themselves, which often includes adopting the prejudices of society towards the stigmatized group (Herek, 2009). Internalized sexism reveals how women can maintain the norms of a patriarchal system, just as much as men, through their own beliefs and actions (Hooks, 2018).

Croft and colleagues (2015) explained how internalized sexism diminishes one's personhood by limiting their sense of who they should be or who they could

become. Regardless of the numerous opportunities society promotes to solve the gender inequality issue in today's world, the "glass ceiling" in society still exists, partially due to the internalized beliefs of women that limit their self-confidence and feelings of self-competency. Early gendered messaging in households and society may greatly contribute to differences in women's financial literacy and investment behaviors. This review therefore (1) examines how early gender socialization contributes to internalized financial beliefs, (2) evaluates gender differences in financial literacy across development, and (3) analyzes how these differences influence investment behavior across the life course. This review contributes to the literature by synthesizing developmental, linguistic, and socialization pathways linking early gendered messaging to later financial literacy and investment participation.

Although prior research has examined gender differences in financial literacy and investment behavior, fewer studies directly connect early gender socialization processes to later financial outcomes. This paper evaluates previous studies that discuss sexism, linguistic relativity theory, and parental influence for early socialization through a broader lens and explores how these factors play into the disparity of financial literacy between men and women and how that may contribute to gendered differences in investing patterns. The contribution of this research is to acknowledge the gender socialization differences in development that women experience and their impact on financial literacy and investment behaviors later in life and initiate the conversation towards finding solutions to improve performance in financial fields, namely investing. While the focus demographic for this review is middle-class men and women, specifically children, adolescents, and young adults, it is important to note that several other demographics may have differing experiences, including differences related to marital status or income and socioeconomic status.

Financial literacy affects how one invests, and studies show a gender difference in investment behaviors between men and women — a topic important to understand in today's context. Financial literacy is defined as: "The ability to read, analyze, manage, and communicate about the personal financial conditions that affect material well-being. It includes the ability to discern financial choices, discuss money and financial issues without (or despite) discomfort, plan for the future, and respond competently to life events that affect everyday financial decisions, including events in the general economy" (Vitt et al., 2000).

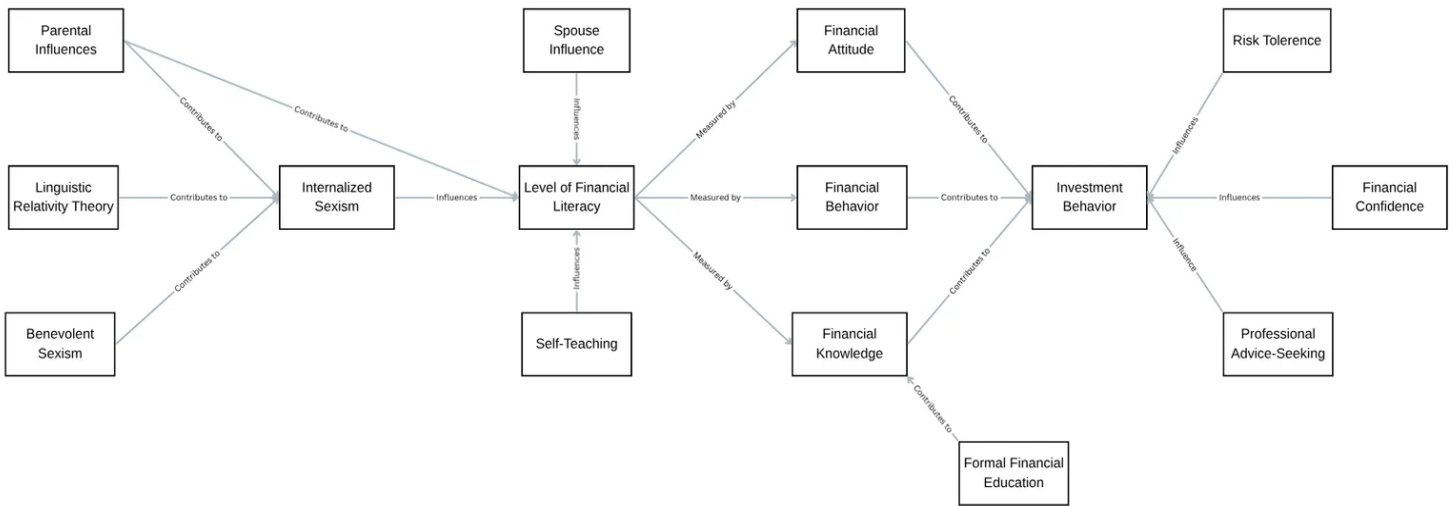
As AI and other technological tools increasingly impact people's real-life decisions, such as financial planning decisions, it is essential to understand how societal biases may influence how these tools provide advice. Large language models (LLMs) such as ChatGPT rely on social "rules" in language and speech to differentiate their communication and results based on the receiver's demographic characteristics, like gender. When there is a societal norm in speaking of areas such as finance as a male-driven subject, AI follows these patterns, replicating real life. Thus, the impact of gendered messages in the household and broader society is far from being a theoretical or historical issue; it is one with real and evolving implications in today's world.

## ***Methods***

This literature review synthesized peer-reviewed research examining gender differences in financial literacy and investment behavior, with attention on the role early gendered socialization plays. Articles were identified using databases including Google Scholar, JSTOR, and PubMed. Search terms included combinations of "financial literacy gender gap," "investment behavior gender differences," "development of internalized sexism," "early gendered socialization," and "financial advice." Priority was given to articles published within the past 10–15 years, though foundational studies were included where relevant.

Because financial literacy is defined and measured differently across studies, this review relied on two commonly used models to guide interpretation. The first model focuses on knowledge of financial decision making concepts as opposed to behavior (Bucher-Koenen et al., 2017), while the second incorporates financial attitude, financial behavior, as well as general financial knowledge within a multidimensional framework (Potrich et al., 2017). Together the models provided a consistent conceptual framework for interpreting how financial literacy was defined across the literature included in this review.

**Figure 1.** Conceptual map of the research idea.



The diagram shows the contributors to the formation of internalized sexism including benevolent sexism, linguistic relativity theory, and parental influences. It illustrates the influences of an individual’s financial literacy, as well as the measurements of financial literacy. The diagram further depicts the contributors and influences of individuals’ investment behavior. This conceptual map is meant to guide the reader along the concepts presented in this research.

## Internalized Sexism and Early Socialization

Early socialization plays a large role in shaping a child’s beliefs about their own ideas of self-competence, risk-taking, and financial decision-making. This section dives into how internalized sexism, benevolent sexism, linguistic structures, and parental influences interconnect to contribute in the development of biased financial beliefs from childhood through early adulthood. Understanding these processes may help explain how gender differences in financial literacy and investment behavior may be seen clearly later in life.

### Internalized Sexism

Many factors influence the formation of internalized sexism in women. Due to the consistent repeated exposure to gendered messages across institutions like media, education, and family, individuals may come to internalize sexist beliefs that align with broader cultural norms. Often, people come to internalize dominant ideologies without conscious awareness and this specifically reflects the strength of socialization and systemic power. A previous study on the process of internalizing sexism

revealed the existence of both direct and indirect relationships between traditional gender roles, accepting external influences, and self-alienation (Bozkur & Şahin, 2022). Becoming aware and understanding these relationships is of grave importance, precisely because of how women may subconsciously aid in the reproduction of stereotypical messages regarding traditional gender roles (Bozkur & Şahin, 2022). The reproduction of these messages may suggest an enhancement of their own internalized oppression through personal exposure, as well as increasing the exposure of said sexist messages to the women around them. An example of this is the implicit influence mothers can have on their daughters through the reproduction of messages from their own internalized oppression. This implicit influence is supported by previous studies indicating a positive relationship between an individual’s internalization of cultural beliefs about gender roles and the adoption of gender ideology perceived by one’s parents (Bishop, 2017; Jasser, 2008; Jones, 2014; Wenzel & Lucas Thompson, 2012). The formation of this internalized sexism can be due to societal influences just as much as parental influences.

## ***Benevolent Sexism***

The ambivalent sexism theory states that there are two interrelated ideologies of prejudice towards women: hostile sexism and benevolent sexism (Glick & Fiske, 1996). When people use the word sexism, most people first think of hostile sexism, which is when women are viewed in a more negative light; they are overly emotional and incompetent, and they are attempting to manipulate men to gain power (Gutierrez et al., 2020). Benevolent sexism, on the other hand, is the ideology that characterizes women as delicate, pure, and in need of men's protection and care (Gutierrez et al., 2020). In previous studies, benevolent sexism has been linked to decreased cognitive performance, self-esteem, and feelings of competency for women, which suggests a connection to the lack of confidence women experience in investment and finance fields.

The development of benevolent sexism can be seen in early ages through the idea of heroes and the helpless (Hammond et al., 2018). Stereotypical attitudes regarding roles for one's gender may be present in early childhood, and the development of female-helpless and male-heroic attitudes evolves differently over time (Hammond et al., 2018). Children between the ages of 7-11 start to recognize and internalize components of benevolent sexism. Hammond et al. (2018) revealed that boys across all ages believed that boys should be heroes; however, this bias decreased with age.

Simultaneously, as boys grew older, they were more likely to say girls deserve preferential treatment and were less likely to say boys should receive it. Men's benevolent sexism followed a positive linear trajectory and tended not to change over time. However, this consistent appeal to men could be due to the romantic appearance or how benevolent sexism subtly maintains men's power (Hammond et al., 2018). On the other hand, girls between the ages of 7-11 showed a significant decrease in endorsing the idea that girls should be placed on a pedestal. This decrease may be due to their increased awareness of gender inequality. Girls' internalized beliefs develop in a U-shaped trajectory where girls' endorsement of benevolent sexism may decline in middle childhood but then rise again in adolescence as societal influences shift, suggesting a possible connection to the romantic appearance men are attracted to as well. Although sexism levels were high in the youngest cohorts, the decrease in endorsement of sexist attitudes over time suggests that early awareness efforts may be effective, especially given how flexible beliefs are at a young age (Hammond et al., 2018).

Men and women experience benevolent sexism towards women entirely differently. Benevolent sexism is linked to men helping women in ways that foster dependence on men, which has also been found to be associated with decreased support for gender equality (Gutierrez et al., 2020). Higher accounts of women's benevolent sexism are connected to life stages where women are making larger financial decisions, including higher education, careers, and establishing serious relationships (Hammond et al., 2018). These stages in a woman's life are typically when she should be investing; however, due to the increased levels of benevolent sexism, there is a lack of self-confidence when making financial decisions. However, another study finds a positive correlation between levels of benevolent sexism when in relationships and a woman's tendency to take financial risks (Teng et al., 2021). From these connections, it can be predicted that when a woman is in a relationship with higher levels of benevolent sexism, she takes more financial risks due to the financial support that gives her confidence (Teng et al., 2021). This is a counterargument due to the fact that benevolent sexism is showing an increase in a woman's confidence rather than a decrease. This could possibly convey that women who are single/not married experience a more negative effect of benevolent sexism while women in relationships could experience a more beneficial effect of benevolent sexism. There is a lack of research in this specific relationship between the factors of relationship status and financial risk taking therefore this phenomenon will not be focused on in this literature review.

## ***Linguistic Relativity and Gendered Messaging***

The structure of languages which are used to communicate these gendered societal expectations, including benevolent sexism, may also influence how women internalize them, ultimately impacting their financial literacy and investment behaviors later in life. Linguistic relativity theory describes how the structure of languages plays a distinct role in shaping the thoughts of their speakers and forming an individual's experience. The underlying premise of this theory is that when a language uses gender differences, individuals are more likely to distinguish between males and females in everyday phrases (Siewierska, 2016). English has a sex-based system, meaning the language's gender system is linked to a biological sex, and it utilizes gender-differentiated pronouns in the third-person singular for he and she (Hechavarría et al., 2017). The use of gendered verbiage

and gender-differentiated pronouns when discussing careers, specifically in investing or finance, can foster the development of internalized sexism in a child through exposure to stereotypes in that specific society (Hechavarría et al., 2017; Boroditsky, Schmidt, & Phillips, 2003). These internalized stereotypes of society through the linguistic relativity theory support the hypothesis of gendered linguistic structures being a predictor of women staying away from investing due to this internal belief that it is not meant for them, thus creating and reinforcing gender stereotypes and inequalities (Cameron, 1998; Prewitt-Freilino et al., 2012).

### ***Parental Influence and Early Financial Socialization***

The language parents use subconsciously can have an implicit influence on their children. For instance, the literature supports that mothers influence their daughters through the reproduction of messages from their own internalized sexism, which may have partially been formed by the gendered linguistic structure of English (Jones, 2014; Jasser, 2008). Not only parental language but parental characteristics and their roles in the household hold an exceptionally significant influence on a child's development of internalized sexism. Focusing specifically on the parental influence on financial literacy, previous studies convey how parents can influence how their children view financial matters. It is critical to note that children internalize the transmission of financial values, norms, and behaviors from their parents, which all contribute to the child's economic well-being, defined as their developing understanding of money, financial attitudes, and confidence in managing financial decisions shaped through early household experiences (Ranyard, 2018). Whether these lessons are passed down intentionally or unintentionally, teaching specific financial knowledge and applying the particular knowledge can foster feelings of self-confidence and competence in managing finances independently (Ranyard, 2018).

### ***Gender Differences in Financial Literacy***

Financial literacy is an essential component in determining decision-making regarding monetary issues. It strongly predicts retirement planning, wealth, and investment outcomes. Notably, individuals who are more financially literate are more likely to participate in the market, which contributes to higher returns (Lusardi et al., 2023). Lusardi et al. (2017) also found that in the

United States, lack of financial literacy can be attributed to 30-40% of wealth inequality at retirement. The implications of improvement in financial literacy are immense, as it plays a critical role in shaping economic well-being and reducing wealth disparities. A lack of financial knowledge limits individuals' ability to make informed financial decisions and contributes significantly to long-term economic inequality.

One fundamental aspect of financial literacy that demands deeper attention is the large disparity in financial literacy between men and women. Potrich et al. (2017) conducted a study following the structure of the second model discussed previously that indicated an equal difference (12.8%) in lower and higher levels of financial literacy between men and women. Bucher-Koenen et al. (2017) utilize a different approach to understanding financial literacy in men and women—the model aimed to understand participants' basic understanding of interest rates, inflation, and risk diversification. The results of the study found that more men (55%) correctly answered questions related to interest rates and inflation compared to women (38%), and fewer women (22%) answered all three questions correctly compared to men (38%). The study further compared financial literacy among men and women in the United States, the Netherlands, and Germany and found that similar patterns prevailed. These results reveal that women are less financially literate than men, identical to the results of the study conducted by Potrich et al. (2017).

### ***Gender Differences Across Development***

The developmental and social influences from an early age that shape financial literacy are essential to consider to understand the root of this persistent gender gap. Financial literacy must be introduced and taught during development to increase the likelihood of success in retirement planning, investing, and other financial decision-making. Parents are the primary influencers of financial literacy, while self-teaching or a spouse is a secondary influence (Clarke et al., 2009). Particularly for women, the significant influence of a spouse can be understood through the lens of internalized and benevolent sexism. As many women are socialized to perceive financial management as a male responsibility, they may defer to their partners due to internalized beliefs about their own financial incompetence. Benevolent sexism further reinforces this dynamic by framing men as natural providers and protectors, subtly discouraging women from independently developing financial literacy. Clarke et al. (2009) also discuss that practicing financial tasks

and thoroughly teaching finances at home, rather than outside, makes adolescents feel more financially prepared. However, perceived parental influence significantly impacts financial attitude, not financial knowledge; it also indirectly influences financial behavior, mediated through financial attitude (Jorgensen et al., 2010). A study also found that males have their first financial discussion in the home at a younger age than females on average, which suggests that financial socialization in the home may be subject to a gender bias, over time contributing to differing financial literacy knowledge levels between the genders (Agnew & Cameron-Agnew, 2015). Thus, financial attitude/preparedness, which influences financial behavior, is highly influenced by parents during development. Parents harboring gendered biases might then significantly impact the financial literacy of their children, particularly in girls.

The most common form of indirect parental economic socialization is through role modeling. Children learn about money and financial behavior best by observing and imitating the most relevant models (Ran-yard, 2018). Variables such as the parents' highest level of schooling and a mother's presence in the household were positively correlated with a student's financial knowledge (Chambers et al., 2019). Agnew (2015) found that students attending medium decile schools had the smallest difference between male and female roles. Low socioeconomic families tended to see males as more likely to be the predominant breadwinner, indicating a more extreme view of gender roles. The largest difference in gender stereotypes in homes around financial literacy was when the students were asked to say which parent influences how they spend their money. Students across genders were more than twice as likely to answer that their father had the biggest influence. These findings emphasize the traditional stereotypes around the father being more financially knowledgeable than the mother and playing a larger role in financial discussions than the mother.

Moreover, parents explicitly teaching children and adolescents about finances better aids women in making more informed financial decisions than men. A study by Jorgensen et al. (2010) found that both men and women had better financial attitudes if they believed they were explicitly taught about finances by their parents. Still, women who were perceived to have explicitly learned about finances from their parents had higher financial behavior scores than men. Furthermore, although students expect to learn financial knowledge from their parents, parents may not explicitly teach it to their children (Jorgensen et al., 2010), as parents might view

financial literacy as something to be taught in school rather than in the household. Teaching financial literacy during development is especially important for women, as women report feeling less financially prepared for tasks such as investing than men, even when mothers significantly model investing (Clarke et al., 2009). This gender gap in financial attitude suggests that financial teaching in households, beyond simply modeling financial behaviors, is crucial for women to feel more confident in the topic and increase future engagement, such as investing. In addition to family influence, financial education is another critical factor for improving financial knowledge in both men and women and helping close the gender gap in financial literacy. Goldsmith et al. (2006) found that while neither men nor women are adequately financially literate, men scored higher on real investing knowledge than women. Men's subjective knowledge of investing was also higher than women's. However, the study found that this gap in perceived financial/investing knowledge virtually disappeared when students were given formal education through a Family Financial Analysis Finance course. Through this course, both men and women substantially increased real investment knowledge. This study proves that consumer education increases financial literacy and decreases the responsible financial behavior gap between men and women, as financial knowledge in women increases (Tang et al., 2015).

## **Impact on Investment Behavior**

### ***Risk Tolerance***

Financial literacy is crucial in developing optimal investment strategies, and men and women differ in their choices when deciding which personal investment option to invest in. Men prefer to invest in risky investments such as common stocks and real estate investments, while women prefer to invest in funds, time deposits, and gold (Bayyurt et al., 2013). Ulifalean (2024) also found that women prefer bank deposits more than men (by 23.21%), as bank deposits are considered low-risk investments. The risk of losing that money due to a personal choice is eliminated with bank deposits, making it an enticing option for women. Contrary to the findings of Bayyurt et al. (2013), however, Ulifalean (2024) found that men do prefer funds more than women (by 23.81%). Both studies agree that men prefer to invest in stocks more, which is arguably one of the riskiest investments. However, there is an equal preference between men and women for bonds, which Bayyurt et al. (2013) identified as one of the

riskier investment options. While women preferred bank deposits, it was considered one of the least popular options among men, alongside savings accounts (Ulfalean 2024). These findings align with the argument that women prefer low-risk investments that generally require less knowledge of finance and market fluctuation.

Gender differences in risk tolerance can be linked to early financial socialization in women. Women are likely first exposed to financial learning opportunities in college, where they have exposure to more financial learning opportunities than men (Tang et al., 2015). Female college students also have more conversations about finances with their parents than males (Tang et al., 2015; Edwards et al., 2007). Interestingly, Edwards et al. (2007) found that higher financial dependency contributes to more conversations with parents on financial learning. Nevertheless, these studies found that young women are still less likely to take financial risks and tend to have more anxiety about finances. This implies a gender difference in how parents socialize women regarding finance, in that young women do not get many financial learning opportunities until college. When they inquire about finances with their parents, women potentially receive advice to be more conservative with their finances.

### ***Confidence and Participation***

Early financial socialization and women's patterns of risk-aversion suggest that gendered messages in the household may strongly influence women's financial confidence. According to a survey study by Gill and Biger (2009), women's perceived lack of financial literacy is the most significant factor contributing to the disparity in investment decisions. The study reveals that women often view themselves as less financially knowledgeable, which may affect their investment behavior. Crost et al. (2015) highlight that internalized sexism limits one's sense of self by diminishing personhood, entailing that women who have internalized differing forms of sexism might view themselves as incapable of male-dominated activities such as investing. Therefore, lack of confidence in their financial expertise might stem from internalized sexism, a result of various social factors, most notably the exposure to benevolent sexism. These findings align with previous research, emphasizing the role of gendered perceptions in shaping financial decisions.

Thus, a lack of confidence in financial literacy contributes to gender differences in personal investing. Men tend to be overly confident in matters regarding finance, as finance is generally seen as a more male-dominated industry. Furthermore, growing research suggests that this is due, in part, to the fact that men are more

exposed to financial matters and losses in early development (Blaschke, 2022). A study observing self-confidence in respondents' financial literacy and measuring financial literacy found a gender gap in the reported self-confidence and the number of participants holding risky assets. Results indicated that men tend to be more confident in their financial abilities and obtain higher scores in financial literacy across several countries. Individual confidence in men tends to be a significant predictor of holding risky assets, as stated by Cupák et al. (2020).

### ***Long-Term Financial Outcomes***

Overconfidence in financial literacy also contributes to unsuccessful returns, as overconfidence steers towards higher trades and lower expected utilities (Barber & Odean, 2001). Due to men being more confident in finance, men tend to trade more than women, leading to excessive trading. Overconfident investors believe in their ability to accurately assess securities' values, which yields unrealistic expectations of how high their returns will be (Barber & Odean, 2001). High trading frequency has been seen to lower investors' returns, and buying and holding an investment leads to better returns (Willows et al., 2015). Specifically, trading less leads to higher long-term returns, and single men trade 67% more than single women (Barber & Odean, 2001). Thus, a degree of risk aversion and healthy financial confidence driven by high financial literacy is needed to make the best informed financial decision.

Further, studies find that knowing when to be more confident and risky and when to be more conservative in one's investments could potentially hold strong returns for investors. During the 2008 through 2009 financial crisis in South Africa, women outperformed men in trading/investing; after the crisis, however, men invested better (Willows et al., 2015). This suggests that since women are more conscious of where and when they invest their money, it may serve as an advantage during an economic crisis when reducing risk-taking is advised. Men might be seen as better investors after an economic crisis, as it is better to be more risk-tolerant and confident when the economy is recovering from such a crisis.

### ***Gendered Financial Advice and Decision Support***

Given the gendered messages that women receive throughout their development, which affect their investment behavior, it is also important to examine how investment advice-seeking in adulthood may reinforce or challenge these messages. As there are significant differences in how men and women invest, it is advisable for

financial advisors to tailor their approach based on their clients' gender. However, this does mean that men who harbor pre-existing biases regarding gender may provide biased advice to women on how they should invest. A study found that financial planning firms, as opposed to securities firms, give suboptimal advice to female clients based on gender, particularly if they indicate lower risk tolerance, lower confidence, and a domestic outlook (Bhattacharya et al., 2024). This is because if an advisor already has preexisting biases and holds either hostile or benevolent sexist ideologies, they tend to offer gendered financial advice. Interestingly, a study also found that large language models such as ChatGPT offered gendered recommendations based on whether they perceived the profession as masculine or feminine. They provided less risky, prevention-oriented recommendations to female professions, and texts written to women had a patronizing tone and were more simplified than those written to men (Etgar et al., 2024). These findings suggest that gender biases in investing can manifest in AI-driven recommendations alongside financial advisors, thus aligning with the idea that preexisting biases can be tied to systematically different financial guidance based on the receiver's gender.

Moreover, parental socialization influences financial advice-seeking habits in women. Simms (2014) found that only 24% of women reported using investment advice in the past five years since the study was conducted. In the findings, women were labeled as either "strugglers" or "thrivers," with lower self-assessed risk aversion being one crucial distinguishing factor between the two groups. The study found that "thrivers" are less likely to seek financial advice when someone in the household knows more about finances than they do. Thus, risk tolerance is crucial in predicting whether a woman will seek financial advice. Such advice-seeking behavior is indirectly tied to parental style and whether one received an allowance during development; it is also directly tied to financial literacy and risk tolerance. Receiving an allowance during adolescence is associated with a greater financial risk tolerance, and higher levels of financial knowledge and risk tolerance are correlated with a higher likelihood of seeking professional financial advice (Fan et al., 2021). Therefore, early financial experiences through parental socialization contribute to the development of financial confidence and a willingness to seek professional advice — factors that influence the gender gap in investing and finance.

## Discussion

The literature suggests that early gendered messaging may shape internalized beliefs about financial competence, which influence financial literacy development and ultimately contribute to financial behavior and investment participation patterns across adulthood. There is a disparity in financial literacy between men and women based on tests of financial knowledge, attitude, and behavior. Financial literacy is a determinant of investment patterns, as a lack of financial literacy, or perceived lack thereof, can contribute to less financial confidence in women. Financial confidence is tied to risk tolerance in investing, and men have been found to prefer to invest in riskier investments than women. Moreover, women's lack of financial confidence can be linked to experiencing benevolent sexism, as it is correlated with decreased cognitive performance, self-esteem, and feelings of competency for women. Because financial literacy develops early in life, parental socialization plays a central role in shaping these confidence differences across development. Several studies have found that direct financial education by parents is crucial in determining a child's financial literacy later in life (Clarke et al., 2009; Jorgensen et al., 2010), as parental characteristics and roles significantly influence the development of their children's mindsets. Children who learn about finances from parents tend to have more financial knowledge and better financial behaviors later in life. However, males have financial discussions at home at a younger age than females, suggesting gender biases in financial education in the home. Linguistic relativity theory, the idea that languages with gender-differentiated structure may create and reinforce gender stereotypes and inequalities, may then explain why women tend to invest less, or be more risk-averse, than men. These findings suggest that gender differences in financial behavior are not only shaped by access to financial knowledge but also by early socialization processes that influence confidence, perceived competence, and participation across the life course.

## Limitations

There are, however, limitations to this work. Financial literacy is patterned by many demographic factors, including gender, race, ethnicity, social class, culture, etc. (Chen, H. & Volpe, R. P., 1998). However, this review focuses solely on the influence of gender on socialization. Acknowledging that the connections made in this review may not apply to certain demographic groups or regions

is essential. A separate limitation is the lack of longitudinal research on women's early socialization and its long-term effects on financial behavior. Future research can help identify and confirm this link through longitudinal studies. There are also potential biases due to the data collection methods, which consist of self-reports in the literature reviewed. While this review revealed valuable information on gendered financial socialization, these limitations emphasize the need for further research to understand the multiple factors intertwining to shape financial literacy entirely.

## Implications

The findings of this review suggest several implications for education, policy, and future research. The studies have shown that financial education is critical, specifically early financial education. Women worldwide lack financial literacy due to a lack of financial education, leading to a greater gender wealth gap. Moving forward, policymakers should consider early financial education as a critical element and effective method of promoting gender equity in the long term (Bae, 2023). The empirical tests for the effect of financial education on financial literacy suggest that women who receive early financial education to improve their financial literacy can better understand the compounding effect of interest rates on loans, portfolio diversification, and mortgage payments. It was also revealed that early financial education on financial behavior positively correlates with women's increased participation in the stock market, insurance activities, and savings habits (Bae, 2023). Looking forward, linguistic relativity theory should be considered when discussing societal changes related to gendered language and its influence on financial confidence and participation. The use of gendered verbiage and gender-differentiated pronouns when talking about careers, specifically in finance and investing, can foster the development of internalized sexism in children through exposure to societal stereotypes (Hechavarría et al., 2017; Boroditsky, Schmidt, & Phillips, 2003). Research suggests that the implicit use of gendered-verbiage can lead girls to internalize the idea that investing and financial fields are not meant for them, specifically when considering their gender identity. This internalization may contribute to long-term disengagement from a girl's future financial opportunities. Suppose changes are made as a society in terms of the use of gendered verbiage by shifting towards more inclusive language, where feminine pronouns are used more to describe professions. In that

case, this may help reduce the gender gap in financial literacy and investment behavior.

## Conclusion

This literature review demonstrates that early gendered messaging plays an important role in shaping women's financial literacy development and investment behaviors throughout the life course. By synthesizing research on internalized sexism, parental socialization, linguistic structure, and financial confidence, this review emphasizes how early social environments contribute to persistent gender differences in financial behavior. Understanding these developmental pathways provides a foundation for future research and intervention strategies aimed at reducing the financial gender gap.

## References

- Agnew, S., & Cameron-Agnew, T. (2015). The influence of consumer socialisation in the home on gender differences in financial literacy. *International Journal of Consumer Studies*, 39(6), 630–638. <https://doi.org/10.1111/ijcs.12179>
- Andersson, M. A., & McSwain, A. N. (2025). Internalized sexism and well-being in the united states. *Journal of Health and Social Behavior*, 0(0). <https://doi.org/10.1177/00221465241305586>
- Bae, K., Jang, G., Kang, H., & Tan, P. (2022). Early financial education, financial literacy, and gender equity in finance. *Asia-Pacific Journal of Financial Studies*, 51(3), 372–400. <https://doi.org/10.1111/ajfs.12378>
- Barber, B. M., & Odean, T. (2001). Boys will be boys: gender, overconfidence, and common stock Investment. *The Quarterly Journal of Economics*, 116(1), 261–292. <https://doi.org/10.1162/003355301556400>
- Bayyurt, N., Karisik, V., & Coskun, A. (2013). Gender differences in investment preferences. ResearchGate. [https://www.researchgate.net/publication/277313389\\_Gender\\_Differences\\_in\\_Investment\\_Preferences](https://www.researchgate.net/publication/277313389_Gender_Differences_in_Investment_Preferences)
- Bhattacharya, U., Kumar, A., Visaria, S., & Zhao, J. (2024). Do women receive worse financial advice? *The Journal of Finance*, 79(5), 3261–3307. <https://doi.org/10.1111/jofi.13366>
- Bishop, A. (2017). Intergenerational transmission of gender ideology: the unique associations of
- Blaschke, J. (2022). Gender differences in financial literacy among teenagers - Can confidence bridge the gap? *Cogent Economics & Finance*, 10(1). <https://doi.org/10.1080/23322039.2022.2144328>
- Boroditsky, L., Schmidt, L. A., & Phillips, W. (2003). Sex, syntax and semantics. In D. Gentner & S. Goldin-Meadow (Eds.), *Language in mind: Advances in the study of language and thought* (pp. 61–79). Boston Review.
- Bozkur, B., & Arıcı Şahin, F. (2022). Relationships among traditional gender roles, acceptance of external influence and self-Alienation: the mediator role of internalized sexism. *International Journal of Progressive Education*, 18(4), 43–53. <https://doi.org/10.29329/ijpe.2022.459.4>
- Bucher-Koenen, T., Lusardi, A., Alessie, R., & Van Rooij, M. (2016). How financially literate are women? An overview and new insights. *Journal of Consumer Affairs*, 51(2), 255–283. <https://doi.org/10.1111/joca.12121>
- Cameron D. (1998). Gender, language, and discourse: A review essay. *Signs*, 23(4), 945–973.
- Chambers, R. G., Asarta, C. J., & Farley-Ripple, E. (2019). Gender, parental characteristics, and financial knowledge of high school students: evidence From multicountry data. *Journal of Financial Counseling and Planning*, 30(1), 97–109. <https://doi.org/10.1891/1053-3073.30.1.97>
- Chen, H., & Volpe, R. P. (1998). An analysis of personal financial literacy among college students. *Financial Services Review*, 7(2), 107–128. [https://doi.org/10.1016/S1057-0810\(99\)80006-7](https://doi.org/10.1016/S1057-0810(99)80006-7)
- Clarke, M. C. (2005). The acquisition of family financial roles and responsibilities. *Family and Consumer Sciences Research Journal*, 33(4), 321–340. <https://doi.org/10.1177/1077727x04274117>
- Croft A., Schmader T., Block K. (2015). An under examined inequality: cultural and psychological barriers to men's engagement with communal roles." *Personality and Social Psychology Review* 19(4):343–70.
- Cudd, L., & Jones, E. (2005). Sexism. In R. G. Frey and C. H. Wellman (Eds.) *A companion to applied ethics* (pp. 102–117). Oxford: Wiley Blackwell Publishing.
- Cupák, A., Fessler, P., & Schneebaum, A. (2020). Gender differences in risky asset behavior: The importance of self-confidence and financial literacy. *Finance Research Letters*, 42, 101880. <https://doi.org/10.1016/j.frl.2020.101880>
- David, E. (2014) *Internalized oppression: The psychology of marginalized groups* (pp. 191–225). Springer. dissertation. Colorado State University.
- Edwards, R., Allen, M. W., & Hayhoe, C. R. (2007). Financial attitudes and family communication about students' finances: The role of sex differences. *Communication Reports*, 20(2), 90–100. <https://doi.org/10.1080/08934210701643719>
- Etgar, S., Oestreicher-Singer, G., Yahav, I., The Vicky and Joseph Safra Research Institute for Banking and Financial Intermediation, & Tel-Aviv University. (2024). Implicit bias in LLMs: Bias in financial advice based on implied gender. In *The Vicky and Joseph Safra Research Institute for Banking and Financial Intermediation*. [https://coller.tau.ac.il/sites/coller.tau.ac.il/files/media\\_server/Recanati/management/safra\\_galo.pdf](https://coller.tau.ac.il/sites/coller.tau.ac.il/files/media_server/Recanati/management/safra_galo.pdf)
- Fan, L., Lim, H., & Lee, J. M. (2021). Young adults' financial advice-seeking behavior: The roles of parental financial socialization. *Family Relations*, 71(3), 1226–1246. <https://doi.org/10.1111/fare.12625>
- Gill, A., & Biger, N. (2009). Gender differences and factors that affect stock investment decision of Western Canadian investors. *International Journal of Behavioural Accounting and Finance*, 1(2), 135. <https://doi.org/10.1504/ijbaf.2009.027449>
- Glick, P., & Fiske, S. T. (1997). Hostile and benevolent sexism: measuring ambivalent sexist attitudes toward women. *Psychology of Women Quarterly*, 21(1), 119–135. <https://doi.org/10.1111/j.1471-6402.1997.tb00104.x>
- Goldsmith, R. E. (2006). The effects of investment education on gender differences in financial knowledge. ResearchGate. [https://www.researchgate.net/publication/268341254\\_The\\_Effects\\_of\\_Investment\\_Education\\_on\\_Gender\\_Differences\\_in\\_Financial\\_Knowledge](https://www.researchgate.net/publication/268341254_The_Effects_of_Investment_Education_on_Gender_Differences_in_Financial_Knowledge)
- Gutierrez, B.C., Halim, M.L.D., Martinez, M.A. et al. (2020) The heroes and the helpless: the development of benevolent sexism in children. *Sex Roles* 82, 558–569 <https://doi.org/10.1007/s11199-019-01074-4>
- Hammond, M. D., Milojev, P., Huang, Y., & Sibley, C. G. (2017). Benevolent sexism and hostile sexism across the ages. *Social Psychological and Personality Science*, 9(7), 863–874. <https://doi.org/10.1177/1948550617727588>

- Hechavarría, D. M., Terjesen, S. A., Stenholm, P., Brännback, M., & Lång, S. (2018). More than words: do gendered linguistic structures widen the gender gap in entrepreneurial activity? *Journal of Cross-Cultural Psychology*, 42(5), 1297-1312. <https://doi.org/10.1177/0022022111430254>
- Herek, G. M. (2009). Sexual prejudice. In T. D. Nelson (Ed.) *Handbook of prejudice, stereotyping and discrimination* (pp. 441-468). New York: Psychology Press.
- Hira, T., & Mugenda, O. (2000) Gender differences in financial perceptions, behaviors and satisfaction.
- Hooks, B. (2004). *The will to change: Men, masculinity, and love*. Atria Books.
- Jasser, J. L. (2008). *Inauthentic self in relationship: The role of attitudes toward women and mothers' nurturance*. Doctoral dissertation. University of Florida.
- Jones, K. (2014). *Parenting styles and the intergenerational transmission of gender ideology*. Master's thesis. Colorado State University
- Jorgensen, B. L., & Savla, J. (2010). Financial literacy of young adults: The importance of parental socialization. *Family Relations*, 59(4), 465-478. <https://doi.org/10.1111/j.1741-3729.2010.00616.x>
- Lusardi, A., & Mitchell, O. S. (2023). The importance of financial literacy: Opening a new field. *The Journal of Economic Perspectives*, 37(4), 137-154. <https://doi.org/10.1257/jep.37.4.137>
- Lusardi, A., Michaud, P., & Mitchell, O. S. (2017). Optimal financial knowledge and wealth inequality. *Journal of Political Economy*, 125(2), 431-477. <https://doi.org/10.1086/690950>
- parental gender ideology and gendered behavior with adolescents' gender beliefs. Doctoral Potrich, A. C. G., Vieira, K. M., & Kirch, G. (2017). How well do women do when it comes to financial literacy? Proposition of an indicator and analysis of gender differences. *Journal of Behavioral and Experimental Finance*, 17, 28-41. <https://doi.org/10.1016/j.jbef.2017.12.005>
- Prewitt-Freilino J.L., Caswell T.A., & Laakso E.K. (2012). The gendering of language: A comparison of gender equality in countries with gendered, natural gender, and genderless languages. *Sex Roles*, 66(3-4), 268-281.
- Ranyard, R. (2017). *Economic psychology*. John Wiley & Sons.
- Rudeloff, M., Brahm, T., & Pumptow, M. (2019). Does gender matter for the use of learning opportunities? Potential explanation for the gender gap in financial literacy. *Citizenship, Social and Economics Education*, 18(3), 128-142. <https://doi.org/10.1177/2047173419892208>
- Showkat, M., Nagina, R., Nori, U., Muzamil, A. B., & Shah, M. A. (2024). Empowering women in the digital age: can digital financial services fulfil the promise of financial autonomy and gender equality in the attainment of Sustainable Development Goal 5? *Cogent Economics & Finance*, 12(1)<https://doi.org/10.1080/23322039.2024.2342459>
- Siewierska A. (2016). Gender distinctions in independent personal pronouns. Available at <http://wals.info/chapter/44>.
- Simms, K. (2014). Investor profiles. *Financial Services Review*, 23(3), 273-286. <https://doi.org/10.61190/fsr.v23i3.3200>
- Swim, K. J., & Campbell, B. (2001). Blackwell handbook of social psychology: Intergroup processes. In R. Brown & S. L. Gaertner (Eds.), *Sexism: Attitudes, beliefs, and behaviors* (pp. 218-237). Blackwell Publishers.
- Tang, N., Baker, A., & Peter, P. C. (2015). Investigating the disconnect between financial knowledge and behavior: the role of parental influence and psychological characteristics in responsible financial behaviors among young adults. *Journal of Consumer Affairs*, 49(2), 376-406. <https://doi.org/10.1111/joca.12069>
- Teng, F., Miao, Y., Cheng, W., & Huang, X. (2021). Counting on you: benevolent sexism increases women's financial risk-taking. *The Journal of Social Psychology*, 162(5), 580-594. <https://doi.org/10.1080/00224545.2021.1936438>
- Uifalean, R. (2024). Risk attitudes, financial literacy and financial behavior: a gender specific comparison. *The Review of Finance and Banking*, 16(2), 249-271. [https://www.researchgate.net/profile/Uifalean-Razvan/publication/388397862\\_Risk\\_Attitudes\\_Financial\\_Literacy\\_and\\_Financial\\_Behavior\\_-\\_A\\_Gender\\_Specific\\_Comparison/links/67964abb207c0c20fa5c51c5/Risk-Attitudes-Financial-Literacy-and-Financial-Behavior-A-Gender-Specific-Comparison.pdf](https://www.researchgate.net/profile/Uifalean-Razvan/publication/388397862_Risk_Attitudes_Financial_Literacy_and_Financial_Behavior_-_A_Gender_Specific_Comparison/links/67964abb207c0c20fa5c51c5/Risk-Attitudes-Financial-Literacy-and-Financial-Behavior-A-Gender-Specific-Comparison.pdf)
- Vitt, L. A., Anderson, C., Kent, J., Lyter, D., Siegenthaler, J., & Ward, J. (2000). Personal finance and the rush to competence: financial literacy education in the U.S. in the fannie mae foundation & institute for socio-financial studies, A National Field Study. [https://www.researchgate.net/profile/Lois-Vitt/publication/240619141\\_Personal\\_Finance\\_and\\_the\\_Rush\\_to\\_Competence\\_Financial\\_Literacy\\_Education\\_in\\_the\\_US/links/56203f3f08aed8dd194046de/Personal-Finance-and-the-Rush-to-Competence-Financial-Literacy-Education-in-the-US.pdf](https://www.researchgate.net/profile/Lois-Vitt/publication/240619141_Personal_Finance_and_the_Rush_to_Competence_Financial_Literacy_Education_in_the_US/links/56203f3f08aed8dd194046de/Personal-Finance-and-the-Rush-to-Competence-Financial-Literacy-Education-in-the-US.pdf)
- WALS. (2016). *The World Atlas of Language Structures*. <http://wals.info>
- Wenzel, A. J., & Lucas-Thompson, R. G. (2012). Authenticity in college-aged males and females, how close others are perceived, and mental health outcomes. *Sex roles*, 67(5), 334-350. <https://doi.org/10.1007/s11199-012-0182-y>
- Willows, G., & West, D. (2015). Differential Investment Performance in South Africa based on gender. *International Business & Economics Research Journal (IBER)*, 14(1), 221. <https://doi.org/10.19030/iber.v14i1.9040>

# About the Authors



**Malimi Fernando** is a fourth-year Marketing Analytics and Finance major. Her research area focuses on gender inequality, with a focus on the gender wealth gap. Her research advisors are Dr. Melinda Adnot from the Honors College, Dr. Jennifer Ames Stuart from the Department of Marketing, Dr. Stephanie Bradley from the Department of Sociology, and Dr. Gene Lai from the Department of Finance.

**Gabriella Osorio** is a fourth-year Biology major, with a minor in Child & Family Development. Her research area focuses early socialization and its influence on females' views of their place and capabilities in society. Her research advisors is Dr. Jennifer Ames Stuart from the Department of Marketing.





***Prima aestate, Isabel Fee, 2021***

As a native North Carolinian, I seek to capture the everyday beauty of North Carolina. Each piece is hand-painted, oil-on-canvas and depicts a different landscape in the Piedmont region. Inspired by impressionism, photorealism, and critical regionalism, the work celebrates the uniqueness of NC and promotes its preservation. Prints of the growing collection are for sale at [carolinaartco.com](http://carolinaartco.com).

