Journal of Undergraduate Research

UNIVERSITY OF ROCHESTER

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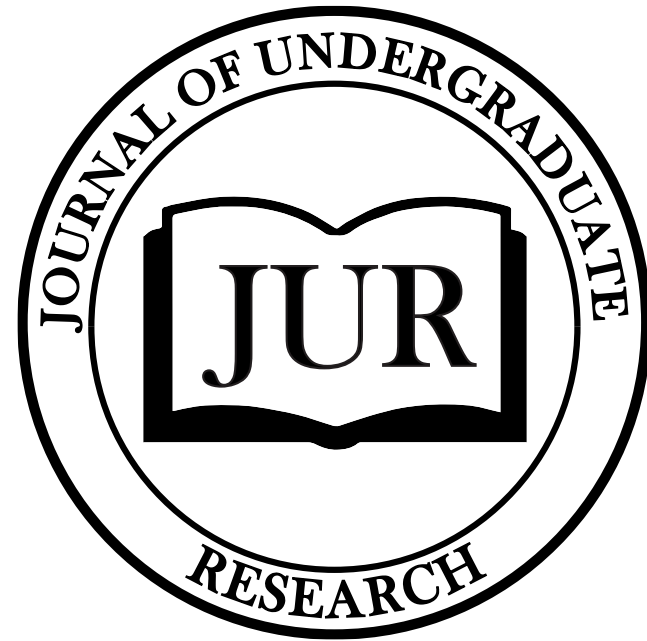How does crab camouflage affect substrate preference?" (p. 36)

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The Journal of Undergraduate Research (JUR) is dedicated to providing the student body with intellectual perspectives from various academic disciplines. JUR serves as a forum for the presentation of original research, thereby encouraging the pursuit of significant scholarly endeavors.

Letter from the Editors

To all of our readers, faculty, and staff, we are thrilled to present the Spring 2022 issue of the Journal of Undergraduate Research, a remarkable compilation of research conducted by undergraduate students here at the University of Rochester. It has been an honor to serve as the Editors-in-Chiefs of the publication this year, as we are continuously amazed by the quality of submissions we receive. It is clear within each page the level of dedication, academic rigor, and sophistication that is required to write and prepare these articles.

In this issue, we highlight six articles that showcase the wide breadth of diverse research being conducted at the University. From Regan Collins' examination of the camouflage defense mechanism of European green crabs to Julia Bergel's investigation of the ethics of volunteer tourism and mission trips, we believe that the research in this issue demonstrates the creative, innovative and intellectual capacity of our undergraduate student body. We want to highlight the abstracts from students who presented at the Undergraduate Research Expo in April 2022. We hope that our interview with Jack Paine, an associate professor in the Department of Political Science, encourages more undergraduates to pursue research in any field they are interested in. We hope that the upcoming articles in this issue inspire our readers to think critically, investigate fully, and be courageous in their academic pursuits.

We would especially like to thank our layout team and managing editors who assembled the journal and worked to ensure our articles were of the highest quality. Additionally, we thank our dedicated faculty who put in the time and effort to review each submission with great care and consideration. Our journal would not be possible without the support of the Undergraduate Research Office. Once again, thank you to our authors, faculty, and editorial team for making this publication possible. Every single contribution is appreciated. Finally, to our readers, we hope you enjoy this collection of interdisciplinary works from our undergraduate research community.

Sincerely,

Nisha Arya & Jocelyn Mathew

Editors-in-Chief

Professor Interview

Jack Paine, PhD

Associate Professor
Political Science
University of Rochester

Prof. Paine is an associate professor in the political science department at the University of Rochester. His work lies at the intersection of comparative politics, international relations, and applied formal theory. His projects broadly encompass the strategic and historical origins of authoritarian/democratic political institutions, and their consequences for regime stability and conflict. Specifically, he studies power sharing in authoritarian regimes and consequences for conflict, colonial origins of democracy and dictatorship, democratic backsliding, and the resource curse. His work uses a mixture of applied game theory and original data collection/analysis. He teaches courses on authoritarian politics, democratization, applied game theory, and the senior honors seminar.

JUR: What has been your relationship with research as an undergraduate, and then as a PhD, and then as a professor? What have been the differences, if there are any, in how you view the process of research between those periods?

Paine: In terms of PhD training and then into faculty positions, getting involved in original academic research is the single most important thing that determines the trajectory of your career. On the undergraduate side, I wrote a senior honors thesis in economics, and that definitely constituted original research. However, in my undergraduate major, I would say that most of my assignments did not count as "original research," in the sense that I would write papers for class and would only occasionally advance things that weren't entirely established in the literature. Most of my papers were talking about what other people have said, which I think is very valuable to engage with existing research, but it doesn't really constitute research in its own right.

JUR: For those who might not see themselves as having a career in academia, what might be the case you would make for still engaging with research as an undergraduate?

Paine: There are two aspects here: One is on the consuming and reading research that's been written, which I think is hugely valuable. That's essentially the purpose of the undergraduate courses. We want to teach you things about politics and the lens through which we know about politics. There are obviously your lived experiences, but a lot of it is based on the published body of research on whatever topic. In the classes I teach, there is my take on things, but there's always associated readings drawing on the best research on these topics.

Another part of the teaching job is that we want to make sure that we're communicating the ideas in a way such that a reader who hasn't gotten advanced math or statistics training can understand the essence of the argument and evidence. I think that's hugely important, as that's how you'll learn about politics. On the producing research side, in a case where a professor wants to hire a research assistant, usually it's going to be for a gathering data purpose. If there's a professor that needs an undergraduate research assistant and it falls into a topic area that the student is interested in — or frankly even if not — it can be a valuable experience just to understand how data is gathered. Even if the student has less input on the later stages of the paper, in terms of relating the evidence they find to particular arguments and theories or statistically analyzing the data, they're obviously closer to the project. They can get a sense of how the sausage is made, and hopefully convince you that we're not just making up a lot of things. There's an actual systematic, rigorous process that goes into research.

Finally, the senior honors program is the single best opportunity for any undergraduate to actually pursue their own research. Here, you're doing your project and you have a faculty advisor to help you shape it. That really gives you experience of going through the steps needed to write a research project. Hopefully for the students doing this, even if they don't go on to academia (which most of them don't), you learn the steps needed to produce original knowledge about the social world, and hopefully learn a lot about a topic that you're actually interested in.

JUR: When COVID-19 began, many people turned to the field of medical research to provide a vaccine. A lot of people

might view the natural sciences to be for this purpose entirely — to make a physical, novel discovery. To use the conflict in Ukraine as an anchor point, what do you view to be the role or responsibility, now, of the political science academics? When you analyze authoritarian regimes in your case, what do you think the purpose of your work ends up being in the context of events erupting in the world?

Paine: There's two ways to think about this: One is that broadly, whether or not a topic is in the focus of the media at any particular time, our goal is to build up a stock of knowledge about how politics works. We are also developing broader ideas for how to think about political phenomenon.

But that's kind of abstract, so I do like the second way to think about this. The only way to possibly respond to events that come up in the news — and obviously the war in Ukraine is the most pressing current example — is to already have a stock of knowledge about why countries invade other territories, what the role of nationalism in defending territory is, and specific knowledge about Russia, Ukraine, and the former Soviet Union. If we didn't already have an established body of knowledge about these things — even that which was built up before the time it was in the media —we wouldn't really have anything knowledgeable to say about it now. That's why building up a stock of knowledge and a general understanding of these different phenomena are not separated at all from how we provide informed commentary on current events. We wouldn't be able to provide informed commentary on the war in Ukraine if we hadn't already built the stock of knowledge through years of previous research.

JUR: Especially in the last ten years, the velocity of information has sped up tremendously. After an event occurs, social media is swarmed with analysis, and by the time a deep, comprehensive analysis can be performed in academia, often the next thing has already occurred. Do you view there to be growing tension between the thorough, methodical work of a book and the rapid analysis where most people are getting their information? Has that tension influenced how you conduct the work that you do?

Paine: We'll talk about Twitter for a second. There are big pros and cons about Twitter for disseminating informed analysis of a current event. The obvious cons are that you just get people on Twitter who have a platform to say things that they otherwise wouldn't. That's generally not a good thing. At the same time, in the last ten years at least in the political science discipline, there have been a small segment of political scientists who would regularly provide commentary to the media. Twitter, in that sense, actually makes it much easier for us to communicate our thoughts about current events in a way that just wasn't available ten years ago. If you're on these social media platforms and the content you're following is people who are actually knowledgeable about these issues, these social media platforms can be very effective at getting information out much faster.

On the more rigorous research side, journal submissions take a long time – in a way that's not necessarily a bad thing – because you want constructive feedback and dialogue. But there's always this tension for current events amongst the people that supposedly are the experts. You want to know what the experts have to say about it right away, but at the same time, even the so-called experts need time to really develop their ideas. So, there can be this interplay between the rapid, hopefully informed responses we can come up with and the hidden academic publication research, at least relative to the public view.

On social media, I'd say there's three types of posts that people have. One can be comments about contemporary issues, like things in the media. Second is the "I published a paper, here's a short summary of it." My posts on social media are almost always in this category. And finally, there's the tweeting about random nonsense. There's actually a pretty good balance among the three types, so there is good commentary on current events or at least you'll get a wide range of people's perspectives, which I think is a good thing.

JUR: What do you want the trajectory of your research to be in the future? How long-term do you think when you're going about certain projects?

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Then I have another strand of research looking at authoritarian power sharing. In the U.S., you can just look at the structure of the Constitution and have a pretty good sense of how things work. In authoritarian regimes, even if they nominally have a constitution, it's hard to figure out who actually makes what decisions and why, and why do the institutions look like that. I've written a lot of papers about why you see different types of institutions and in different authoritarian regimes.

But then as you can probably guess from the classes I teach, I've developed strong interests in American politics. This is a question of how people in power design the rules of the game to get what they want. There are a lot of similarities between how standard "dictators" structure their institutions and rules and how institutional engineering occurs in these democracies. So, what I found is that a lot of the things I've thought about in the context beyond U.S. politics has applications that haven't been developed. That's something I'm interested in going forward.

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JUR: What would be your advice for an undergraduate student looking to engage with research, generally or specifically in the field that you are in?

Paine: There are various opportunities for undergraduates. I think the single best one is the senior honors program because you'll work on and develop your own project. But obviously that's a small subset of the entire major. Another valuable opportunity is working as an undergraduate research assistant for a professor that is interested. There are also Independent Study courses where you can essentially shape your own syllabus around a topic that you're interested in. Though internships fall into a slightly different category, they at least provide you with a chance to actively engaging with politics. Additionally, even when you write papers in the courses you take, try to use them as an opportunity to explore a topic in a different area. There's a multitude of opportunities for students that are interested in either doing their own research or, more realistically in most cases, helping out professors with their research.

The Gendering of Harmful Magic: The Process of Gendered Differences in Witchcraft

Kirsten Bell '24, *History*

Advised by Laura Smoller, Department of History

When one thinks about witches, the first thing that probably comes to mind is a woman practicing demonic spells or riding a broomstick across a full moon. Perhaps images of Halloween costumes or witchcraft in popular culture also appear. Regardless of the specifics surrounding modern depictions of witches, the connecting thread between all these portrayals is that the "witch" is most often a woman. But according to scholars like Michael D. Bailey, this gendered association only came about in the fifteenth century. In his article "The Feminization of Magic and the Emerging Idea of the Female Witch in the Late Middle Ages," he states that starting in the fifteenth century, through the influences of misogynistic works such as the *Formicarius* (1437) by Johannes Nider and the *Malleus maleficarum* (1486) by Heinrich Kramer, "an aspect of witchcraft emerged that...is perhaps the most striking and compelling element of the stereotype—the pronounced association of witchcraft with women rather than with men".[1] However, could this phenomenon have started earlier than the fifteenth century? Surprisingly, there are sources dating back to as early as the ninth century that demonstrate an association of women with certain types of magic and their increased susceptibility to the devil's influence.[2] Thus, this phenomenon may have developed over a much longer period of time.[2]

Additionally, is there more to Bailey's argument that involves men in a greater capacity? Could this process demonstrate gendering beyond just feminization? I argue that magic as a whole was not just feminized, but gendered from the very beginning. Some forms of magic such as village-level magic[3] and eventually witchcraft became affiliated with femininity, but more "complicated" magic like necromancy was initially gendered as masculine. The process that Bailey illustrates occurred much earlier than the fifteenth century because in the Early Middle Ages, magic was already gendered, but women who were using magic were not seen as harmful. By the end of the medieval period, this gendered magic came to be seen as dangerous due to increased fear of the Devil.

I will explore an example of earlier gendering from the primary source Burchard of Worms' *Corrector* titled, "Have You Believed?" written in the tenth century but containing iterations originating possibly as early as the ninth century. This work demonstrates how certain forms of magic were already associated with women in the Early Middle Ages. However, clerics saw these women as harmless and were primarily concerned with the false belief in magic. I will then explore components from Bernard Gui's 1323 Manual for Inquisitors, "How to Investigate Workers of Magic" to demonstrate the gendering of magic already present at the time and the next

step on the timeline of harmful magic. Then I will investigate an excerpt written by Enguerrand de Monstrelet called "Politically Inspired Necromancy" from 1407 to display the forms of magic gendered masculine. Finally, I will end with analyzing sections from the "Arras Witch Treatises" written anonymously in 1460 to show the types of magic gendered as feminine and masculine in the fifteenth century as well as elucidate how magic was finally seen as harmful compared to the Early Middle Ages.

The current scholarly discussion surrounding this topic mainly includes generalizations about the religious and socioeconomic circumstances of the witch hunts of the sixteenth and seventeenth centuries. However, this paper will focus on the scholars who have focused on the Middle Ages. One prominent scholar on this topic is Michael D. Bailey, who has written about the feminization of witchcraft. One of his main arguments is that witchcraft became associated with women due to the stereotypes surrounding different forms of magic. Witchcraft is feminine because its followers have to submit to demonic influence, while necromancy is masculine because of its complicated rituals.[4] Additionally, scholars like Frank Klaassen and Richard Kieckhefer have studied the development of necromancy in the clerical setting. In Klaassen's article "Learning and Masculinity in Manuscripts of Ritual Magic of the Later Middle Ages and Renaissance," he discusses potential desires for clerical men to participate in necromancy, such as gaining wealth, effortless learning, and exerting control over male superiors and women.[5] Kieckhefer's chapter on clerical necromancy in his book *Magic in the Middle Ages* suggests that one of the possible effects of necromancy in the clerical underworld was its contribution to the increased suspicion of other types of magic in the general public.[6] This essay will fit into this conversation by building on Bailey's argument of feminization by demonstrating that magic was gendered and not just feminized, examining masculine forms of magic, supplementing Klaassen and Kieckhefer's arguments to provide additional evidence for the gendering of harmful magic, and illustrating a longer timeline than Bailey.

Early Gendering and "Harmless Witches"

One early example of the gendering of magic can be found in "Have You Believed?" by the Bishop Burchard of Worms. This work directs priests on how to interrogate and assist penitents. It contains a series of inquiries about whether they believe in certain aspects of "local" or "village-level" magic as pre-Christian practices and thoughts. One section discusses how penitents must repent if they believe in the notion that

certain women are able to "use certain sorceries and spells to change people's feelings—namely, from hate to love or from love to hate—or can damage or steal people's property with her bewitchments."[7] This quote focuses on the belief that women could practice this magic, as opposed to having the natural ability to do so. Women who believe they can change feelings were mainly associated with this village-level magic such as love magic. They were thought to be "deceived by the Devil" because clerics did not believe that magic could actually be practiced,[8] demonstrating how clerics were primarily concerned with the belief in magic rather than the practice of it.

The following paragraph in the text also exhibits this notion, stating that those who believe that women have the ability to "on certain nights, along with a mob of demons transformed to look like women...ride on various animals and be counted in their assembly" also need to repent.[8] This idea of women riding at night with demons is dated to as early as the ninth century, which demonstrates how early certain forms of magic were already gendered. Nevertheless, the focal point of this quote is again that the belief in the ability of women to practice magic is absurd because of its impracticality. The connecting thread between these two quotes is their discussion about the belief in specifically women practicing magic. At this point, it is clear that women practice certain types of magic that men do not.

However, the most demonstrative component on gendering in the Bishop's work is the separation of questions for men and women. One question includes inquiries about the belief and rituals aimed at the "three Sisters...the ones named *Parcae* by ancient tradition and ancient foolishness." The next question asks whether women believe they are able to "go out while the doors are closed and you are still in your body, able to cross great stretches of land along with other women taken in by the same illusion of killing people who have been baptized...and then eating their cooked flesh...and after eating you bring them back to life again." The last questions are focused on whether, after a newborn's death, the Devil influenced women to "remove the little one's corpse, put it in some secret place and drive a stake through the tiny body, claiming, had they not done this, that the baby would rise and could injure many people."[9] Again, these quotes focus on the belief of practicing magic and not the reality of it, which is highlighted in the belief that ancient traditions are called "foolish." They also show a distinct separation between men and women, and how Burchard of Worms believed that only women would believe or commit the acts in this last section.

Additionally, the insistence in this source that those who believe in magical practices simply need to repent shows that magic was not seen as particularly harmful. Believers under the influence of the Devil could be forgiven through penance. This form of repenting for the sin of belief in magic was far less severe than the violent witch trials that occurred in the later sixteenth and seventeenth centuries. A believer simply had to fast for an extended amount of time – sometimes as

long as seven years – but this punishment was far less hostile than being burned at the stake in the later witch trials.

At this point, it is clear that magic was already gendered as early as the tenth century, which points to a longer process than what Bailey describes. Women were already associated with certain forms of magic, such as those involving submission to the devil, some forms of village-level magic involving children or infants, the "three Sisters," and love magic. But women supposedly practicing this magic were not seen as harmful because the source focuses on the belief in women practicing magic instead of its dangerous reality. This section of the paper focuses on the Early Middle Ages, while the next section will discuss the next step in the timeline of the gendering of harmful magic and additional gendering present in the fourteenth century.

Fourteenth Century Conceptions of Magic

Almost three hundred years after the Burchard of Worms source, an example of gendered differences involving magical practices can be found in Bernard Gui's "Manual for Inquisitors." Gui was a Dominican friar and bishop who wrote this manual in 1324. In the section on sorcerers, diviners, and demon invokers, he says, "You should not interrogate everyone without discrimination or after a single fashion. Men and women are questioned differently."[10] Similar to the previous source, this important detail distinctly separates magic users who are women and those who are men. After this quote, Gui lists certain types of questions without specifying the gender to which they were oriented. Additionally, Gui seems to hold the notion that magic users are simply influenced by the illusions of demons and the real problem is the belief in magic. Yet due to the thoroughness of his proposed investigations, he demonstrates that there is a new seriousness to magic at this time which was not seen in the Early Middle Ages.

Of the questions that Gui poses, those that are most likely directed towards women involve children, interactions between spouses, and pregnancy. Some of these questions include what they know about "children or infants who had been ill-wished or were to have the ill-wishing lifted...agreement or disagreement between married couples...[and] the impregnation of those who are barren."[11] It is hard to believe that any of these questions concerning family matters or children would be directed towards a man, especially because at this point in time, masculine clerical necromancy was already occurring.[12] Certain forms of magic were already aligned with masculine ideals, such as necromancy, and these types of questions demonstrate clear reliance on feminine stereotypes. This exhibits that gendering of certain types of magic was already present.

Male magic users would most likely be questioned about technical processes of magic and from whom they learned these processes. Gui says that a sorcerer should be asked "what kind of divinatory/magical techniques (*sortilegia*) or methods of prognostication (*divinationes*) or invocations he knows, how many he knows, and from whom he learned

them."[13] As Bailey mentions in his article, the idea of necromancy is masculine because it requires training, education, and intelligence.[14] Therefore, questions concerning the more technical side of magic as opposed to those concerning children or family magic for women would most likely have been directed towards men. At this point, it can be observed that magic was not just feminized, but gendered, where some forms were seen as feminine while others were seen as masculine.

Furthermore, another important aspect of this source is how it fits into the timeline of the development of harmful magic. Gui says, "the diverse plague of casting lots/sorcery, making divinations, and invoking evil spirits...is found in various lands and regions in keeping with the various inventions and false notions belonging to...superstitious people who pay attention to the spirits of error and the teachings of evil spirits."[15] He later asks whether those being interrogated believe that magic was real.[16] Gui seems to think that the belief in magic is caused by delusional people under the influence of "evil spirits." If Gui thought that magic was harmless, he would not have gone into such depth about specific types of magic and from whom people learned this magic. This fits into the timeline of the gendering of harmful magic as it is a shift away from early medieval perceptions of magic; however, the notion of magic being harmful has not completely developed yet. Even though men and women who use magic are still seen as superstitious people fooled by evil spirits, there is definitely a new weight given to its use.

Harmful Magic in the Fifteenth Century

Transitioning into the forms of magic deemed masculine, specifically during the fifteenth century, I will turn to the excerpt "Politically Inspired Necromancy" by Enguerrand de Monstrelet, a French chronicler, written in 1407. Monstrelet describes a speech where Jean Petit, a professor of theology at the University of Paris, accuses the late Duc d'Orléans of hiring a monk to use necromancy in an attempt to murder the King. Monstrelet states that the Duc was "so inflamed and smitten by greed to obtain empty honours and worldly riches for himself and wifor his children, and so steal from our lord King...most noble lordship and crown of France, that he plotted and studied through...acts of witchcraft...to destroy the person of our lord King..." [17] The specific acts of magic he employed are detailed later in the source as acts of necromancy because they involve summoning demons. The use of necromancy in a very masculine way demonstrates gendering in the fifteenth century, a time when women were not included in the political sphere. Thus, a man is accusing another man of using magic for political gain directly genders necromancy as masculine rather than feminine. Necromancy was taken extremely seriously at this time; even the accusation of having engaged in it was enough to cause conflict.

Another example of the pattern of gendering certain types of magic during the fifteenth century is present in the Arras Witch Treatises, anonymously written in 1460. At one point

in the text, the differences in incentives for demonic submission between men and women are detailed:

> "In addition, he [the Devil] bestows the power and the strange and extraordinary abilities to attain offices of secular power and lordship, or dignities and benefices in the church, by fawning and simony, so as to amass riches, or to achieve other damnable ends. Or he promises the power of remaining in the good graces of magnates and princes, or of great men, by means of love powders or potions, which he gives to his people so that they can obtain from those princes whatever is asked, and can control them, or can achieve other goals, on which more below...Moreover, beyond the various powers listed above, the presiding demon then gives to such women received into the congregation some tangible token—such as a ring of gold, of copper, or of silver, or a thread, or a roll of paper showing unknown letters, or some such thing—by the touch or use of which some effect that provides the special power that has been granted [to her] is caused."[18]

In this quotation, there is a clear distinction between what the Devil supposedly offers the men of the congregation compared to the women. Men are able to gain political benefits, an increase in wealth, and even achieve other goals, while women are simply given a token such as a ring or a roll of paper. Interestingly enough, these incentives are similar to the incentives that Klaassen describes for practicing necromancy: gaining wealth, effortless learning, and influence over male superiors and women.[19] This source also acknowledges that there are more women present at these demonic congregations than men. The author's inclusion of more satisfactory incentives for men illustrates gendering of this form of magic. Men were more suited to necromancy than witchcraft, so they needed to have more worthwhile reasons for joining these congregations. These included incentives similar to those of necromancy, while women would be satisfied with a small token because they are more prone to the Devil's influence.

Additionally, other sections of this work illustrate a shift in thinking in terms of the harmfulness of magic in the fifteenth century as opposed to in the Early Middle Ages. The violent depiction of witches at this time demonstrates the increased fear of magic and the devil. In the "Arras Witch Treatises," the witches are portrayed as exceedingly evil, directly renouncing Christianity, and doing terrible things. They desecrated the cross, threw holy water behind themselves and trampled it with their feet, and created a parody of the cross by "knocking herself under the chin."[20] This portrayal of witches as acting wicked and conspiring with the Devil to renounce Christian reflects changed beliefs about magic by the fifteenth century. No longer is it something that misguided people believe in, but it is a very real threat.

Both of these fifteenth century sources illustrate that magic was not just feminized but gendered. In general, certain forms of magic such as witchcraft were seen as feminine because of the necessity of its followers to submit to the Devil,

which is demonstrated in the "Arras Witch Treatises." However, some forms of magic were masculine, as portrayed in both of these sources. Necromancy and complicated ritual magic fit into the masculine sphere because of its association with politics, wealth, and control. Additionally, these sources demonstrate that by this time, magic was seen as harmful too.

Conclusion

According to scholars like Michael D. Bailey, the feminization of magic primarily appeared in the fifteenth century. However, I believe that this process started much earlier. Burchard of Worms' "Have You Believed?" demonstrates that women were already associated with certain forms of magic by the ninth or tenth centuries, including village-level magic involving children, ancient traditions like the "three Sisters," and love magic. There is a clear distinction of what constitutes "feminine" magic, but the women who practiced this magic were not seen as particularly harmful. Clerical authorities were more focused on the false belief in magic rather than the practice of it.

Additionally, sources from the fourteenth century show a gendering of magic beyond standard feminization. Bernard Gui's "Inquisitors' Manual" explicitly states that one should interrogate women and men differently. This clearly distinguishes magic users on the basis of their gender, and Gui's questions Gui demonstrate different types of magic being deemed feminine and masculine. Furthermore, this source illustrates the timeline of harmful magic. Gui is still concerned with belief in the reality of magic, but unlike his predecessors, he also shows concern about its practice due to the specificity of his questions.

Finally, the two sources "Politically Inspired Necromancy" and the "Arras Witch Treatises" illustrate that even by the fifteenth century, magic was not just feminized but gendered. Specifically, witchcraft was deemed feminine because of its submission to the Devil, whereas other forms of magic like necromancy were gendered masculine.

Though this process of gendering magic dates back to the Early Middle Ages, it continues to have a resounding effect today. In present-day Western society, witchcraft has been transformed into a form of entertainment. Witchcraft and magic has been popularized through widely successful cinematic and literary adaptations, Halloween costumes, and even the commodification of these practices once deemed heretical. Nevertheless, the most important aspect of these representations is that women are chosen as the main perpetrators. In popular culture, the witch is often portrayed as the villain who uses her demonic magic to harm others. But if we take a step back and think about what this portrayal represents, there is a much deeper implication. This notion affects modern women today because it reinforces the gendered stereotype of women being weaker and more easily manipulated than men, or on the opposite end of the spectrum, having a greater affinity for evil than men. It inherently plants in our minds the negative and wicked association we have of witchcraft with women as a whole, which contributes to the sexism and discrimination modern women continue to face today. Thus, understanding the evolution of this phenomenon that is taken for granted today may help remove societal biases surrounding women and witchcraft, empower artists to make more conscientious decisions, and can perhaps help propel us toward a more equal and unbiased society.

About the Author: Kirsten Bell

I got involved with this research when I was in Professor Smoller's Gateway to History class about Medieval Deviants. This topic of witchcraft and why the stereotype of the female witch even exists was fascinating to me, because before this course I had never really thought about why witches are only associated with women. Some advice for other students pursuing research would be to not limit yourself based on what the stereotypical definition of "research" is. When I was writing this paper, I did not consider what I was doing to be research because it did not involve things like labs or tests, but historical research sometimes involves alternative methods.

Footnotes

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2. "Have You Believed? Burchard of Worms, Corrector, 5.60-70, 151-3, 170-80," in The Book of Magic from Antiquity to the Enlightenment, ed. and transl. Brian Copenhaver, (Harmondsworth, UK: Penguin, 2015).

3. Ibid.

4. Bailey, 127.

5. Frank Klaassen, "Learning and Masculinity in Manuscripts of Ritual Magic of the Later Middle Ages and Renaissance," The Sixteenth Century Journal 38, no. 1 (2007): 61.

6. Richard Kieckhefer, "Necromancy in the Clerical Underworld" in Magic in the Middle Ages, (Cambridge: Cambridge University Press, 2014), 175.

7. "Have You Believed," 273.

8. Ibid.

9. Ibid., 274.

10. "How to Investigate Workers of Magic. Bernardo Gui: Practica inquisitionis heretice pracitatis (1323/4)," in The Occult in Medaeval Europe, 500-1500, ed. and transl. P. G. Maxwell-Stuart (New York: Palgrave Macmillan, 2005), 88.

11. Ibid.

12. Jennifer Kolpacoff Deane, "Medieval Magic, Demonology, and Witchcraft" in A History of Medieval Heresy and Inquisition, (Lanham, MD: Rowman & Littlefield Publishers, 201), 191.

13. "How to Investigate," 88.

14. Bailey, 126.

15. "How to Investigate," 88.

16. Ibid., 89.

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18. Andrew C. Gow et al., ed. and transl., The Arras Witch Treatises: Johannes Tinctor's Invectives contre la secte de vauderie and the Recollectio casus, status et condicionis Valdensium ydolatrarum by the Anonymous of Arras (1460) (College Park, PA: Pennsylvania State University Press, 2016), 41.

19. Klaassen, 61.

20. The Arras Witch Treatises, 38.

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Data movement distance: An ordinal evaluation metric

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1 Abstract

With the death of Moore's law, data movement has become the performance bottleneck of much large scale computation.[1] However, the fine grained cost of data movement is lost in traditional algorithm analysis. Asymptotic function notation relates input size to the number of memory accesses, but does not account for the varying cost of individual memory accesses. We propose and evaluate a new memory-centric metric, data movement distance (DMD) for program data movement evaluation. The saliency and extensibility of DMD is explored in the form of benchmarks and compiler additions.

2 Introduction

Improving the efficiency of algorithms has become essential given the increasing prevalence of big data, as well as the environmental demand to reduce energy consumption.

The design and implementation of algorithms is a dynamic field. Ever changing hardware and application domains require programmers to understand algorithm behavior. Outside the scope of the implementation, this behavior is affected by program input size and the algorithm's underlying architecture. Within the program's implementation, the behavior is typically modeled with asymptotic function notation (Big-O, Big-Θ, Big-Ω). There are shortcomings to this approach which may leave programmers with unexplained behavior.

Asymptotic function notation (AFN) cannot:

1. Distinguish constant-factor performance differences (P1)

2. Be trivially compared to other functions of the same evaluation (P2)

3. Account for the effect of hierarchical caching (P3)

There has been work to overcome the shortcomings of AFN. Static program data movement analysis for parallel and distributed programs,[2,3] and static I/O complexity is a well researched area.[4-7] For example, Olivry et al. produced "static analysis to automatically derive non-asymptotic parametric expressions of data movement lower bounds with scaling constants, for arbitrary affine computations."[4] The Olivry algorithm takes a control flow graph (CFG) of an affine program and outputs an evaluation, which acts as a lower bound on performance. This evaluation solves P1 because its input factors in all computations performed by the program as opposed to a naive loopbound check. However, this evaluation is a function of program input and cache size, thus the Olivry algorithm does not overcome P2 or P3.

DMD is a program evaluation metric which builds upon the flexibility of AFN and the precision of the Olivry algorithm to solve P1, P2, and P3.[8]

2.1 A Geometric memory model

The idea of a geometric stack must be clear to understand how DMD overcomes P1, P2, and P3.

A classic memory model, when considering program data movement, is a linear stack (LS).[9] Memory is laid out in a continuous array, say S[]. S[0], the first element, can be considered the processor. For a computer to perform a computation on any data, that data must be loaded into S[0]. Access to index i of S, S[i], is i units of distance from S[0] in a linear memory model. A datum's position in the stack is directly proportional to its distance from the processor. This idea is known as a linear stack distance (LSD). Although the LSD is an appropriate model in many contexts, it is not the most useful model for predicting hardware performance. As shown in Figure 1, the access latency of some datum in a stack at position **i** is not linear in the magnitude of **i**, but instead a fractional power.

The geometric stack (GS) abstracts this fractional power function to be the square root function. This is known as the geometric stack distance (GSD).[8]

Definition 1 *Let the GSD of a = √i, where i is the LSD of some datum a in the stack.*

Just as the GSD more accurately models access latency, its foundation, the geometric stack, more accurately models existing computer architecture. As shown in Figure 2, the geometric stack, juxtaposed with the classic linear stack, is a two-dimensional representation of the linear stack. Not only does this two dimensional model better represent modern processor design, but it provides a visual representation of Definition 1.

2.2 Data movement distance

DMD will use GSD rather than LSD to compute the cost of a memory access, solving P3. P1 and P2 can both be solved with a single idea. The idea is to reduce the behavior of a program to a single ordinal value, as opposed to a function (as in AFN and the Olivry algorithm). The DMD of a program is defined as the sum of all GSD's for all accesses of that program.[8]
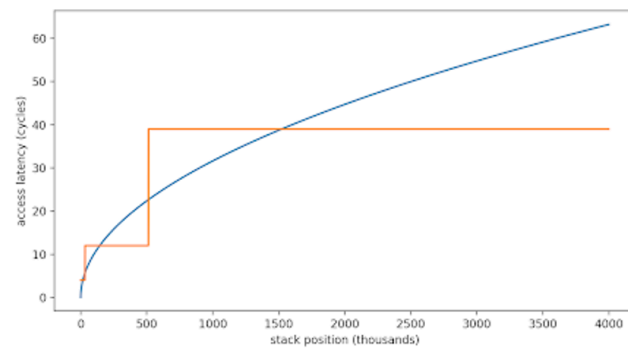
Figure 1: Access latency vs stack depth on the AMD Zen2 architecture. Data are in orange, a three (L1, L2, L3 cache) step function. Fractional power function fit in blue.
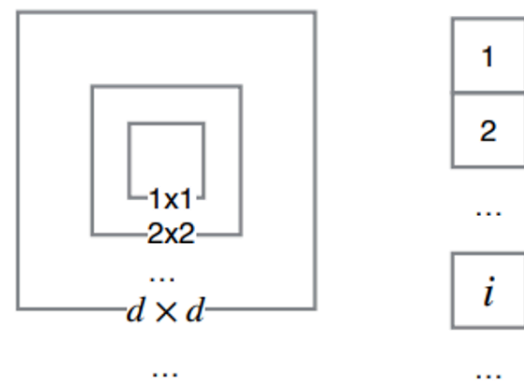
Figure 2: A geometric stack (left) and a classic linear stack (right)

Definition 2 $DMD = \sum_{i=0}^{I} d_i$ *where **I** is the number of memory accesses of some program **p**, and d_i is the GSD of the ith memory access of program **p**.*

DMD accounts for all memory accesses made by the program (P1). With DMD, program behavior is mapped to a single value. This value can be easily compared to other programs with identical AFN evaluations (P2). Popular cache locality evaluations, such as miss ratio curves, require the cache size to be a variable. This maps programs to functions of cache size. Comparatively, DMD is a cache oblivious algorithm (P3) that maps programs to values.

3 Contributions

3.1 Goals

The primary goal of this work is to explore data movement distance (DMD) and evaluate its viability as a program evaluation metric. We sought to achieve this goal by implementing, instrumenting, and computing DMD for relevant algorithms.

Specifically, we wanted to see how DMD captures program behavior beyond that which is described by AFN. We wish to test whether DMD could answer questions such as:

- Does DMD capture the essence of program behavior? (Q1)

- Can DMD expose and numericize known performance differences between algorithms with identical asymptotic bounds? (Q2)

- Are performance variations due to hardware differences captured? (Q3)

- Does DMD accurately capture this behavior as input size increases? (Q4)

- What does symbolic (on input size) DMD look like for well known algorithms? (Q5)

- Can DMD be done at compile time? (Q6)

Tests to answer Q(1,2,4) are all described below. The viability and future of Q(3,5) are discussed in the discussion.

3.2 DMD in program analysis

As described in the Introduction, program analysis is a deep field. Static program analysis has been popular due to its ease of integration into existing programs and parametric results.[2-7] However, these analysis tools are parametric with respect to input size and/or cache size, meaning their output cannot be easily compared to other programs (P2). DMD aims to be a hardware oblivious metric maintaining the flexibility of other static analysis tools.

4 Methods

4.1 Environment

All tests were performed in Linux Fedora using rustc 1.57.0, without optimizations, on an Intel Xeon CPU E5-2630 with a 20,480 KB shared L3 cache.

4.2 Setting

The DMD pipeline, including related and to-be-tested algorithms, was implemented in Rust, with statistical analysis done in Python. Quicksort, naive matrix multiplication (NMM), Strassen's matrix multiplication (SMM), and Cooley-Tukey FFT (CTFFT) were manually instrumented. All code is available at https://github.com/AidanGoldfarb/tracker.

4.3 Benchmarks

Pseudo-random values were generated through nanorand.[10]

4.3.1 Quicksort

Quicksort was tested on pseudo-random arrays with sizes 10, 20, 30, 40, 50, 60, 70, 80, 90, 100. For array size **s**, the test on that array was repeated and averaged **s** times.

4.3.2 NMM and SMM

Naive recursive matrix multiplication and Strassen matrix multiplication were tested on sizes 1x1, 2x2, 4x4, 8x8,

```
Algorithm 1 DMD calculation
 1: procedure DMD(trace)
 2:     freq_map = Reuse Distance (trace)
 3:     dmd_value = 0
 4:     for (distance, frequency) ∈ freq_map do
 5:         dmd_value+=frequency * sqrt(distance)
 6:     end for
 7:     return freq_map
 8: end procedure

 9: procedure Reuse Distance(trace)
10:     stack = Stack()
11:     freq_map = HashMap< distance, freq >();
12:     for index, element ∈ trace do
13:         If stack.contains(element) do
14:             pos ← stack.positionOf(element)        ▷ O(m)
15:             If pos = stack.top() do
16:                 freq_map ← (1, freq_map[pos] + 1)
17:             else
18:                 freq_map ← (position, freq_map[pos] + 1)
19:                 stack.moveToTop(position)
20:             else
21:                 stack.push(element)
22:     end for
23:     return freq_map
24: end procedure
```

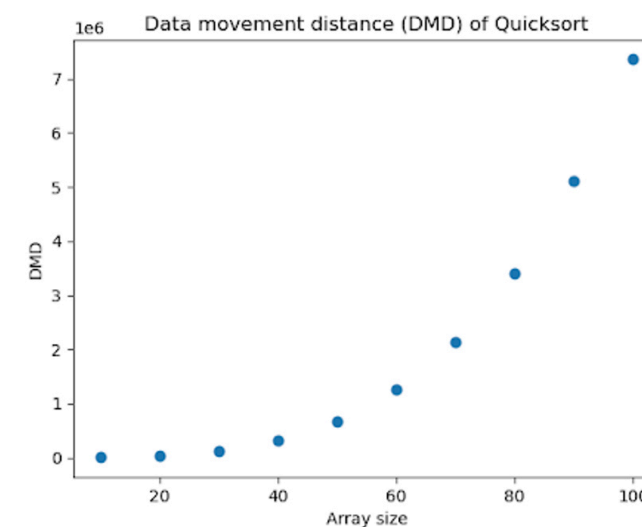16x16, and 32x32. For matrix size sxs, the test on that matrix was repeated and averaged **s** times.

4.3.3 CTFFT

Cooley-Tukey FFT was run on matrices sizes 1x1, 2x2, 4x4,..., 8192x8192. Tests were repeated and averaged 50 times for each matrix size.
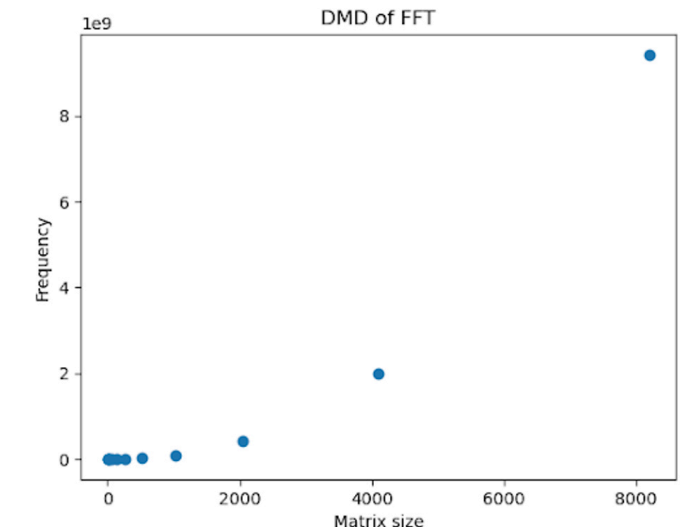
5 Results

We need a DMD calculator and instrumented polyhedral programs to evaluate the salience of data movement distance (DMD) as a portable, ordinal architecture independent program evaluation metric.[11]

The DMD algorithm 1 was written in two distinct implementations. One form takes as input a complete memory trace of a program, and the other computes DMD as the to-

be-evaluated program is executed. These implementations will be referred to as trace DMD and runtime DMD, respectively.

Four algorithms — quicksort (QS), Cooley-Tukey FFT (CTFFT), naive recursive matrix multiplication, and Strassen matrix multiplication — were selected for their affine structure and popularity in the scientific community.[11]All four algorithms were written and manually instrumented in Rust, compiled without optimizations.

5.1 Proof of concept

We first tested DMD on QS and CTFFT, intended as smoke tests. Initial results, QS, shown in Figure 3a and CTFFT in Figure 3b, demonstrate correct function growth. The DMD calculator correctly captures the memory behavior of the programs.

We were curious how DMD changes as input size increases. We considered the fact that the linearithmic ($O(n*\log(n))$) nature of QS and CTFFT would lead to unrepresentative DMD values. To verify our concerns, we computed DMD per time complexity (Figure 4b) and DMD per trace length (Figure 4a) and fit the function with a square root model. The square root model was selected because it best represents the hierarchical memory model, as shown in Figure 1. Moving forward, we chose to use DMD per element (i.e. DMD divided by the length of the trace) as the primary program evaluation metric, as we wanted to account for the effect of hierarchical caching on growing input sizes.

The smoke tests on QS and CTFFT show that DMD correctly captures program behavior. This is supported by the number of unique memory accesses correctly scaling the DMD value as input size increases.

5.2 Algorithm comparison

(a) Data movement distance (DMD) of quicksort, run on pseudo-random arrays size powers of ten up to 100.

(b) Data movement distance (DMD) of Cooley-Tukey FFT on pseudo-random matrices size powers of two up to 8192.

Figure 3: DMD proof of concept results

(a) Trace length

(b) Time complexity (n*log(n))
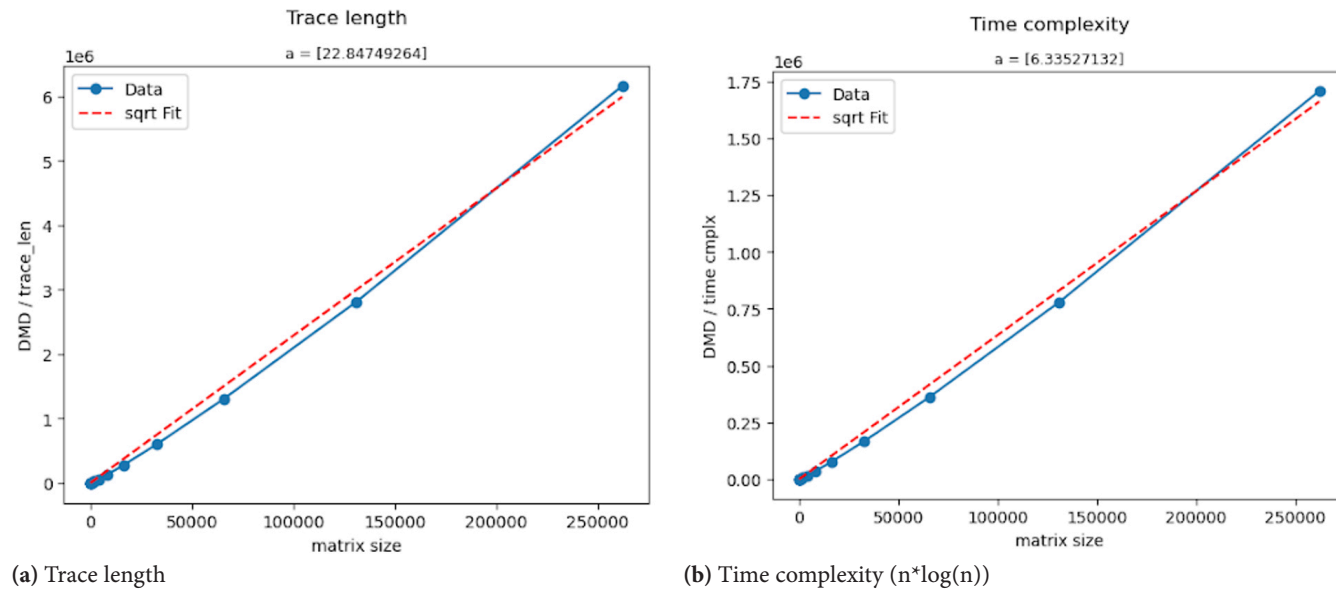
Figure 4: Data movement distance (DMD) of Cooley-Tukey FFT on pseudo-random matrices size powers of two up to 8192. Data is in blue, and square root fit, a*sqrt(matrix size) in red.

(a) Accesses to A and B

(b) Accesses to temporaries

(c) Accesses to C
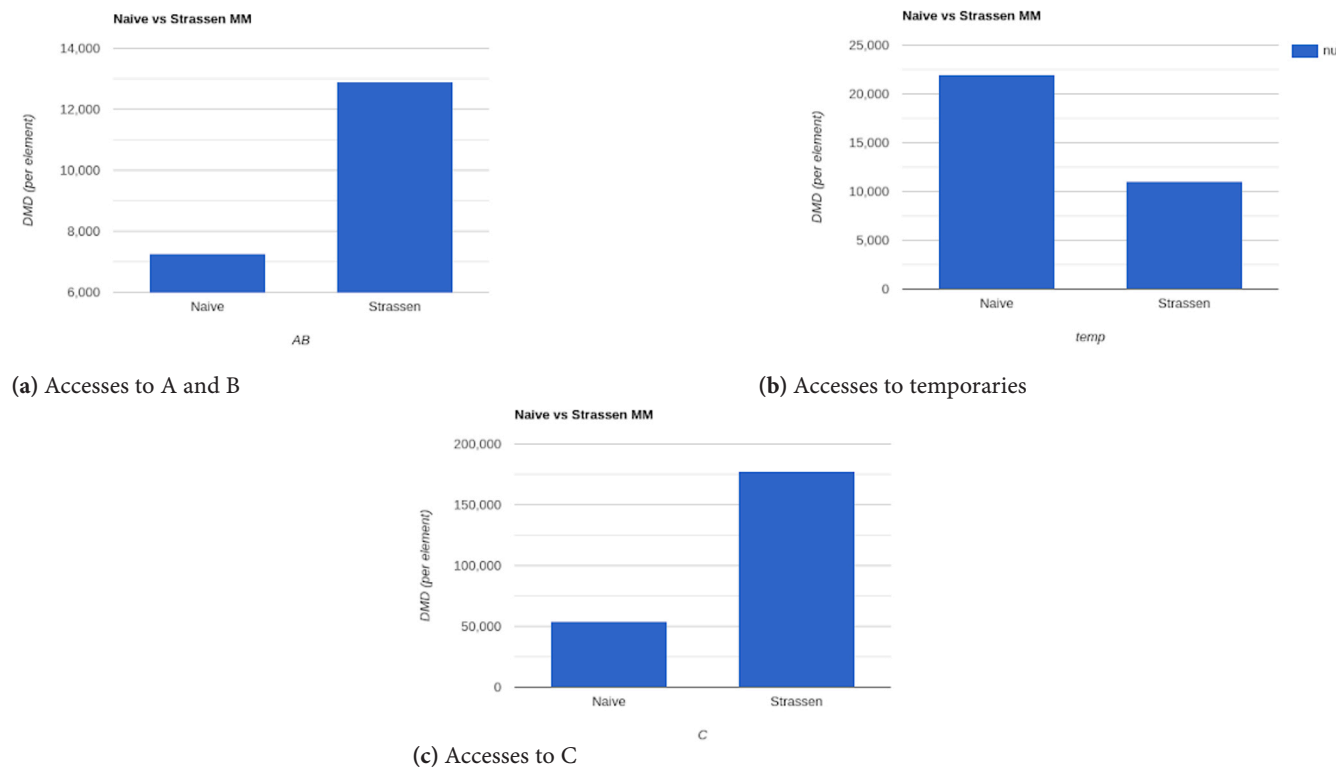
Following the success of the QS and CTFFT tests, we wanted to demonstrate DMD's ability to expose poor locality in asymptotically superior programs.[12] NMM ($O(n^3)$) and SMM ($O(n^{2.8})$) were perfect candidates for evaluation. SMM, seemingly more performant per its asymptotic function, is generally less efficient than NMM in practice.[13] We separate the components of matrix multiplication memory access into three categories, and compute DMD for each in a single run, using DMD runtime.

Consider A*B=C as the matrix multiplication of two matrices A and B, resulting in matrix C, with reads and writes to temporary matrices. Comparison between NMM and SMM of reads to A and B, writes to C and reads and writes to temporary matrices are shown in Figures 5a, 5c and 5b respectively. The poor locality of SMM is evident in Figure 5a and Figure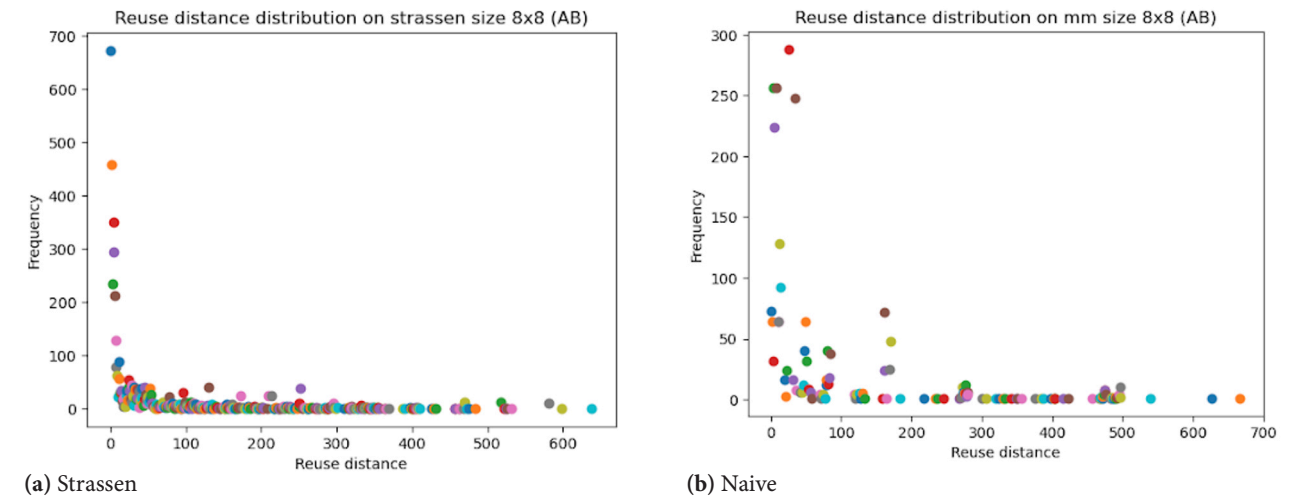 5c.[12] The former has a DMD per element of almost seven times that of NMM, while the latter has a DMD per element of almost four times that

(a) Strassen

(b) Naive

Figure 6: The reuse distance distribution histogram for accesses to A and B in matrix multiplication, size 8x8. Frequency is the number of times the reuse distance occurred throughout the execution of the program.

of NMM. The histograms of data reuse for NMM and SMM are shown in Figure 6a and Figure 6b respectively, where it is evident that SMM has significantly more data I/O than NMM.

These tests show that DMD can expose poor locality hidden by the constant factors lost in AFN. The comparison between NMM and SMM demonstrates that DMD can predict program performance as input size increases. SMM poor memory performance in access to A, B, and C matrices was captured by DMD.

5.3 Compiler extension

Given the results from the matrix multiplication evaluations, which support the validity of this metric, we believed an appropriate next step was eliminating the need for manual instrumentation of an individual program. To achieve this we modified Static Parallel Sampling (SPS) to compute DMD at compile time.[14] This extension is untested but is an area of promising future work that would allow pure affine programs to compute DMD at compile time.[11]

6 Discussion

This work describes the foundation and architecture of the program evaluation metric data movement distance (DMD).[8] DMD not only evaluates the performance of a program, but may hint at its effective energy consumption. Extraneous energy consumption by large data centers is becoming one of the leading contributors to fossil fuel emissions. Programmers are being asked to reduce their energy footprint, especially in large scale scientific computation.

The current implementation runs in time quadratic in the worst case, meaning it is rarely the bottleneck for large scale

affine programs.[11]More efficient algorithms exist that could be used to compute approximate DMD.[15]

The limitations and side-effects of computing DMD for a program means that the metric is not appropriate for all situations. DMD is intended as an optimization tool. A possible pipeline is to compute DMD for one program, perform some optimizations, and recompute DMD to quantify locality improvement.[12] Attempting to gain information from a single DMD evaluation is unlikely to be fruitful, unlike with AFN or the Olivry algorithm. AFN and the Olivry algorithm return functions whereas DMD is a single value. While symbolic DMD is possible for specific algorithms, in order to generally predict program behavior on different input sizes, one must construct a dataset one DMD execution at a time. Implementation of a LLVM compiler pass has shown feasibility in practice, mentioned briefly in subsection 5.3. The scope of compatible programs is limited, but shows potential to be expanded. The current implementation correctly captures program behavior on branchless, pure affine programs. Although few programs like this are used in practice, it could be possible to isolate and analyze polyhedral code segments.

Moving forward with this work, we aim to follow several paths. The SPS compiler extension would be the most applicable to programmers.To overcome the prediction problem discussed above, we have also begun using the DMD algorithm to derive symbolic DMD for algorithms. We have made promising progress on naïve recursive matrix multiplication. This success demonstrates that a symbolic DMD for a generic program could be possible in an unconstrained (not purely affine) environment.

7 Conclusion

DMD has been shown to be a viable and salient program evaluation metric. A calculator was written and tested on

several well-known and relevant algorithms with a range of input values. Although the DMD calculation incurs run-time overhead, it was not noticeable in program execution at any input size. The future and extensibility of DMD is a dynamic area, and several ideas were explored in this work. A more efficient approximation of DMD is possible.[15] The early version of the DMD as a compiler pass hints that DMD could be a tool leveraged by software engineers and large data services to improve performance without incurring runtime overhead. Most importantly, however, is DMD's potential to estimate program power consumption. Achieving high performance computing while maintaining a low carbon footprint is no longer desired, but demanded. As the climate crisis worsens, it is even more important for programmers to be aware of the energy consumption of their programs.

About the Author: Aidan Goldfarb

I got involved in Professor Ding's lab following a research oriented course taught he gave (CS 200). I transitioned to this lab out of the Hoque HCI lab, searching for ethical research paired with lower level systems work. I would strongly encourage any student looking for research to not hesitate to reach out to professors directly, they don't bite.

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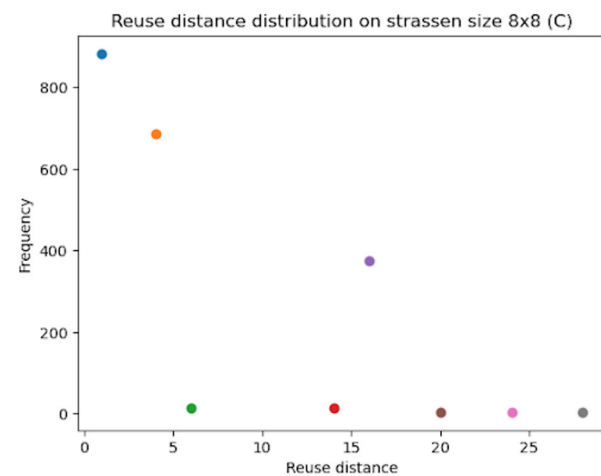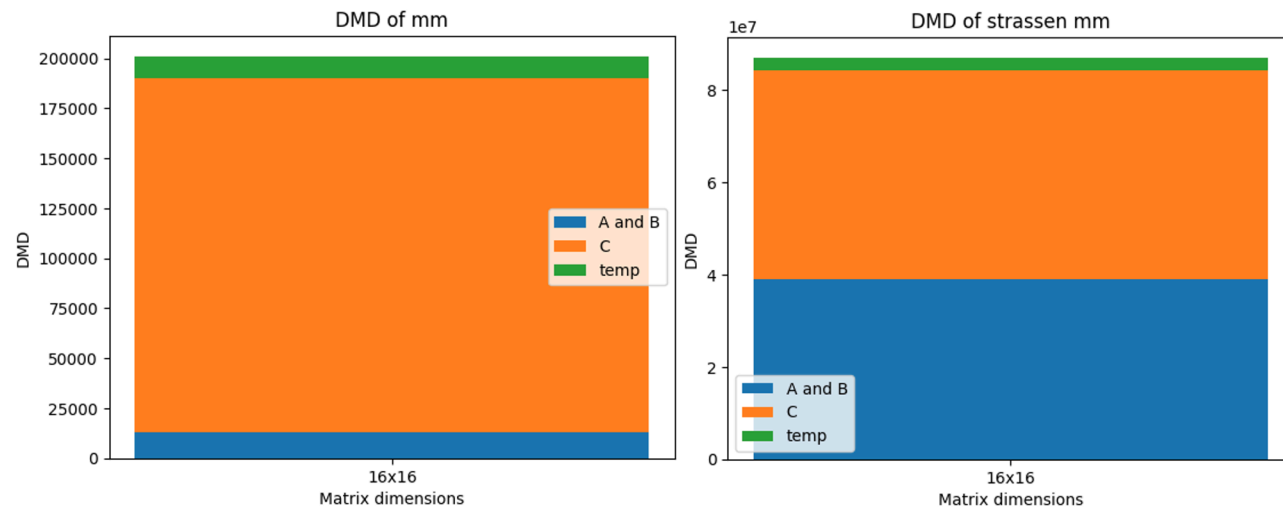
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Predicting Contraceptive Method Choice of Women Based on Demographic & Socio-Economic Characteristics

Jose L. Luna Jr. '23, *Statistics*
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Abstract

Ever since the widespread use of contraceptives, starting in the 1960s, the access to contraceptives has increased significantly. Because of this increase, the number of women choosing to use contraceptives has increased as well. With a large number of women having used contraceptives in the world, one could perform surveys asking women about their socio-economic traits and their preference of contraceptive method usage in order to draw a correlation between the two, the goal being to understand motives and reasons behind the use of contraceptives. The purpose of this paper is to predict the contraceptive method use of women using socio-economic and demographic characteristics. These contraceptive methods are categorized as "no use", "long term use", and "short term use". There are a total of nine variables: "wife's age", "husband's education", "number of children ever born", "wife's religion", "wife's now working?", "husband's occupation", "standard of living index", and "media exposure". We seek to evaluate the validity of these variables as predictors of women's contraceptive use. Using a Baseline-Categorical Logit Model, we make two regression models comparing the probability of women choosing contraceptive no-use vs. long-term use and the probability of women choosing contraceptives short-term use vs. long-term use. A Pearson's χ^2 Test of Independence is performed and all variables tested have a tiny p-value, which concludes support for the hypothesis that the five aforementioned variables indeed are good predictors for contraceptive method use. These findings could lead to better understanding of why women choose a certain method choice based on their socio-economic characteristics.

Background

Beginning in the 1960s, the widespread use of and access to contraceptives have increased significantly, and due to this increase, the number of women choosing to use contraceptives has increased as well.1 With a large number of women having used contraceptives in the world, performing surveys to ask women about their socio-economic traits and their preference of contraceptive method usage is crucial to understanding the motives and reasons behind women's use of contraceptives. The purpose of this paper is to predict the contraceptive method use of women using socio-economic and demographic characteristics. The results will provide a clear understanding of any common socio-economic patterns among women. The dataset used for this research paper was collected by Tjen-Sien Lim, which comes from a subset of the 1987 National Indonesia Contraceptive Prevalence Survey. More in-

formation about this dataset will be given in the Methods section. The specific hypothesis is that the variables 'Wife's Age', 'Wife's Education', 'Number of Children Ever Born', 'Wife's Religion', and 'Standard-of-Living Index' are good predictors of Contraceptive Method Use. The null hypothesis is that the variables 'Wife's Age', 'Wife's Education', 'Number of Children Ever Born', 'Wife's Religion', and 'Standard-of-Living Index' are not good predictors of Contraceptive Method Use.

Methods

The data collected belongs to a subset of the 1987 National Indonesia Contraceptive Prevalence Survey. This data originated by Tjen-Sien Lim, and the purpose of collecting this data was to "predict the current contraceptive method choice (no use, long-term methods, or short-term methods) of a woman based on her demographic and socio-economic characteristics."2 The total predictor variables given in the dataset include: Wife's Age, Wife's Education (1=low, 2, 3, 4=high), Husband's Education (1=low, 2, 3, 4=high), Number of Children Ever Born, Wife's Religion (0=Non-Islam, 1=Islam), Wife's Now Working? (0=Yes, 1=No), Husband's Occupation (1, 2, 3, 4), Standard-of-Living Index (1=low, 2, 3, 4=high), Media Exposure (0=Good, 1=Not good). The outcome variable is called "Contraceptive method used" (1=No-use, 2=Long-term, 3=Short-term). The sample size of this dataset (n=1473) consists of married women with ages ranging from 16 to 49 with a median age of 32 years old. The median number of children born per woman is 3, with numbers ranging from 0 to 16 children. As nine predictor variables would return a large regression model, which would be tedious to record and interpret, only the most relevant variables will be used, which include: Wife's Age, Wife's Education, Number of Ever Children Born, Wife's Religion, and Standard of Living Index. These variables are selected because they are more related to a woman's life choices than the other variables. The 'Wife's Age' variable is included to better understand the relationship between a woman's age and her contraceptive usage, even if a woman can't control her age.

One bias found in this dataset is this sample of women is from Indonesia and not the United States. This data may not be relevant or accurate for women in the United States as there are different norms and laws regarding access to contraceptives and method choice.

Another bias found in this dataset is that the women's religion is only binary, expressing Islam or non-Islam. According to Table 1, which displays the summary statistics for all relevant

variables, we see that most women in the sample size are Muslim (85.06%), which is not representative of women in the United States, there being more adult women in the U.S. that identify as Christian than Muslim.3

An additional problem with this dataset is that it's not very clear exactly what the creator of the dataset, Tjen-Sien Lim, means by husband's occupation being categorized as x=1, 2, 3, 4. Does x=1 mean that the husband's occupation is a low paying job? If that's the case, how does the creator define these categories? Is there an income bracket where these numbers represent a certain annual salary or wage? If so, that data is not offered or explained, which produces a source of ambiguity for this research paper.

The last problem found within this dataset is the ambiguity of categories of the output variable; short-term usage of contraceptives isn't clearly defined or ever mentioned, and there are different types of contraceptives for women that the creator of this dataset chose not to include.

The numerical analysis for the data is summarized in Table 1., showing the five predictor variables mentioned before in their bivariate relationship with the output variable (Contraceptive Method Use). Additionally found in Table 1., the five variables are shown displaying their univariate summaries. Figures 1-4. graphically represent the bivariate summaries of Wife's Age, Wife's Education, Number of Ever Children Born, and Standard of Living Index in relationship to the output variable. The predictor variable "Wife's Religion" was not included as a graph due to its simple and unimpressive appearance (however the percentages can be found in Table 1.).

To interpret the baseline-categorical logit equations, there will be a log odds interpretation on the intercepts and the coefficients for some variables, those variables being given priority to avoid writing out multiple tedious observations. A Pearson's χ^2 Test of Independence will be performed as well on all the five predictor variables to see if there is an association between each of the variables and the output variable. The last test performed will yield the standardized Pearson residuals to find association between each predictor variable and output variable. All tests can be found on my file: finalproject.Rmd

Results

These are the potential variables of interest needed to predict the contraceptive method use of women: Wife's Age; Wife's Education; Number of Children Ever Born; Wife's Religion; Standard of Living Index. We want to predict womens' contraceptive method use within three categories, those being 'no use', 'long term use', and 'short term use'. Let's categorize the probabilities of predicting contraceptive method use as P_1 = P(no use), P_2 = P(long term use), P_3 = P(short term use). Because these categories are nominal, we will be using a baseline-categorical logit model. However, first we must examine the predictive capability of the model in order to discern the best set of predictor variables. Using R, we convert the categorical variables into factor variables. Then, we use the backward elimination process to determine whether the predictor vari-

ables stated previously should be kept or rejected from the baseline-categorical logit model. Because the backward elimination model has a low AIC (2835.233), we are going to use the model to fit the data. Based on the results of the backward elimination model, the best baseline-categorical logit regression models are determined to be:

$$log\left(\frac{P_1}{P_2}\right) = \text{P(contraceptive no-use vs. long-term use)}$$
$$= 2.777 + 0.045x_{wa} - 0.927x_{we2} - 1.737x_{we3} - 2.727x_{we4} - 0.343x_{nc}$$
$$+ 0.461x_{wr} - 0.595x_{s2} - 1x_{s3} - 1.262x_{s4}$$

$$log\left(\frac{P_3}{P_2}\right) = \text{P(contraceptive short-term use vs. long-term use)}$$
$$= 4.163 - 0.068x_{wa} - 0.641x_{we2} - 1.152x_{we3} - 1.658x_{we4} + 0.011x_{nc}$$
$$+ 0.125x_{wr} - 0.192x_{s2} - 0.438x_{s3} - 0.496x_{s4}$$

Legend: wa: Wife's Age, we2: Wife's Education (2nd to low), we3: Wife's Education (2nd to high), we4: Wife's Education (high), nc: Number of Children Ever Born, wr: Wife's Religion, s2: Standard of Living Index (2nd to low), s3: Standard of Living Index (2nd to high), s4: Standard of Living Index (high)

How does the model fare in making accurate predictions? The next process is to fit an ROC curve based on the models we obtained previously. We build a "Receiver Operating Characteristic" (ROC) curve displaying both sensitivity and specificity of the regression models. Having a curve that is farther away from the straight line is better because the area under the curve tells us how specific and sensitive the model is. A number closer to 1 is ideal in this scenario, similar to judgments of correlation.

In Figure 1., the ROC curve is displaying favorable sensitivity and specificity as shown by the curve. The area under the ROC curve for $log(P_1/P_2)$ is 0.7798. This indicates a strong predictive capability and a fitting model.

In Figure 2., the ROC curve is displaying favorable sensitivity and specificity as shown by the curve. The area under the ROC curve for $log(P_3/P_2)$ is 0.7529. This indicates a strong predictive capability and a fitting model.

For each 1 year increase in the wife's age, the probability of not using contraceptives (rel. using contraceptives long-term) changes multiplicatively by $e^{0.0453} = 1.046$, holding all other variables constant (number children to 0, wife's education to low, non-Muslim, and low living standards). For each 1 year increase in the wife's age, the odds of using contraceptives short-term (rel. using contraceptives long-term) changes multiplicatively by $e^{-0.068} = 0.934$, holding all other variables constant.

When the wife's education is low, the number of children is 0, the religion is not Muslim, the standard living condition is low, and the wife's age is 0, the probability of not using contraceptives is $e^{2.777} = 16.071$ times the probability of using contraceptives long-term. Holding all conditions constant as before, the probability of using contraceptives short-term is $e^{4.163} = 64.264$ times the probability of using contraceptives long-term.

Predictor Variable	Variable Category	Total Sample n=1473	Contraceptive Method Use		
			No Use n=629	Long-Term Use n= 333	Short-Term n=511
Wife's Age	N/A	*(in years)* median: 32 : 8.23 range: 16-49	*(in years)* median: 35 : 8 range: 17-49	*(in years)* median: 32 : 8.25 range: 16-49	*(in years)* median: 29 : 8.25 range: 16-49
Number of Children Ever Born	N/A	*(in number)* median: 3 : 2.36 range: 0-16	*(in number)* median: 3 : 1 range: 1-9	*(in number)* median: 2 : 2 range: 0-8	*(in number)* median: 3 : 1.75 range: 0-7
Wife's Education	low	10.31%	16.38%	2.70%	7.83%
	2nd to low	22.67%	27.98%	11.11%	23.68%
	2nd to high	27.83%	27.82%	24.02%	30.33%
	high	39.17%	27.82%	62.16%	38.16%
Wife's Religion	Non-Islam	14.94%	11.92%	22.82%	13.50%
	Islam	85.06%	88.08%	77.18%	86.50%
Standard Living Index	low	8.8%	12.72%	2.70%	7.83%
	2nd to low	15.55%	18.60%	9.01%	16.05%
	2nd to high	29.26%	29.25%	27.03%	30.72%
	high	46.44%	39.43%	61.26%	45.40%

Table 1) Summary Statistics for total sample of predictor variables on Contraceptive Method Use
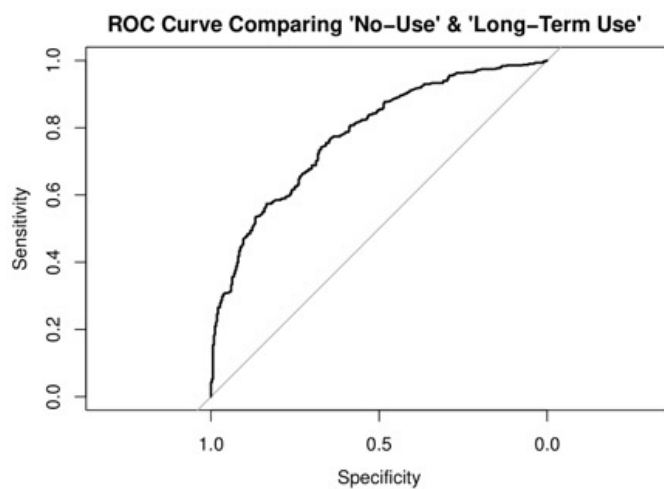

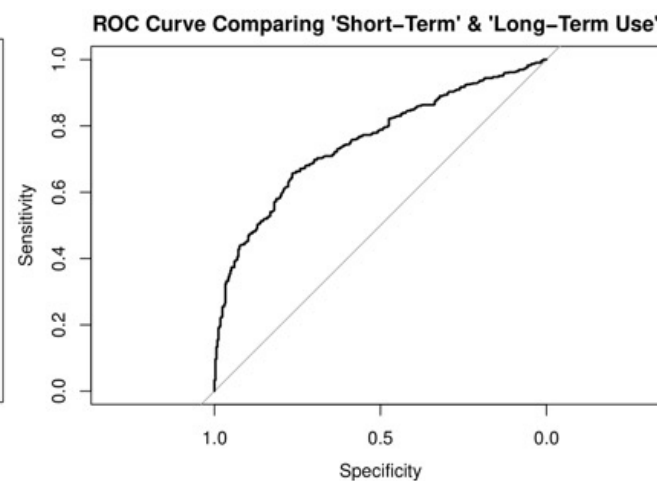**Fig. 1)** ROC Curve of $\log(P_1/P_2)$

Fig. 2) ROC Curve of $\log(P_3/P_2)$

When the wife's education is high, the number of children 3, the religion is Muslim, and the standard living condition is high, the probability of not using contraceptives is $e^{2.777} = 16.071$ times the probability of using contraceptives long-term. Holding all conditions constant as before, the probability of using contraceptives short-term is $e^{4.163} = 64.264$ times the probability of using contraceptives long-term.

The following probabilities $P(x_1)... P(x_8)$ are the highest and lowest probabilities, respectively, that could be calculated when using only the median numbers for 'wife's age' and 'number-of-children' as well as using only the high and low categories of 'wife's education' and 'standard living.':

The probability $P(x_1)$ of a woman choosing to not use contraceptives — given the wife's education is high, the wife's age is 32 years old (median), the number of children is held to 0, the wife is non-Muslim, and living conditions are high — is 40.32%.

$$P(x_1) = \frac{e^{2.77+.045(32)-2.727-1.262}}{1 + e^{2.77+.045(32)-2.727-1.262} + e^{4.163-.068(32)-1.658-.496}} = 0.40321$$

The probability $P(x_2)$ of a woman choosing to not use contraceptives, given the wife's education being low and all other variables the same as above, is 77.8%.

$$P(x_2) = \frac{e^{2.77+.045(32)-1.262}}{1 + e^{2.77+.045(32)-1.262} + e^{4.163-.068(32)-.496}} = 0.77798$$

The probability $P(x_3)$ of a woman choosing to not use contraceptives — given the wife's education is low, the wife's age is 32 years old (median), the number of children is held to 0, the wife is non-Muslim, and living conditions are low — is 89.04%.

$$P(x_3) = \frac{e^{2.77+.045(32)-2.727}}{1 + e^{2.77+.0453(32)-2.727} + e^{4.163-.068(32)-1.658}} = 0.89037$$

The probability $P(x_4)$ of a woman choosing to not use contraceptives — given the wife's education is high, the wife's age is 32 years old (median), the number of children is held to 0, the wife is non-Muslim, and living conditions are low — is 65.06%.

$$P(x_4) = \frac{e^{2.77+.453(32)-2.727}}{1 + e^{2.77+.453(32)-2.727} + e^{4.163-.068(32)-1.658}} = 0.65056$$

The probability $P(x_5)$ of a woman choosing to not use contraceptives — given the wife's education is high, the wife's age is 32 years old (median), the number of children is held to 3 (median), the wife is non-Muslim, and living conditions are low — is 39.49%.

$$P(x_5) = \frac{e^{2.77+.453(32)-2.727}}{1 + e^{2.77+.453(32)-2.727} + e^{4.163-.068(32)-1.658}} = 0.3949$$

The probability $P(x_6)$ of a woman choosing to not use contraceptives — given the wife's education is high, the wife's age is 32 years old (median), the number of children is held to 3 (median), the wife is non-Muslim, and living conditions are high — is 19.36%.

$$P(x_6) = \frac{e^{2.77+.453(32)-2.727}}{1 + e^{2.77+.453(32)-2.727} + e^{4.163-.068(32)-1.658}} = 0.1936$$

The probability $P(x_7)$ of the wife's education being high and choosing to not use contraceptives — given the wife is the median age of 32 years old, the number of children is held to 3 (median), the wife is Muslim, and living conditions are high — is 26.39%.

$$P(x_7) = \frac{e^{2.77+.453(32)-343(3)-2.727}}{1 + e^{2.77+.453(32)-343(3)-2.727} + e^{4.163-.068(32)+.011(3)-1.658}} = 0.26391$$

The probability $P(x_8)$ of the wife's education being low and choosing to not use contraceptives — given the wife is the median age of 32 years old, the number of children is held to 3 (median), the wife is Muslim, and living conditions are — is 80.16%.

$$P(x_8) = \frac{e^{2.77+.0453(32)-.343(3)+.461}}{1 + e^{2.77+.0453(32)-.343(3)+.461} + e^{4.163-.068(32)+.011(3)+.125}} = 0.80158$$

All five predictor variables were run through a Pearson's χ^2 Test of Independence to determine if there were any significant associations between each variable and the output variable (contraceptive method use). All five variables resulted in a p-value less than $2.2e^{-16}$ except for the number of children, yielding a p-value of 0.0004998. Because the p-value is small (<0.05), we reject the null hypothesis. The standardized Pearson residuals were found on all five variables, and we found that were unusual. Non-Muslim women were more likely to use contraceptives long term than Muslim women (stdres = 11.6). Women who lived in high standard conditions were more likely to use contraceptives long-term (stdres = 12.07), and the opposite is true, where women living in low standard conditions were more likely to not use contraceptives (stdres = 8.9). Women who had a high level of education were more likely to use contraceptives long-term (stdres = 18.9). Women between the ages of 16 and 27 were more likely to use contraceptives short-term (stdres = 16.7). Lastly, women who have 2 to 3 children were more likely to use contraceptives long-term (stdres = 4.2) whereas women with 0 to 1 child were less likely to use contraceptives long-term (stdres = -8.03).

According to Figure 3., women who possess a high level of education make up the highest proportion (62.16%) for long-term contraceptive use. This would seem consistent as knowledge about contraceptives might make highly educated women more inclined to use them relative to women who may not know about their existence or proper use. Interestingly enough, among the women who don't use contraceptives, the proportion of their education remains stagnant (see Table 1. for further details). The pattern for women who use contraceptives short-term is similar to the long-term category except for
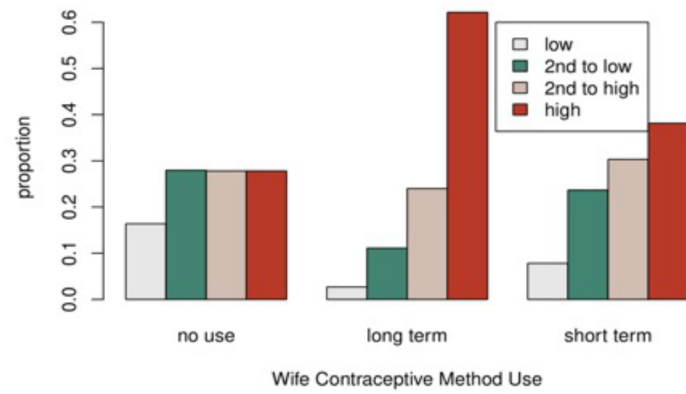
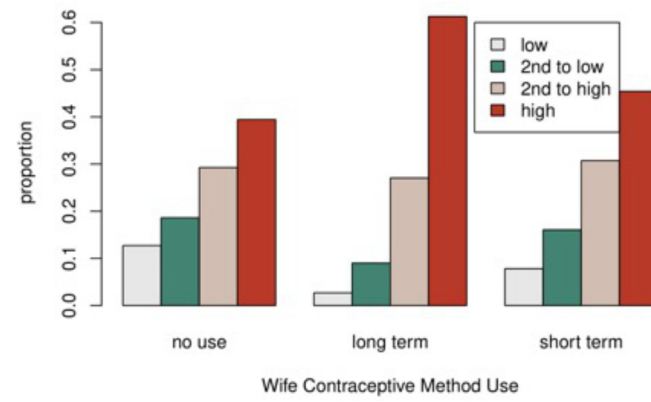**Figure 3)** Stacked Barplot of Contraceptive Method Use Given Wife's Education

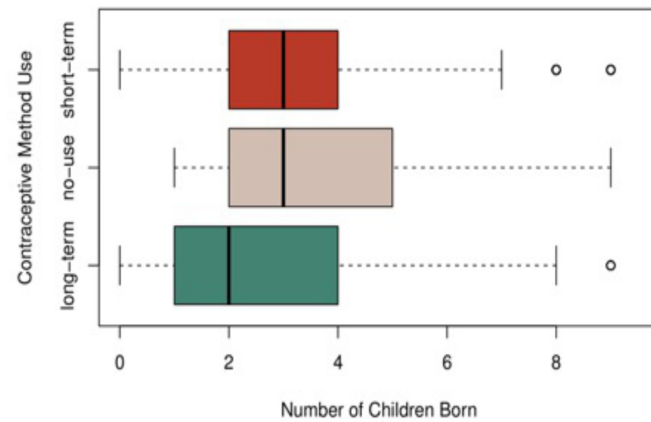**Figure 4)** Stacked Barplot of Contraceptive Method Use Given Standard Living Index

Figure 5) Side-By-Side Boxplot of Contraceptive Method Use Given Number of Children
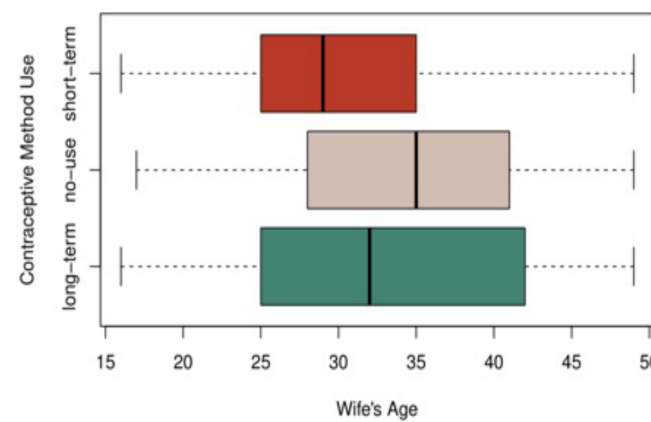

Figure 6) Side-by-Side Boxplot of Contraceptive Method Use Given Wife's Age

the distribution among the education levels being more evenly distributed.

According to Figure 4., standard of living is more evenly distributed for women who don't use contraceptives; those who have a high standard of living make up the largest proportion for those who don't use contraceptives. The same pattern applies to women who use contraceptives short-term. However, similar to Figure 1., the proportion of women who have a high standard of living and use contraceptives long-term has the highest proportion (61.26%).

According to Figure 5., there is little variability (the data between Q1 and Q3 are smaller) among women who use contraceptives short-term compared to the other two categories (long-term & short-term). This means that the data is more consistent and slightly more concentrated toward the median in this category versus the other categories. There were many outliers in all three categories; however, for the sake of readability, most of them were omitted from graphical display.

All three boxplots in Figure 6. show much variability as the boxes (data between Q1 and Q3) are wide. The least variability among the three contraceptive method choices is 'short-term' (ranging from 25-35 years). This means it is slightly easier to predict short-term use given age whereas the opposite is true

for long-term usage since there is more variability in that boxplot.

Interestingly enough, the median age for women who did not use contraceptives is higher than both women who used contraceptives short-term and long-term.

Conclusion

The purpose of this research paper was to discern whether there were accurate predictors of a woman's choice of contraceptive. As Pearson's χ^2 Test of Independence shows, all the predictor variables have a strong association with the output variable (Contraceptive Method Use). Because all the p-values of each variable were less than α (=.05), we reject the null hypothesis and conclude the variables 'Wife's Age', 'Wife's Education', 'Number of Children Ever Born', 'Wife's Religion', and 'Standard-of-Living Index' are good predictors of Contraceptive Method Use. That being said, there are some limitations in this project such as having a moderate or decent predictive capability as shown by Figure 1. & Figure 2. To properly investigate the same issues, it would be optimal for future papers to use data from the U.S. and be more specific in the categories of the variables. The impacts of these findings allow for a better

understanding of how choices of women are affected by social and demographic variables that women can and can't control. Pharmaceutical companies could also use this knowledge to allocate more resources towards advertising contraceptives targeting certain groups of women depending on either their living conditions, the number of children they have, their age, etc. This research paper leaves open the question of why certain traits are more associated with how much contraception women use. This paper mainly focused on whether certain variables make for good predictors on determining a woman's contraceptive method use, so learning more about the predictor variables themselves or including more variables such as geography or political views could make for an interesting future research paper.

About the Author: Jose Luna Jr.

I got involved in my research by taking Professor Ciminelli's course, Categorical Data Analysis, and applied everything I learned in his class to analyze and interpret the data of women choosing to use contraceptives given certain socio-economic characteristics. Even though this research paper was a final project required for the Ciminelli's course, I still enjoyed doing the research and running the tests with R (a statistical software). Doing research with a statistical background is easier than one might think if one has the right data and mentor. My advice for anyone is to find a good mentor to guide you along the research process.

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The Purchase of Virtue: The Commodification of Altruism in the Voluntourism Industry.

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Advised by John Osburg, *Department of Anthropology*

Introduction

Would you like to travel abroad and "become part of an ongoing effort to empower disadvantaged communities" (Projects Abroad)? Well, have I got a vacation for you! Spend your ten days "equipping children with skill and confidence to make good decisions" and "helping refugees apply for asylum and other identification documents," all while building your CV (Projects Abroad). Seems like a win-win, right? Unfortunately, as I pull back the veil on these voluntourism trips, we find that not everything is as great as it seems.

Volunteer tourism is becoming one of the most profitable sectors of the tourism market, with an estimated worth of over 2.5 billion dollars every year. It boasts beautiful cultural exchange while helping your fellow man. Nonetheless, there is an acquisitive motivation inherent in the industry. Wealthy westerners buying experiences of "helping" communities which they then use as props to construct a facade of virtue is a direct consequence of commodifying a priceless human value. This paper explores the ways that the voluntourism industry allows for the purchase of virtue, among other criticisms, through previous scholarship, an interview, and a case study of a volunteer tourism company's website.

What is Voluntourism?

The concept of paid-for volunteer programming was first created in 1971 by Earthwatch, a sustainability-focused nonprofit organization, in response to a lack of government funding. Earthwatch's goal was to concurrently solve their funding problem and connect scientists with citizens to raise interest in environmentalism. This concept of paid-for tourism quickly spread, and volunteer trips started to be considered a sector of the tourism market by the 1990s.

The volunteer tourism industry has grown rapidly, as "more than 1.6 million volunteer tourists are spending about $2 billion each year" (Kahn, 2014). Voluntourism trips are promoted as a way to simultaneously do good and explore a foreign country. In general, these trips cater towards teens and young adults and includes: building schools, visiting orphanages, wildlife conservation, and providing medical assistance. There is also a prominent type of voluntourism that has the additional goal of spreading Christianity through mission trips. These trips often involve building churches and Christian-affiliated schools, as well as the typical service work found in secular trips.

Critiques from the Relevant Scholarship

The concept of using vacation time to help others seems good in theory, but as the industry has grown, the flaws of its structure have been disseminated by critics. Daniel Guttentag, Assistant Professor of Hospitality and Tourism Management in the School of Business at the College of Charleston, has categorized the main five critiques of voluntourism: "Completion of Unsatisfactory Work," referring to the inexperienced volunteers trying to "help" in fields they are uneducated in and actually creating more problems for the communities; "Decreased Labor Demand and Promotion of Dependency," referring to how unskilled volunteers actively pay to do jobs that could be done by local laborers, creating a dynamic where local workers are unable to compete with these organizations, thus promoting a cycle of dependency on foreign aid; Creation of the 'Other' and "Poverty Rationalizations," referring to the stereotype often used in marketing for these trips, often playing into the "us" vs "them" dynamic, as well as reinforcing the "poor-but-happy" attitude of minimizing the impacts of material poverty; "Cultural Change," referring to wealthy tourists coming into these communities and flaunting their wealth and western lifestyles with the goal of changing their culture to be more aligned with western views of development; and "Neglect of Locals Desires", referring to these voluntourism trips valuing the experiences of the volunteer over the needs and autonomy of the community (Guttentag, 2009).

Purchase of Virtue

While I agree with these five main critiques, I also offer a sixth: the purchase of virtue. Oftentimes, the organizations that run these trips will charge thousands of dollars per person to attend. This money does not directly go to the communities, but rather towards flights, housing, training, and other expenses for the volunteers so that they can have an active role in their service. It would make more sense to donate that money directly to these communities so that they can decide how it would be best used, but that is not the goal of these trips. I argue that the main purpose of these voluntourism trips is to allow wealthy, predominantly white westerners to buy their way into being viewed as good people.

As Marx explains in "The Power of Money," money can buy its possessor the appearance of values. Under capitalism, "money is the supreme good, therefore its possessor is good," and the voluntourism industry succeeds because of this (Marx, 1972). Wealthy westerners who are able to buy nearly anything they desire use these communities as props in the construction of their facade of altruism. They are willing to pay a steep price in exchange for the appearance of having a direct role in whatever service they intend to provide, effectively buying the experience of helping others. Marx explains "that which I am unable to do as a man...I am able to do by means of money," and for these voluntourists, they feel unable to be truly altruistic, so they buy the image of altruism instead (Marx, 1972). These voluntourists often fill their social media feeds with images of themselves posing with (often Black) children who are visibly malnourished, all smiling, as if to say, "these people have nothing, but look at how much joy I brought to them!" These images are posted so that other people see them and view the volunteer as a virtuous savior, creating an image of "a racialized, needy other [that is] understood as needing the benevolent help of the west," (Freidus, 2016).

This commodification of altruism can be seen through the lack of fungibility of the funds that go into these trips. Jessica Cattelino explains the importance of fungibility in this quote from her ethnography, *High Stakes*, in which she explores the introduction of casinos and casino funds in the Seminole tribe:

> "Gaming has enabled Seminoles to reproduce valued forms of cultural and political distinctiveness, and in turn reinforce tribal sovereignty. They do so by exploiting the fungibility of money—its substitutability and exchangeability for itself—to selectively convert casino revenues into other forms of value." (Cattelino, 2008)

What allowed the Seminole tribe to benefit from the casinos was the fungibility of their profits; they had autonomy over how their money was spent and used it towards improving their community and cultural revitalization efforts. In these voluntourism trips, all the funds are non-fungible. A large chunk of the money tourists spend is put towards flights and lodging and is not available to be used by the community. The remaining funds are put towards a project that is already decided upon by the voluntourism company, often without significant representation or input from the community. These voluntourists are not converting their money into benefits for these communities; they are converting it into a virtue for themselves. These companies are valuing the active role and experience of voluntourists over the autonomy of these communities. Laurie Occhipinti makes a similar claim regarding the purchase of virtue, stating that these voluntourism trips are not just résumé enhancers, but "a form of moral subject-making that emerges specifically from neoliberalism, as the volunteer demonstrates an ethos of entrepreneurialism and superior social capital," (Occhipinti, 2016).

What goes into these trips?

As we look into the impact of voluntourism, it is important to first examine trip specifics. I Interviewed a clergyman who runs a service trip over winter break for a fraternity at an American university. For confidentiality purposes, I will be referring to him as R. In our thirty minute conversation, R mainly discussed the details of this secular winter break trip. This winter break trip is a fourteen year-long tradition where the fraternity brothers raise about $15,000 and spend break in the Dominican Republic. In the past, they have built a church, painted houses and have built outhouses. In his description of the trip, R continuously referred to it as a "cultural exchange," where the brothers lived with a host family and learned about their culture. The trip usually is around two weeks long, and approximately half of the total money is spent on transportation and housing for the brothers. When I asked him to explain how the trip came to be, he told me that there was another clergyman who had moved from the US to the Dominican Republic and organized service work for a small community there. R stated, "it is always important to me to have a connection to someone who knows the culture." This was interesting because instead of directly working with the community leaders, he chose to work through another westerner as the spokesperson for this community.

Throughout the discussion, R mainly talked about these trips from the perspective of the brothers. When explaining the quality of work they do while building these outhouses, R said "it's not like here where the construction manager signs off on things, they are just very grateful they have any kind of support." This idea that impoverished people are grateful for any support is highly problematic, as it implies that because they live in material poverty, they should be happy to get anything, instead of deserving quality necessities. R also mentioned that "last year, because of the pandemic, the brothers set up a virtual trip and sent the money down there to hire people to do [the labor] for [them]." This indicates that there are skilled laborers who can do the job, but the trip favors the involvement of the volunteers over the actual quality of the service they provide. This also showed that they have systems set up where one hundred percent of the money could be sent to these communities, allowing them to have autonomy over their spending. However, these trips prefer to spend money that could otherwise go directly to this community and fly out unskilled students to construct poor quality structures.

What is the actual impact?

Once these trips end and the volunteers go home, what is the lasting impact? Similar to my conclusions about the fraternity winter break trip, many scholars and critics agree that the actual impact volunteers have is not equivalent to the money they spend. For instance, international volunteers paid $30,000 to build just one house. That same house could be built by locals for $2,000 and "if well-wishers had contributed money instead of labor, fifteen times more houses could have been built. The helpful choice would have been to stay at home" (Rosenberg, 2018).

Voluntourists get to go home after a week, ignoring the poverty or struggles they witnessed, post their pictures, and commend themselves for all the good they have done. The communities, on the other hand, are left with the same systems that will keep them in poverty. The services these volunteers provide are oftentimes unsustainable, and sometimes even costly to the communities. Tina Rosenberg provides a strong example of this in her article about voluntourism:
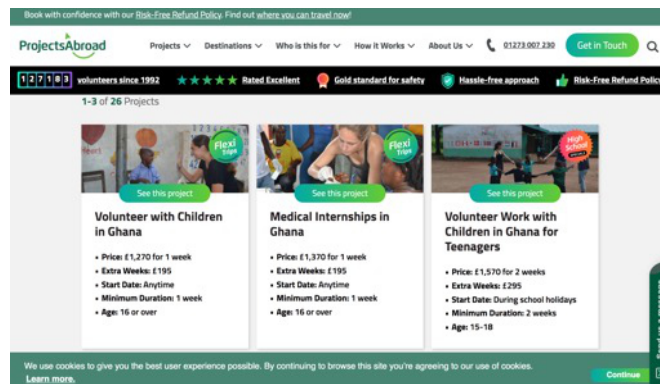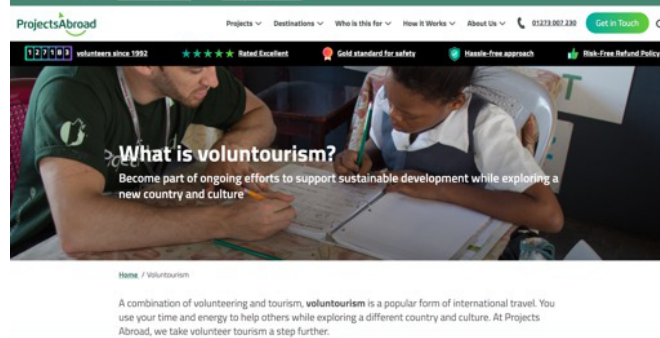
Figure 1

Figure 2

Figure 3

Figure 4

"An American volunteer in Tanzania recalled: "We … were so bad at the most basic construction work that each night the men had to take down the structurally unsound bricks we had laid and rebuild the structure so that, when we woke up in the morning, we would be unaware of our failure." (Rosenberg, 2018)

In cases like these, the community is left with the same problems as before, and the burden of fixing the damage done so wealthy westerners can feel like they are good people.

On a larger scale, the popularity of these voluntourism trips and the images that come from them enforce a neocolonialist ideology that these impoverished "others" need white people to save them.

Case Study: Projects Abroad Website

In my research, I came across a British travel company called "Projects Abroad." This is one of the leading voluntourism companies, and the trip's structures and ideas they promote are typical of the industry. The format of the Projects Abroad website is what first caught my attention (Figure 1). The site opens to an "About/FAQ" page where the first question is "What are the benefits of volunteering abroad?" The second line in the section being "What can I gain from volunteering abroad?" effectively shows who the focus is on these trips, and it isn't the communities. Only one out of seven of the listed answers even allude to the service work's impact, with everything else being exclusively about the benefit to the volunteer. From the answers and images of mainly white teens and young adults scattered all over the site, you can tell the in-
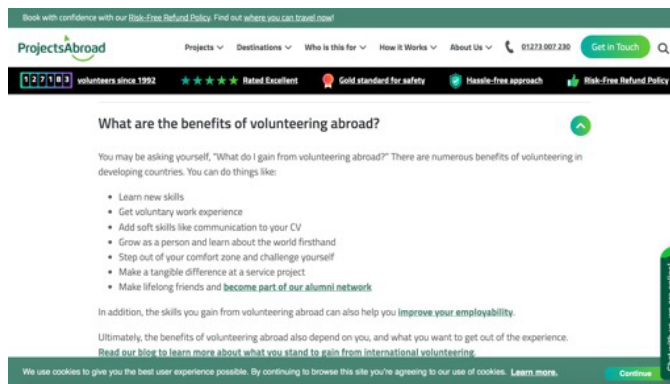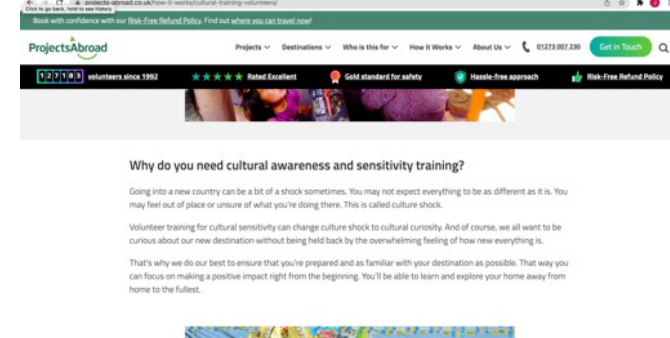
tended audience is "high school and university students, as most seek to acquire resume fluff, self-enhancement, and adventure," (Kimberly, 2021). Additionally, the "Who is this for?" tab is simply the different age groups that they take on these trips, not an explanation of who this is helping.

Companies like Projects Abroad are "capitalizing on their demographic's desire to 'help' countries to exist in the capitalist market; everything is to make a profit," and they make a big profit, too (Kimberly, 2021). This screenshot is of the prices for some of their Ghana trips. The irony of the words "volunteer" and "internship" being followed a line down by "price" is a simple example of the fallacy of volunteer tourism (Figure 2). Additionally, the images of the smiling white volunteer with a Black child are plastered all over the site, as shown in the next screen shot, not just in the pages about the projects in African countries.

In their "What is voluntourism?" page, we are again greeted by a white young adult helping a Black child (Figure 3). This photography trope is also common in the types of photos voluntourists post about their trips. Both uses are harmful, as it associates Black children with poverty needing to be saved and white people being saviors. Additionally, this page offers no information about the controversial nature of these trips, instead framing them as a universally accepted way to "support sustainable development."

There is an overall lack of self-awareness in this website, as their page on cultural awareness and sensitivity training is exclusively about why it is important for the volunteer, with no mention of respect or comfort of the community (Figure 4).
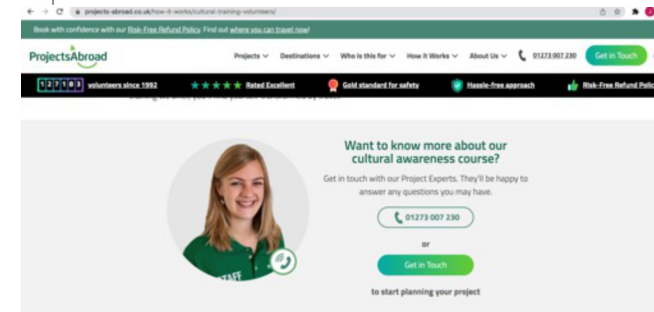

Figure 5

Figure 6

They conclude this page (see below) with the statement, "You'll be able to learn and explore your home away from home to the fullest," cementing the idea that even cultural sensitivity training is for the comfort of the volunteer.

If you scroll down to the bottom of the cultural awareness training page, you will see the smiling face of one of their "project experts," who is a white woman (Figure 5). As a trend, I noticed that every image of their staff is a white person, furthering this intentional dichotomy of the educated, western, (white) savior, and the poor Black child in need of saving.

I was curious as to how they proved their impact in these projects, and I found that they release a "Global Impact Re-

port" every year to show the work they do (Figure 6). This (see right) is a screenshot from their most recent report, and you will notice that all the impacts they have listed about non-environmental impacts are vague. "Supporting the education of more than 4,200 children," could mean anything from teaching a lesson to handing a child a pencil. Additionally, none of their listed impacts comment on the actual sustainability of their work. This report says they built or renovated one school, but questions like "who will pay the teachers? How much are uniforms going to cost? Where will the uniforms be made? How much is school tuition?" are all left unanswered (Kimberly, 2021). If the community cannot afford to keep the school running, it becomes a burden. This is one of the problems that arises when dependency is created and communities do not get to decide for themselves what they need and can sustain.

Conclusion

As seen in the case study, due to the steep price of these trips, it is primarily wealthy westerners who are able to participate in and benefit from these trips. They are attempting to buy morality without putting in the difficult work of confronting their own roles in the system that places people in poverty and keeps them there. The communities they appear to help are simply pawns in their game.

I do still believe that it is a natural desire for humans to want to help their fellow man, but how can this be accomplished without feeding into the trend of commodification? There is no single good answer. The most accessible way would likely be donating money directly to communities with displayed need in your local area and thinking critically about who is benefiting most from any volunteer work you do. It is a complicated topic, but researching the organizations you plan to volunteer with and making sure they primarily value the impact on the community would be the best first step.

About the Author: Julia Bergel

In my senior seminar class with Professor John Osburg, we discussed the topic of commodification as a main focus for the semester. Through our readings, I became interested in the concept of commodification of morality, where seemingly innate values could being turned into industries where the wealthy could buy experiences mimicking these values. This concept lead me to do more outside research, and eventually turned into this paper. I did not anticipate doing research as an undergrad when I first came to the University, but I soon realized that the term "research" extends far beyond the natural sciences, and that every field depends on research and has opportunities for it.

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Color Polymorphism and Its Effects on the Substrate Preference of European Green Crabs (*Carcinus maenas*)

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Advised by William Kimler, *Shoals Marine Lab*

Introduction

The European green crab, Carcinus maenas, was first introduced to the northeastern coast of the United States in 1817[1]. Their native range stretches from Northern Europe to Northern Africa and includes highly contrasting intertidal ecosystems ranging from the rocky subarctic seas of Iceland to the sandy beaches of northern Africa. This adaptability of C. maenas to a variety of intertidal conditions allowed its invasive populations to expand and thrive worldwide. They are easily distinguishable by five triangular spines stretching from behind the eyes to the widest part of the carapace[2]. Despite their name, the European green crab can range in color from dark brown to bright green on their dorsal carapace. These diverse color polymorphs are a form of crypsis that helps C. maenas blend into their intertidal environments.

Crypsis is a defense tactic against visual predators that relies on the morphological and physiological traits of prey organisms to avoid detection by providing a camouflaging ability. Two common forms of crypsis are background pattern matching and disruptive coloration. Background pattern matching describes an organism whose coloration resembles its natural backdrop. Disruptive coloration describes the use of color patterns to obscure important body parts by disguising them against a natural backdrop[3]. Cryptic fishes, like the least killifish (Heterandria Formosa), have been observed selecting resting backgrounds that match their morphological appearance and enhance their cryptic defense against predators[4]. Recently, researchers from the University of Miami observed the same active background choice in the tropical pallid ghost crab (Ocypode pallidula)[5]. With this research in mind and given the expansive color polymorphs of the European green crab, this project investigated whether the same active background choice would be observed in C. maenas through a combination of field and laboratory studies.

Hypothesis and Predictions

C. maenas will prefer a substrate that closely matches its polymorphic color pattern when given the choice between light and dark substrate in order to increase crypsis and avoid visual predation.

If C. maenas prefers substrate that matches its individual color polymorph and there exist two distinct brown and green color morphs of C. maenas in the Isle of Shoals, then it is expected that crabs with the darker brown color morph will prefer darker substrates and crabs with the lighter green color morph will prefer lighter substrate to match their morphological traits to their surrounding environment and enhance their cryptic defense, thereby increasing their fitness.

Materials and Methods

This was a two-part study, beginning with field observation before moving into a four-part lab experimentation.

Location

All C. maenas samples were studied at the Shoals Marine Lab on Appledore Island, ME (42°59'19"N, 70°36'52"W). The crabs (n=20) were observed in and collected from Babb's Cove in June of 2021 between the hours of 1500 and 1700 (EDT) during low tide.

Crab Sampling and Carapace Color

C. maenas were observed in the intertidal zone during low tide and photographed individual crabs against their natural substrate using a GoPro Hero8 Black Camera with a wide 16-33mm lens and automatic ISO. These images were later uploaded in their original 4000x3000 pixel format for computer analysis. Once each crab was photographed, they were carefully caught by hand and placed in an individual plastic holding container before being transported to a temperature-controlled sea table. Around 60 crabs were collected over 4 days from the intertidal zone, and 20 crabs with the most diverse range of color morphs were selected to be used in this study.

The carapaces of the C. maenas specimens were mottled with multiple color hues which presented a challenge when each crab was categorized as either light or dark without a portable spectrometer. Rather than subjectively evaluating the color of each crab by sight, each crab was photographed before the experimental trials and processed these photos using MulticolorEngine's TinEye Lab Color Extractor (Figure 1). This program identified every color and calculated its relative area on the carapace. The colors were identified with a hexadecimal color (hex) value that was then translated into an RGB color value to make it easier to compare different hues. After completing this color extraction for each crab, it was found that the lightest carapace color had an RGB value of (197, 196, 184) and the darkest carapace color had an RGB value of (27, 21, 4). The mean RGB value for carapace color was calculated to be (85, 87, 90). Any specimen with a red, green, or blue color value above one of these three numbers was considered a light crab, and any specimen with a lower value was considered a dark crab.

Fig 1. Differentiating color patterns between crabs using MulticolorEngine's TinEye Lab Color Extractor. The hex values of each color in the crab's carapace were converted to an RGB value which was then compared to the mean RGB to determine if the crab was lighter or darker than the average experimental specimen.

Substrate Choice Experiment

The substrate choice experiment took place in a square arena measuring 1.03m wide. It was filled with 7.5cm of saltwater pumped from the surrounding ocean. The water temperature was 15.5-17.5°C, and the water level and temperature were maintained by fresh seawater flow into the tank between trials. The arena was divided in half with bricks to ensure an even substrate split, and it was filled with a 2cm layer of substrate. One half of the arena was covered with light substrate and the other half was covered in dark substrate before the bricks were removed. Both the light and dark substrates were collected from Babb's Cove at low tide.

For the first trial, one crab was placed on the midline of the two contrasting substrates with rocks present to mimic the natural intertidal zone. For the second trial, the same crab was placed on the substrate opposite of what it chose in the first trial to ensure that there was no correlation between substrate preference and the initial orientation of the crab. For the third trial, the rocks were deleted and the crab was placed on the midline of the two contrasting substrates once more. For the fourth trial, they were once again placed on the opposite substrate with no rocks present in the arena.

The procedure for each of the four trials was the same. First, each crab was measured across the widest part of its carapace using a standard ruler. They were then sexed according to the appearance of their ventral carapace. Males had a distinct triangular ventral carapace whereas females had a broad, rounder one2. The crab was then photographed with an iPhone 11 set to automatic ISO in indirect sunlight against a neutral, unpolished wooden background. A white background was found to be too reflective for accurate color representation. They were then placed in the middle of the arena inside a ceramic mug (or bowl for crabs larger than 3.75cm) on top of a piece of neutral substrate. This neutral substrate was constructed from a piece of cardboard wrapped in duct tape to remain water-resistant and to achieve a high-value contrast against both the dark and light substrate. Then, 2 neutral substrates were cut in an octagonal shape to fit the dimensions of either the mug or the bowl. This octagonal shape allowed accessibility to grab the sides of the neutral substrate and lift it at the end of the acclimation period with minimal disturbance to the crab.

After placing the crab into the tank, a five-minute acclimation period began. When this time ended, the mug or bowl and neutral substrate were gently lifted away, allowing the crab to explore the substrate arena. The crab was observed for five minutes and its initial substrate location and subsequent substrate location was recorded every 60 seconds for five minutes. When the observation period ended, the crab was either caught and placed in the acclimation container to re-acclimate for the contrasting substrate test, or it was placed back into a separate container inside the sea table. This prevented crabs from being used multiple times in one trial. A total of 20 crabs were tested for both Trial 1 and Trial 2 where the arena was filled with rocks, and a total of 15 crabs were tested for both Trial 3 and Trial 4 where the arena had no rocks. On the first day of experimentation,Trials 1 and 2 were conducted. After Trial 1, if a crab exhibited a substrate preference either through burial behavior or by remaining on the medium the whole time, Trial 2 was immediately conducted on the contrasting substrate with another 5-minute acclimation period between trials. Trials 3 and 4 were conductedon the second day of experimentation, with Trial 4 immediately following Trial 3 after another 5-minute acclimation period.

After all four trials were completed, descriptive statistics were collected (means, standard deviations, frequencies, and percent) to describe the characteristics and substrate choices of crab types for each trial. To compare differences between dark and light crabs for sex and initial substrate choice, a chi-square test was run. To compare differences between dark and light crabs for average carapace length and average percent time spent on substrate choice (from 1 to 5 minutes), independent samples T-tests were run. To compare differ-

Table 1A - Condition Middle with Rocks (Trial 1)			
Characteristic	Dark Crabs (n=10)	Light Crabs (n=10)	P value for T-test comparing between groups
Mean % of time spent on Dark Substrate from 1-5 minutes (SD)	62.0 (40.5)	50.0 (52.7)	0.58
Mean % of time spent on Light Substrate from 1-5 minutes (SD)	38.0 (40.5)	50.0 (52.7)	0.58
P value for Paired T-test	0.37	1.00	

Table 1B - Condition Middle with Rocks (Trial 1)			
Characteristic	Dark Crabs (n=10)	Light Crabs (n=10)	P value for T-test comparing between groups
Carapace mean length, cm (SD)	3.1 (1.3)	2.7 (1.0)	0.45
			P Value for Chi-Square test comparing between groups
Males/Females, n (%)	8/2 (80/20)	7/3 (70/30)	0.61
Initial substrate choice, Dark/Light n (%)	8/2 (80/20)	6/4 (60/40)	0.33

Table 2 - Condition Contrast with Rocks (Trial 2)			
Characteristic	Dark Crabs (n=6)	Light Crabs (n=10)	P value for T-test comparing between groups
Initial contrasting substrate placement Dark/Light n (%)	2/4 (33.3/66.7)	5/5 (50/50)	0.51

Table 3A - Condition Middle with No Rocks (Trial 3)			
Characteristic	Dark Crabs (n=8)	Light Crabs (n=7)	P value for T-test comparing between groups
Mean % of time spent on Dark Substrate from 1-5 minutes (SD)	82.5 (22.5)	94.3 (15.1)	0.26
Mean % of time spent on Light Substrate from 1-5 minutes (SD)	17.5 (22.5)	5.7 (15.1)	0.26
P value for Paired T-test Comparing within Groups	0.005	0.0002	

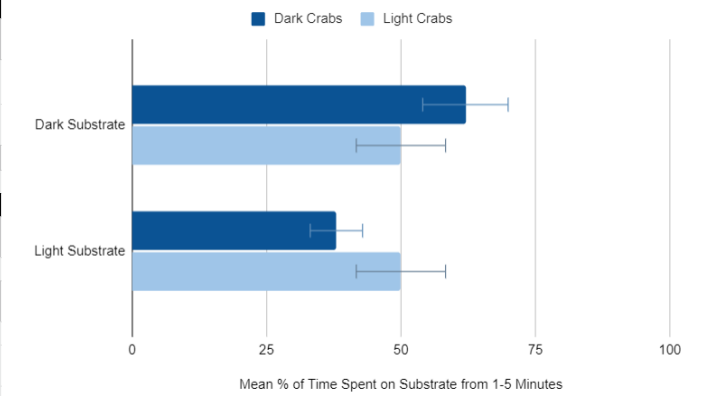| Table 3B - Condition Middle with No Rocks (Trial 3)			
Characteristic	Dark Crabs (n=8)	Light Crabs (n=7)	P value for T-test comparing between groups
Carapace mean length, cm (SD)	3.43 (0.9)	2.86 (0.9)	0.23
			P Value for Chi-Square test comparing between groups
Males/Females, n (%)	8/0 (100/0)	7/0 (100/0)	1.00
Initial substrate choice, Dark/Light n (%)	6/2 (75/25)	5/2 (71.4/28.6)	0.87

Fig 2. (**Table 1A & 1B**) Substrate preference of C. maenas when placed on the substrate midline with rocks present in the arena (Trial 1).
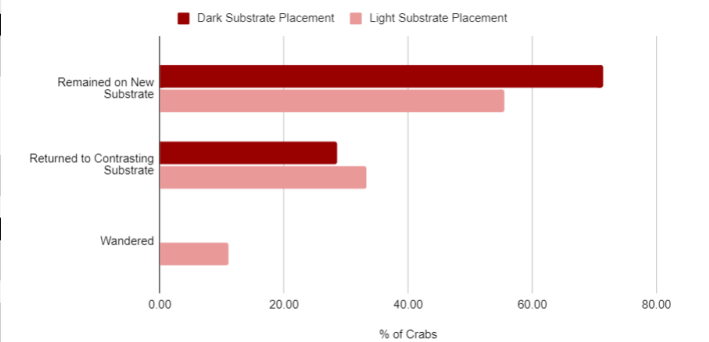
Fig 3. (**Table 2**) Substrate preference of C. maenas when placed on the opposite substrate with rocks present in the arena (Trial 2). Individuals either remained on the new substrate, returned to their preferred substrate, or wandered around the arena with no substrate preference.

ences within crab type (dark and light) for the average percent time spent on a substrate choice (from 1 to 5 minutes), paired samples T-tests were run. P-values for each test are reported with significant differences indicated if the p-value was <0.05. Statistics were run using Statistical Analysis Systems (SAS) software (version 9.4, SAS Institute, Cary, NC).

Results

In Trials 1 and 2, the mean carapace length of the dark crabs (n=10) was 3.1 (± 1.3) cm, and the male to female ratio was 80/20. The mean carapace length of the light crabs (n=10) was 2.7 (± 1.0) cm, and the male to female ratio was 70/30 (Table 1B). In Trials 3 and 4, the mean carapace length of the dark crabs (n=8) was 3.43 (± 0.9) cm, and the male to female ratio was 100/0. For the light crabs (n=7), the mean carapace length was 2.8 (± 0.9) cm, and the male to female ratio was 100/0 (Table 3B).

In Trial 1, dark crabs placed on the midline of the substrate with rocks spent a higher percentage of time on the dark substrate (62.0 ± 40.5%) than they did on the light substrate (38.0 ± 40.5%) (Figure 2). The light crabs spent an even percentage of time on both substrates (50.0 ± 52.7%). When the same crabs were placed on the contrasting substrate with rocks in Trial 2, over half of the crabs (71.4% dark, 55.6% light) remained on this new substrate, regardless of whether it was light or dark (Figure 3).

When the rocks were removed for Trial 3 and the crabs were placed on the midline of the substrate, both light and dark crabs spent significantly more time on the dark substrate. Dark crabs spent 82.5 (± 22.5) % of time on the dark substrate (p=0.005) and light crabs spent 94.3 (± 15.15) % of time on the dark substrate (p=0.0002) (Figure 4). When placed on the opposite substrate in Trial 4, the majority of C. maenas (75.0% dark, 37.1% light) returned to their preferred substrate (Figure 5)

Discussion

The field observational portion of the study supported the initial hypothesis that C. maenas closely matches its carapace color pattern with its surroundings, as all crabs were ob-
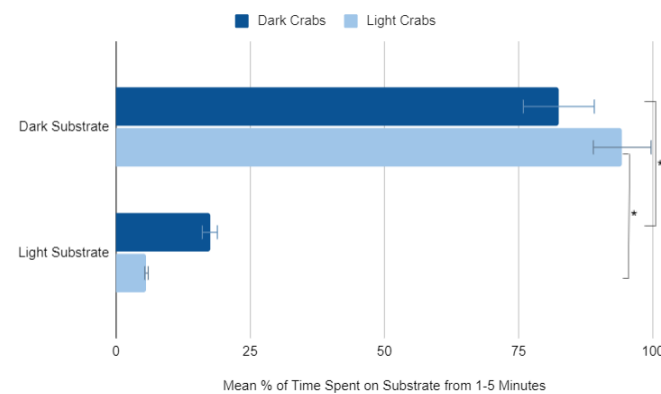
served and photographed on a substrate that similarly matched their coloring. During the lab portion of the experiment, it was found that the crabs had no significant substrate preference when rock cover was available; but when rock cover was removed, the majority of C. maenas (>80%) preferred the dark substrate regardless of carapace color and returned to the dark substrate when placed on the light. This data supports active substrate choice since a significant number of crabs returned to the dark substrate when no rock cover was available (p<.01).

The sand substrates were collected from the natural environment, so any existing olfactory cues were not removed. As such, the potential influence of olfaction on crab substrate choice cannot be excluded, and it is possible that the dark substrate contained more organic material and was, therefore, more attractive to crabs regardless of carapace color. Additionally, the crabs may have been relying on subtle differences in temperature or moisture between the dark and light substrates that were too subtle to measure in this study but still impacted their preference. Darker sand gets its color because it contains more silt which, when disturbed, makes the water cloudy. This would provide better cover from visual predators both in and out of the water, making the darker substrate a more advantageous substrate choice than the lighter sand containing no silt. Though there is currently no research on the ratio of dark to light color morphs of C. maenas, it is possible that darker phenotypes are more common than lighter phenotypes. If darker color morphs are more common, a preference for darker substrate could be an evolved survival tactic to protect the majority of the C. maenas population by increasing crypsis. Additionally, there is very little research on European green crab visual perception, so it is possible that C. maenas cannot see hues and relies entirely on value contrasts in its environment. Rock crevices, where these crabs were most often observed to be hiding
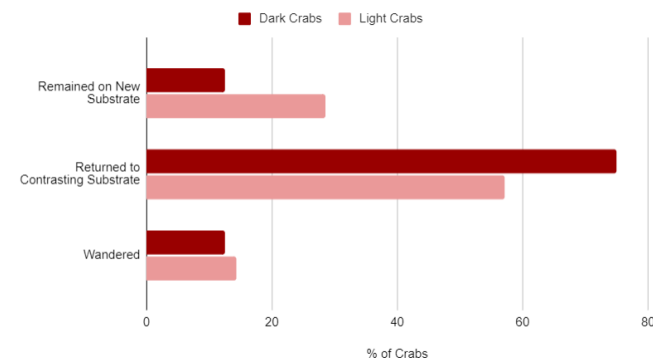
during the field portion of this experiment, have much darker values since they are in shadow. It is possible that the crabs perceived the dark value of the substrate rather than the dark color hue and chose this substrate because of an evolved survival behavior to locate rock crevices with similar dark values in order to avoid predation.

In future studies, it would be beneficial to repeat the experimental procedure with a larger sample size and a longer acclimation period. The crabs in this study might have been exhibiting defensive behaviors like sand burial due to the stress of being moved between tanks. Given a longer acclimation period with an automated release mechanism and camera monitoring to decrease experimenter interference, we could gather better data about the substrate preference of C. maenas and whether it changes noticeably throughout their day-night cycle. Future research could also examine the differences between substrate preferences in foraging crabs versus idle crabs. Foraging crabs must be more vigilant to avoid predation while they gather nutrients, so they might actively choose a matching substrate to lower their risk of predation while hunting. Since idle crabs do not have to be out in the open, it is possible that non-foraging C. maenas individuals would exhibit no significant substrate preference, instead choosing the closest rock for shelter regardless of color matching.

Overall, these results highlight an interconnection between the behavioral and morphological components of crypsis as an anti-predator defense. My experiment shows that crypsis is both a defensive behavior and a defensive morphology, and this duality is essential to understanding complex anti-predator tactics in C. maenas.

About the Author: Regan Collins

I am a third-year undergraduate majoring in environmental science and minoring in film and media studies. I conducted my research at the Shoals Marine Lab on Appledore Island, Maine. The Shoals lab provided the perfect opportunity to get involved in hands-on marine field research and design a study independently.

My advice to other undergraduates interested in research is to keep an open mind. All research experiences will teach you something valuable, so don't be afraid to explore opportunities outside of your field. Be respectful, be curious, and remember that failure is the best part of science!

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Fig 4. (Table 2A & 2B) Substrate preference of C. maenas when placed on the substrate midline without rocks present in the arena (Trial 3). All crabs (n=15) were buried on the dark substrate by the end of the observation period.

Fig 5. Substrate preference of C. maenas when placed on the opposite substrate without rocks present in the arena (Trial 4). Individuals either remained on the new substrate, returned to their preferred substrate, or wandered around the arena with no substrate preference. Since all crabs (n=15) buried on the dark substrate in Trial 3, all initial placement was on the light substrate.

Olfactory Cues Guide Mate Search in *Meloe* blister beetles

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Advised by Robert L. Minckley, *Biology Department*

Introduction

The ability to locate, attract, and recognize mates is a major determinant of reproductive success across all species. Additionally, mate-searching is heavily influenced by ecological conditions and sensory constraints, leading to the evolution of seeking behavior best suited to a species' ecological context and specific sensory capacities. Therefore, behaviors and mechanisms that optimize the ability to locate mates are expected to evolve. For example, use of auditory signals to locate potential mates can be highly adaptive when long-range detection of conspecifics is necessary and the requisite sensory capacity to detect the signals is available. However, when parasites or predators exploit these signals, there may be pressure to use other signals to find mates or even lose the auditory signal altogether (Tinghitella et al., 2018).

Organisms' sensory abilities also dictate which cues can be used for mate searching. Species that invest strongly into a single sense may solely use that sense to direct themselves to potential partners. In moths, which rely heavily on olfaction and have poor vision, males follow sex pheromone trails to reach females (Greenfield, 1981). Other species may integrate different sensory cues or use them at different stages of the mate search such as olfaction and tactile cues for honing, and vision when in short range (Cerveira & Jackson, 2013). Thus, ecological context and sensory capacity play key roles in the evolution and maintenance of adaptive mate-searching strategies. Being able to tease these two influences apart can guide hypotheses about what specific cues an animal may use to locate viable sexual partners.

The genus Meloe (Coleoptera: Meloidae), commonly known as blister beetles, presents an interesting case study in which mate signaling mechanisms remain unknown. Their eponymous trait is derived from the powerful blistering agent cantharidin that they release when disturbed. As a result of this robust chemical defense system, Meloe have very few natural predators—only a few fly and other beetle species are known to attack them (Pinto & Selander, 1970). Meloe also have a complex life cycle involving parasitism of hosts—typically bees, whose nests provide both a nursery and food source in the form of eggs for the predatory Meloe larvae. In some cases, the relationship between the host and parasite is quite intricate. For instance, the triungulins of a Meloe desert species called M. franciscanus imitate the sex pheromone of the female solitary bee, Habropoda pallida, to attract male bees, attach to them, and later parasitize the bee larvae (Saul-Gershenz & Millar, 2006).

Their highly specific host relationships and lack of predators suggest Meloe have persisted for a considerable amount of time, which is remarkable considering their physical limitations. The adult beetles are flightless, and their disproportionately large abdomens make them relatively slow terrestrial dispersers (Pinto & Selander, 1970). M. franciscanus have overcome this constraint by becoming a phoretic parasite reliant on the highly mobile bee to transport its larvae to distant food sources. A similar selective pressure to accurately locate mates over long distances could very well have facilitated the evolution of mate signals in other species of Meloe. The general observed pattern across the Meloidae family is that males take the active role in finding mates, spending relatively little time feeding and more time roaming and initiating courtship (Selander 1964, Bologna 1986). Conversely, females devote much of their time to feeding and have never been observed overtly soliciting courtship (Pinto & Selander, 1970). This suggests that the female is the source of the mating signal. Until now, no formal investigation has been conducted on the sensory mechanisms males use to locate potential mates.

Our focal species, the American blister beetle (Meloe americanus), emerges in the late fall to mate. Because M. americanus has no recorded predators or other natural enemies that may influence mating behavior, the main sense(s) used in mate-searching will be determined by the physical and sensory constraints of this species. This opens a valuable window to ask how sensory systems and the environment guide the evolution of a behavior that has sizable fitness consequences.

In this study we sought to determine whether M. americanus males rely on olfactory or visual cues as they search and locate females. We hypothesized that olfactory cues would be the most important element for three main reasons. Firstly, olfaction has been determined to be an important sensory modality in mate recognition in other beetle species (Tanigaki et al., 2007; Barbour et al., 2007). Secondly, this species has low visual acuity (Pinto & Selander, 1970) and lives in tall grasses, which may further limit visual detection of conspecifics (Marschalek et al., 2020). Thirdly, the usage of odor cues in larvae of other Meloe species suggests the capacity to produce long-range olfactory signals. To test our hypothesis, we presented male M. americanus with separate visual and olfactory cues from females in a four-quadrant choice trial (one quadrant each with the olfactory and visual cue, and two empty quadrants). If the beetles consistently spent more time at the quadrant containing the olfactory cue, this would support the olfaction hypothesis. If instead more time was spent at the quadrant containing the visual cue, this would support the visual hypothesis. Alternatively, if there was no significant difference in the time spent at each cue quadrant, this could either indicate that both are jointly necessary or that a third sense not considered in this study may be involved. Any finding will open additional lines of inquiry for this interesting and understudied species.

Methods

### Sample Collection, Visual and Olfactory Cue Preparation:

In mid-October 2021, shortly after the emergence of the adult blister beetles, we collected 20 Meloe americanus females from an open field in Rochester, New York. The 20 collected females were transported back to the lab in 50 mL plastic Falcon tubes and euthanized by freezing at -20° C. The surface odorant molecules of 10 females were extracted for use as experimental olfactory cues as follows: for each female, we dissected and discarded the abdomen to avoid contamination of odors from gut contents, then soaked the head, thorax, and legs in 1 mL of hexane in a glass vial for five minutes. Extracts were transferred to clean vials. This resulted in 10 separate vials each containing 1 mL of hexane extract from a different female. Since the chemical profile of the M. americanus female hexane extracts has not been characterized, we sought to minimize the accidental degradation of compounds that could potentially be critical to recognition, which would bias our results. We kept extracts shielded from light to avoid any potential UV-mediated compound degradation until used in choice trials. The importance of visual cues was tested using the ten remaining dead females: Each whole body was fully submerged in hexane for five minutes, then placed on a paper towel and allowed to dry. We carefully avoided physically damaging the bodies during the process of odor-washing and did not touch any "odor-washed" body with tools that had previously touched unprocessed females to avoid reintroducing odors to the bodies. We did not use the hexane extracts from full body washes since they were likely contaminated by odors from the females' abdomens and gut contents. Thus, they were not comparable to the 10 olfactory cues previously extracted from heads and thoraxes. In the end we had 10 solvent-washed bodies (visual cues) and 10 hexane extracts (odor cues) to use in the choice trials.

Olfactory and Visual Cue Choice Trials:

We tested if M. americanus males predominantly use olfactory or visual cues to find and recognize females in a closed arena composed of a 40 by 50 cm plexiglass box. We used blue painter's tape on the underside of the box to divide it into four quadrants of equal size (20 by 25 cm). In the top two quadrants, opposite of each other, we placed the olfactory and visual cues (see figure 1). For the olfactory cue we pipetted the 1 mL of female odor hexane extract onto a circular filter paper. For the visual cue we placed the odorless body of another female on a separate circular filter paper of the same size as the one used for the olfactory cue. The location of the visual and olfactory cues (left or right) was alternated for each trial to control for any preference of the males for the left or right side of the arena. We ran 10 choice trials where we presented the olfactory and visual cue at opposite ends of the closed arena. Each trial used a new olfactory and new visual cue. Once olfactory and visual cues were in place, we placed one male at the bottom-center of the arena, covered it, and filmed behavior for six minutes. We used a different male for each trial (N = 10 trials). Trials were conducted at the field study site to avoid potential
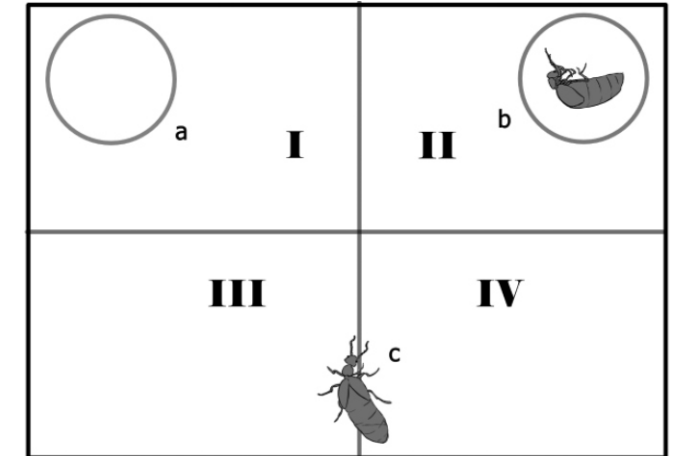
Figure 1) Setup for Olfactory and Visual Cue Choice Trials: Trials were conducted in a 40 by 50 cm plexiglass arena, which was visually subdivided into four quadrants of equal size. On opposite ends of the topmost two quadrants were the olfactory cue (a), consisting of filter paper soaked with hexane extracts of female M. americanus females, and the visual cue (b), which was a solvent-washed odorless body of a M. americanus female. The locations (left and right) of the cues were alternated between trials. Live males collected in situ (c) were placed at the bottom-center of the cage, and their behavior was recorded for six minutes. I: olfactory quadrant. II: visual quadrant. III: under-olfactory quadrant. IV: under-visual quadrant (diagram not drawn to scale). The proportion of the time spent in each quadrant was then calculated to assay the behavioral response.

behavioral perturbation resulting from displacing males to the lab, which has different lighting and temperature conditions than those typically experienced. Therefore, all males were collected in situ at the time of the trials. We wiped the arena with ethanol between trials to avoid odor carryover from one trial to the next and conducted trials no less than three minutes apart.

Data Analysis and Statistics:

For each video we quantified the amount of time the male spent in the olfactory quadrant (quadrant containing the olfactory cue), the visual quadrant (quadrant containing the odorless visual cue), and each of the two empty quadrants using BORIS, a software for quantification of animal

behavior (Friard & Gamba, 2016). We also quantified how long, if at all, the male *M. americanus* touched either of the cues for each trial. In each trial we noted which of the two cue quadrants (visual or olfactory) was visited first. The means of the time spent in each quadrant were compared using a one-way Analysis of Variance Test (ANOVA), followed by a Tukey Honest Significant Differences test to determine if time spent in each quadrant differed significantly. We also pooled the time spent in each cue quadrant with the time spent in the empty quadrant below and compared if the time spent at the "visual half" of the arena (time spent in visual cue quadrant and empty quadrant under visual cue) differed significantly from the time spent in the "olfactory half" of the arena (time spent in olfactory cue quadrant and empty quadrant under olfactory cue). The means for the time spent at each half of the arena were compared using Welch's t-test.

Results

Quantitative analyses were conducted for the 10 trials using an olfactory cue and visual cue from different females (10

females used for olfactory, 10 used for visual, 20 total) and a different male (total = 10 males). In one trial the male rapidly moved into the quadrant under the visual cue (the empty quadrant under the one containing the odorless female's body, labeled IV in Fig. 1), then remained completely immobile for the remainder of the observation period. Because this behavior was markedly different from that observed in all other trials, we excluded it from further analysis. Data from all ten trials is found in Table 1. The maximum amount of time spent by a male in the olfactory quadrant was 354.907 seconds, with a mean of 198.143 seconds across all nine trials. The maximum time spent in the visual quadrant was 97.092 seconds, with an average of 26.230 across all nine trials. The maximum time spent in the empty quadrants under the olfactory and visual cues were 276.258 and 195.497 seconds, respectively. In six out of the nine trials, the male came directly into contact with the olfactory cue, while the visual cue was contacted only in three trials. In six out of the nine trials analyzed the male visited the olfactory quadrant first. In two of the three trials in which the male visited the visual quadrant first, the beetle still spent more time overall in the

Trial	Time spent in Olfactory Quadrant (s)	Time spent in Visual Quadrant (s)	Time spent in Quadrant Under Olfactory (s)	Time spent in Quadrant Under Visual (s)	Time spent in Direct Contact with Olfactory Cue (s)	Time spent in Direct Contact with Visual Cue (s)	First Cue Quadrant Visited
1	0	0	9	360.978	0	0	None
2	347.113	0	0	18.217	0	0	Olfactory
3	354.907	0	6.881	0	2.498	0	Olfactory
4	192.947	97.092	0	12.419	20.512	50.794	Olfactory
5	353.898	0	18.017	0	8.765	0	Olfactory
6	45.827	0	276.258	40.499	7.002	0	Olfactory
7	133.563	49.745	177.079	3.749	3.75	17.248	Visual
8	3.003	74.492	82.989	195.497	0	3.502	Visual
9	53.251	0	233.336	78.502	12.997	0	Olfactory
10	298.785	14.749	31.747	32.248	0	0	Visual
Mean (excluding Trial 1)	**198.143**	**26.230**	**91.811**	**42.347**	**6.169**	**7.949**	
Percentage of 6 minutes spent at quadrant	**55%**	**7.2%**	**25.5%**	**11.8%**	**1.7%**	**2.2%**	

Table 1) Time Spent in Each Quadrant and First Quadrant Visited Across All Male Choice Trials: Displayed for each trial (rows) is the time spent in the quadrant containing the olfactory cue, time spent in the quadrant containing the visual cue, time spent in the quadrants under the olfactory cue and under the visual cue, time spent in direct contact with the olfactory and visual cues, and which cue quadrant (visual or olfactory) was visited first. The second-to-bottom row contains the means for each quadrant calculated for trials 2-9. The bottom row contains the mean percentage of time spent at each quadrant was calculated by dividing the mean time spent at the quadrant by the total recording time per trial (360 seconds). All times are reported in seconds. Note: Trial 1 (highlighted yellow) was excluded from mean calculation and further analysis due to the discordant behavior observed in that trial when compared to all others.
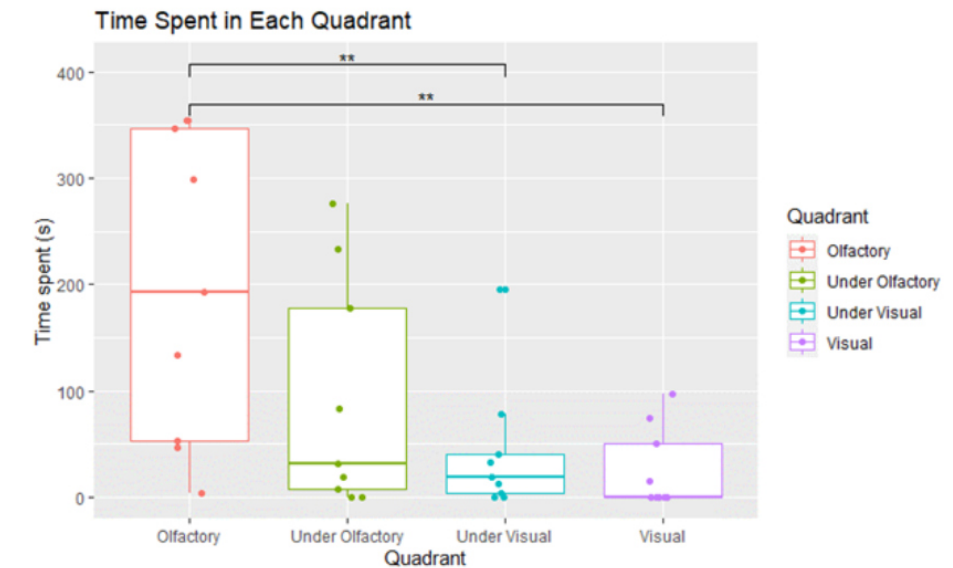
Figure 2) Time Spent at Each Quadrant For Trials 2-9: The boxplots of the time spent at each quadrant for trials 2-9 are displayed. The dots represent specific data points for each trial. **Red** = boxplot of time spent at the quadrant containing the olfactory cue. **Purple** = boxplot of time spent at the quadrant containing the visual cue. **Green** = boxplot of time spent at the quadrant under the olfactory cue. **Blue** = boxplot of time spent at the quadrant under the visual cue. The bottom edge of the boxplots contains the 25th percentile, and the top edge contains the 75th percentile. The thick line in the middle of the boxplots is the calculated mean. The lines extending out from the boxplots indicate the calculated maximum and minimum values. The dots beyond these lines represent outliers. For quadrants that differed significantly in time spent at them, significance bars are displayed above the boxplots.
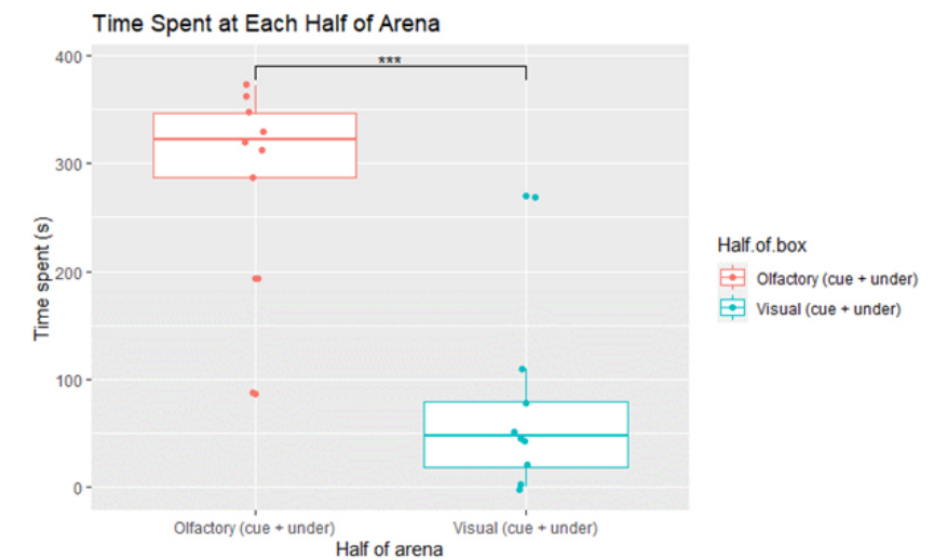
Figure 3) Time Spent at Each Half of Arena: The boxplots of the time spent at each half of the arena for trials 2-9 are displayed. The dots represent specific data points for each trial. **Red** = boxplot of time spent at the quadrant containing the olfactory cue plus the time spent at the empty quadrant under the olfactory cue (Olfactory half of arena). **Blue** = boxplot of time spent at the quadrant containing the visual cue plus the time spent at the empty quadrant under the olfactory cue (Visual half of arena). The bottom edge of the boxplots contains the 25th percentile, and the top edge contains the 75th percentile. The thick line in the middle of the boxplots is the calculated mean. The lines extending out from boxplots indicate the calculated maximum and minimum values. The dots beyond these lines represent outliers. The significance bar is displayed above the two boxplots.

olfactory quadrant. Only in one trial across all nine was more time spent in the visual quadrant than the olfactory one.

The means of the time spent in each of the four quadrants differed significantly (One-way ANOVA, F-value = 5.676, p < .01). The post-hoc Tukey Honest Significant Differences test specifically showed there was a significant difference between the time spent in the olfactory cue quadrant and the visual quadrant (p = .003), as well as the olfactory cue quadrant and the quadrant under the visual cue (p = .009). None of the other pairwise comparisons of time spent between quadrants differed significantly (figure 2). Comparing the time spent at the visual half (visual cue quadrant + empty quadrant underneath) and olfactory half (olfactory cue quadrant + empty quadrant underneath) of the arena, we found that significantly more time was spent in the olfactory half (p < .0001, figure 3).

Discussion

We found evidence that the M. americanus males primarily use olfaction to search and recognize mates. In six out of nine trials analyzed, the male visited the olfactory quadrant first. It is worth noting that in these trials the males headed for the olfactory quadrant almost immediately upon being placed in the arena and remained on or near the hexane-soaked filter paper for an extended period. In two out of the three trials in which males visited the visual quadrant first, they later turned around and directed themselves to the olfactory quadrant. Furthermore, significantly more time was spent at the olfactory quadrant, independent of what side (left or right) the olfactory cue was placed in. Taken together, these data provide strong evidence for a role of female odor, potentially cuticular hydrocarbons and sex pheromones , in directing males to potential sexual partners (Greenfield, 1981; Barbour et al., 2007). In further support of the role of olfaction in mate recognition, only one male across all nine trials actively mounted the visual cue, however, it dismounted rapidly. This suggests that once in close range, vision may play a role in mate recognition, but that this is insufficient in the absence of female produced odors.

One element that was not assessed in this study is if the olfactory cues produced are sex-specific, or the same for males and females. A test in which olfactory cues extracted from males and females were presented could easily answer this question. If odors are different for male and female beetles, then we might expect males to consistently choose quadrants with female odors. However, if the odor profile is not sex-specific, then males would choose at random. It is more likely that volatile sex-specificcompounds are involved in mate search in this species, since a previous experiment showed male M. americanus became more alert and active in a lab setting when in the proximity of females but not other males, and that this was true even when they could not see the females (Pinto & Selander 1970.) Future studies may also seek to characterize the species and sex-specific compounds involved in mate searching and recognition within the Meloe genus.

Mate recognition facilitated by female-produced pheromones is seen in other families of Coleoptera such as Cerambycidae and Tenebrionidae (Happ,1969; Barbour et al., 2007). However, it is difficult to say whether this is a general feature of the Meloidae family. Selander (1964) speculated Pyrota, a genus of Meloidae with yellow-orange aposematic coloration, may employ a visual element to recognize individuals of their own species. Although Meloe lacks the striking color patterns of other blister beetle genera, individuals do vary in the reflective color of the carapace; some reflect green while others are bluer. Whether or not M. americanus is able to detect these differences is subject to further inquiry.

In conclusion, reliance on olfactory cues for mate detection in Meloe beetles is a reasonable adaptation considering their physical, ecological, and sensory constraints. Our study site was composed of tall grasses (decreasing long-range visibility), which when compounded with poor vision, makes this sense potentially less useful to use for locating mates. Their flightless-ness puts a significant limitation on the beetles' mobility and long-range visual detectability. No structures or organs for sound production have been reported for Meloe, making audition another unlikely candidate for main sense used in mate-search. However, chemical signals, can not only travel relatively long distances but also can convey highly specific information about their source. These combined factors could easily create a scenario in which males that are more sensitive to females' scent are favored by natural selection and persist in the population, because these males would locate mates faster and mate more frequently than less perceptive males.

About the Author: Atalanta Ritter

This project was done for an Ecology & Evolutionary Bio lab required for BEB majors. It was a great opportunity to not only self-design a project and execute it but also to get outdoors, collect wild samples, and learn more about a cool local insect species! My advice for undergrads wanting to get into research is: Keep your mind open. Research on the undergrad level is more about learning the general thinking and planning skills associated with research rather than developing precise topics/questions and getting particular data. It's about the journey and experience, not the destination!

About the Author: Federico Sanchez

I am greatly interested in the information animals use when making specific behavioral decisions. I have worked for two years at the Uy lab studying a parasite and host association, investigating how the parasite manipulates its host's behavior to achieve survival and reproduction. Though the paper published here is on another organism, the idea of teasing apart sensory influences on behavior ties directly to my research and has prepared me for further research. I advise anybody interested in research to not be afraid to reach out to professors and other student researchers; a sincere willingness to learn always finds a way!

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Commodifying Jewish Culture and Identity

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Advised by John Osburg , Department of Anthropology

Abstract

Jewish day schools serve as sites of cultural reproduction where Jewish identity and a connection to the Jewish Nation can be purchased through participating in intimate social transactions grounded in financial exchange and a commitment to Jewish knowledge production. Though a connection to one's Jewish identity in Diaspora is perceived and internalized by the international Jewish community as priceless and essential to the continuation of Judaism, many Jews are denied access to a formal Jewish education due to financial constraints. In this paper, I focus primarily on the Jack M. Barrack Hebrew Academy in order to illustrate what the value of a Jewish day school education is, identify the mechanisms that determine the cost of tuition, and unearth the relationships of reciprocity and interdependency between Jewish day schools, established Jewish institutions, and donors that attempt to subsidize the cost of attaining a Jewish day school education.

Despite being offered positions to play basketball "from D-1 schools…programs in the Big West, Mountain West, Big Sky, [and] Ivy League," (Belsky, 2021) Ryan Turrel chose instead to attend Yeshiva University and play D-3 basketball. When asked by his family "'Why in the world would [he] want to go to Yeshiva?'…Ryan said, 'Why in the world did you send me to Valley Torah High School?'" (Belsky, 2021) asserting that it was his Jewish day school education that had prompted him to value a connection with Judaism over athletic glory and financial compensation. Turrel was offered "Division 1 free rides," yet he decided that "ask[ing] his parents to pay $50,000 a year for him to study marketing and play ball at Yeshiva" (Belsky, 2021) was the most beneficial academic option because he understood Yeshiva as being the "institution [that] will best cultivate [his] potential" (Zaloom, 2019,156) through access to Jewish studies and a Jewish community. Ryan Turrel's story and decision to prioritize a Jewish education over secular achievements and financial costs forces one to consider: Why is a Jewish education valuable? Why do students and families choose a Jewish day school education over a secular education? What are the costs associated with attending a Jewish day school? Who is paying for a Jewish day school education?

Jewish day schools are formal educational institutions offering young American Jews access to an elite secular education and an in-depth Jewish studies curriculum. This network of religious schools aims to preserve Jewish continuity both by immersing Jewish students in intimate knowledge and instilling *Jewish Cultural Capital* within each student, thereby enriching the diasporic Jewish community at large. There is a community wide fear that Judaism and Jewishness may not reproduce themselves organically due to assimilation, intermarriage, and the ethno-religion's already scarce population. Jewish day schools serve as a strategic intervention that aims to ensure that Jewish values, knowledge, socialization, and relationships are reproduced in the increasingly secular present.

Though a formal Jewish education is perceived as being integral to the preservation of Jewish identity, the cost of attending this institution is financially exclusive. A relationship to one's own culture is typically seen as unpurchasable, yet a Jewish student can be guaranteed access to their own cultural heritage for an annual tuition cost ranging from "somewhere between $15,000…and more than $30,000 a year" (Wertheimer, 2010). Jewish families that choose to participate in formal Jewish education engage in "intimate social transactions" (Zelizer, 2005, 27) with Jewish day schools and other Jewish institutions in order to facilitate the reproduction of Jewish Cultural Capital. This relationship between family, school, and Jewish philanthropic organizations is essential to communal reproduction because "[m]aintaining any sort of durable social relations depends on creating culturally meaningful institutional supports" (Zelizer, 2005, 36), but because of the cost, it is not a relationship accessible to all those who may want it.

Historical Context

For over two millennia in diaspora, Jewish communities throughout the world have successfully maintained Jewish communal identity through "education [which] has been the principal instrument of Jewish defense" (Black, 2013, 132) against assimilation. Though formal Jewish education has been historically instrumental in maintaining Jewish continuity in Europe and the Middle East, prior to the mid-twentieth century, the United States had a handful of Jewish day schools, and these sites of knowledge production were only catered towards the Orthodox community. Following the atrocities of the Holocaust and the destruction of the "reservoir of highly educated Jewish religious leaders steeped in the traditions of European scholarship and life" (Brown, 1992, 47) that had created and maintained institutionalized Jewish education for centuries, Jewish communities in America realized that they "had to begin creating its own leaders and scholars" (Brown, 1992, 47) and fill the void of Jewish learning that had been lost to genocide.

Due to assimilation and a lack of formal Jewish education in the United States, American Jewish parents in the twentieth century did not have "the knowledge to transmit Jewish learning to their children" and turned towards Jewish day schools for "the formation of Jewish human capital [and be-gan] rely[ing] on a system of Jewish education" (Wertheimer, 2010) to ensure the continuity of Jewish practice and identity. When the Jack M. Barrack Hebrew Academy (the site of a great portion of my fieldwork and the first pluralistic/nondenominational Jewish day School in the United States) first "began enrolling students in the 1940s, less than 5% of American-Jewish children attended day schools, which totaled only roughly 65 institutions" (Zakai, 2013, 285**); today "68,962 students were enrolled in 254 Federation-funded Jewish day schools in [the] 2015-2016" (Jewish Federation Funding Models, 2018) academic year. Though there has been a substantial increase in Jewish day school participation in the United States, at the same time there has been a significant decrease in Jewish connection evident in that only "one-in-five Jews (21%) say religion is very important in their lives, compared with 41% of U.S. adults overall" (Pew Research Center, 2020). Similarly, in the increasingly high rates of intermarriage "among married Jews outside the Orthodox community, about half (47%) say their spouse is not Jewish… [of] Jews who got married in the last decade, 72% say they are intermarried" (Pew Research Center, 2020). As Jewish identity and communal participation continue to decrease while the "fear of assimilation" in the United States increases, Jewish day schools have become "increasingly responsible for maintaining Jewish tradition in America" (Zakai, 2013, 294). Still, their cost of tuition limits which Jews have access to a formal Jewish education.

Defining the Value of a Jewish Day School Education: Jewish Cultural Capital

Individuals and Jewish institutions engaging in intimate social transactions with Jewish day schools are purchasing Jewish Cultural Capital, which is comprised of social reproduction, religious collectivism, and intimate knowledge. Jewish Cultural Capital is valued because it is expected to result in Jewish continuity. A "day school tuition is the cost many parents believe they must bear if their children are to retain their heritage in a society that exerts enormous assimilatory pressures" (Wertheimer, 2010). This intimate social transaction does not merely encompass individual access to cultural capital, but also serves as an investment in the future survival of diasporic Judaism on a communal scale. Individuals and Jewish institutions choose to invest their funds and allocate financial resources towards Jewish day schools because the "priority of Jewish education is for the next generation… Jewish education is keystone to that link of continuum," (Interview with JNF Fundraiser, Pellish, 11/2/21) and investing money, time, and educational resources into institutionalized Jewish learning is believed to result in the continuation of Jewish identity and practice in the future.

Social reproduction, the first major aspect of Jewish Cultural Capital that is being purchased through a Jewish day school's tuition, is "the ways that [cultures] regenerate people, objects, and relationships in order to pursue a collective future" (Cattelino, 2008, 79). Jewish day schools facilitate social reproduction by creating a culturally homogenous space where American-Jewish ideology is learned in the classroom and reinforced through socialization, interpersonal relations, and discourse. Bonds of kinship are thus produced through shared experiences of knowledge production and socialization. Analogous to Seminoles that found that "indigenous discourses about cultural loss can facilitate cultural continuity" (Cattelino, 2008, 65), an emphasis on Jewish continuity is highlighted in Jewish day schools' mission statements, enforced in structured academic conversation, and socially reproduced in interpersonal dialogue in order to constantly highlight and internalize that the value of Jewish education is continuity and serves a communal future. Through this ongoing process of institutionalized social reproduction, students are expected to emerge from a Jewish day school with a strong sense of collective identity with other Jews thus maintaining a close social and communal network that will foster the next generation of Jews.

The second component of Jewish Cultural Capital is religious collectivism. Drawn from Khan's "elite collectivism", (Khan, 2011, 33**) religious collectivism is born from the Jewish day school, which like elite boarding schools are a "total institution…a moral milieu where pressure is placed on individuals to give up parts of themselves to forward the interests of the group…reinforcing a sense of collective identity" thus producing "soldiers for their class" (Khan, 2011, 33-34) and, in the case of Jewish day schools, religion. Jewish day schools provide a "strong identification with the Jewish religion and people" (Wertheimer, 2010) directly contributing to Communal Sovereignty, a concept "constituted by relations of interdependency that take material form in people's bodies, houses, and lands" (Cattelino, 2008, 200). Individuals are bound together through the process of institutionalized social reproduction into "relations of interdependency", causing deep in-group identification that manifests itself in religious collectivism. By paying tuition in a Jewish day school, parents are purchasing their family's place within the community and are performing a commitment to religious collectivism that is marketed as necessary for cultural continuity.

Intimate knowledge, the third component of Jewish Cultural Capital is the culturally "particularized knowledge" (Zelizer, 2005, 14) that is attained through a Jewish day school education. In the dual-curriculum model that most day schools adhere to, the day is split between secular subjects and Jewish studies which is comprised of Hebrew, Torah Study, and Jewish history, law, and philosophy. A great emphasis is placed on intimate knowledge because "the more knowledgeable you are, the more you appreciate your history, your tradition, and where you've come from" (Interview with Head of School, Levin, 11/29/21) and maintain a connection with Judaism into adulthood. Through the dispersal of intimate knowledge, "kids at Jewish day school get [an] inundation of Jewish education which plays a role in the wider community" (Interview with Administrator, El-Mofty, 11/9/21) and serves to further solidify Jewish continuity through the spread of such embodied knowledge. This model allows "Jewish stu-

dents to be both educated Americans and culturally knowledgeable Jews…all the while providing a first-rate general education" (Wertheimer, 2010). The education attained through a Jewish day school, though culturally specific, is analogous to other ethno-religious minority cultures in that it serves as "a political and nation-building measure" (Cattelino, 2008, 72). The Seminole Nation's recent "efforts to save Seminole languages [is often compared] with Israel's success in reviving and codifying Hebrew as an official language" (Cattelino, 2008, 72) and highlights a shared similarity between minority groups and their efforts to avoid total assimilation.

Evaluating the Cost of a Jewish Day School Education

The reality of being both a site of cultural and religious reproduction while at the same time an elite educational institution, forces Jewish day schools to represent themselves as two diametrically opposed entities: an exclusive place of knowledge production, and a welcoming space of social and communal reproduction. Initially, the Jack M. Barrack Hebrew Academy had marketed "the school to quality-conscious parents" as being "academically equivalent to - if not better than – traditional public schools" (Zakai, 2013, 290). By the 1970's as "increasing competition for spots at top colleges was stirring anxiety among middle-class parents, Jewish and non-Jewish (Zakai, 2013, 296), the school rebranded itself as being "the best secular learning [institution] with the finest training in Jewish studies, at a level equal to the best that any other private school can provide" (Zakai, 2013, 297). In order to meet market demands, the school transitioned itself from being a site of knowledge production equal to public education to "present[ing] itself as an elite college preparatory school" (Zakai, 2013, 297) that promised to "cultivate potential" (Zaloom, 2019, 157) by producing students that could be "admitted to prestigious colleges" (Zakai, 2013,297). In order to maintain the prestige associated with being an elite educational institution, tuition is "raised at about 2%" (Interview with Head of School, Levin, 11/29/21) every year because "it's bad practice not to raise tuition, it's the norm. People expect it, as hurtful to the pocketbook as it might be, they still expect it" (Interview with Head of School, Levin, 11/29/21). Having a lower tuition, in comparison to elite secular private institutions, signals to "quality-conscious" parents that the secular aspect of a Jewish day school's product is not as valuable as a secular private school's product.

A school's tuition represents the value of the product being purchased, and in competing with both religious schools and private secular schools, Jewish day schools must find a balance between being both elite and communally accessible. The Jack M. Barrack Hebrew Academy is both a day school and college preparatory based in the suburbs of Philadelphia, which is home to the United States' third largest Jewish community. In comparison to the other Jewish (high school) day schools and three other college preparatory academies in the area, Barrack is the most expensive religious school and the

least expensive college preparatory. Currently, Barrack's tuition is $36,000 a year, Kohelet Yeshiva, the community's Modern Orthodox day school costs $28,350 a year, and the Orthodox all-boys school, The Mesivta High School of Greater Philadelphia, costs $23,640 a year in tuition. Three of the Jack M. Barrack Hebrew Academy's main secular/preparatory competitors are the Shipley School which costs $40,750 a year in tuition, the all-girls Baldwin School, which costs $39,800 a year in tuition, and the Friends' Central School which costs $39,990 a year in tuition.

Tuition for Kohelet, Mesivta, and Barrack is lower than tuition for a competing private school because the majority of Jewish day school students cannot afford to pay full tuition. At Barrack, between "55% and 60% of students are on some kind of financial assistance" (Interview with Head of School, Levin, 11/29/21) and at Kohelet "two thirds of [the school's] students receive some form of financial aid" (https://www.koheletyeshiva.org). As a result of this reality, the minority of families paying the full price of tuition divert a percentage of their tuition dollars into the school's "general scholarship fund to help support other students coming to the school" (Interview with Head of School, Levin, 11/29/21). The rest of the absent tuition dollars are raised by the school annually with Barrack attempting to "raise three million dollars a year that goes towards scholarship payment" (Interview with Head of School, Levin, 11/29/21). Jewish day school's main competitors are not other Jewish day schools, but rather elite private secular schools; Jewish families choosing between a Jewish day school and a private secular school are "nine times out of ten, going to be full paying parents" (Interview with Head of School, Levin, 11/29/21). This trend in American Jewish day schools is widespread. At the Chicago based Bernard Zell Anshe Emet Day School, their "competition is not other Jewish day schools – but other private secular schools" (Interview with Administrator, El-Mofty, 2021).

In addition to providing a competitive secular education, Jewish day schools must front the cost of supporting two additional academic departments (Hebrew and Jewish Studies) and support students financially (because the majority of Jewish day school students are unable to pay full tuition) all while also appearing competitive and as exclusive as the secular private schools in the area. For Jewish day schools , "there is no department as expensive as a Jewish studies department" (Interview with Head of School, Levin, 11/29/21) because there is a "limited market for Jewish studies teachers" (Interview with JF Board Member, Kopelman, 11/30/21) and since "almost everyone is a rabbi, you're paying them at a PhD level" (Interview with Head of School, Levin, 11/29/21). Additionally, in "having a dual curriculum you probably have a third more teachers" (Interview with Head of School, Levin, 11/29/21) in comparison to secular schools. Due to this unavoidable financial burden, Jewish day schools must devote a greater percentage of tuition dollars towards faculty salaries than secular schools. Many Jewish day schools also offer intensive Israel-based education such as

trips and full semester study abroad options in Israel. These culturally significant curriculum and experiences are deemed invaluable to a young Jew's education but are also the cause of increased costs associated with attending and maintaining a Jewish day school.

Having fewer students than the average private secular school and thereby less tuition money to rely on, however, results in Jewish day schools turning towards Jewish institutions, donors, and interpersonal relations to subsidize the cost of a Jewish education. From Jack M. Barrack Hebrew Academy's inception, the majority of the school's "funds [came] from tuition and private donations" yet the school still "ran consistently over budget and school leaders often contributed their own money" (Zakai, 2013, 290) in order to subsidize the cost of maintaining the institution. This reliance on deeply "intimate social transactions" (Zelizer, 2005) was clearly unsustainable-within a few years the school had "been admitted as a constituent of the Allied Jewish Appeal - a Jewish fundraising organization that in 1957 merged with the Federation of Jewish Charities (now known as the Jewish Federation)" (Zakai, 2013, 293) and began heavily relying on institutionalized financial support.

Process of Redistributing Communal Wealth

The conversion of money into culture is produced through interwoven partnerships between the Jewish Federation, Jewish day schools, donors, and Jewish philanthropies that work together in order to achieve Jewish continuity through a community wide redistribution of wealth. Every Jewish community in North America is supported by a local Jewish Federation, which is a branch of the umbrella organization, Jewish Federation of North America. The Jewish Federation gains its money from "the local community," (Interview with JF Board Member, Kopelman, 11/30/21) donations, and governmental grants; those funds are then allocated to agencies of the Jewish Federation (Jewish day schools, food pantries, nursing homes, etc.) through an annual process of monetary redistribution. The Jewish Federation "is almost like a bank that redistributes funds to the Jewish community" (Interview with JF Board Member, Kopelman, 11/30/21) and is able to effectively invest its resources back into the community because the "Federation can look at the Jewish community from 30,00 feet…by supporting Jewish Federation we are tapped into Jewish needs in a way that I wouldn't know as an individual" (Interview with JF Board Member, Kopelman, 11/30/21). The Jewish Federations of North America raises and distributes "more than $3 billion annually and through planned giving and endowment programs to support social welfare, social services and educational needs" (jewishfederations.org). Initially the Jewish Federation provided community resources itself, but now the organization's primary role is to fundraise and allocate resources to their agencies that provide programs and services for the Jewish community. In order to most effectively distribute resources, the Jewish Federation engages in and produces a bureaucratized moral economy in which board members decide how much money

each agency of the Jewish Federation should receive based on evaluating the productiveness and general good each agency provides for the community. Each year a community's local Jewish Federations' Allocations Committee meets to decide where the collected resources should be distributed based on data collected from the Jewish Federation's Grants Committee.

Jewish day schools throughout the country form relationships of mutual indebtedness and reciprocity with the Jewish Federation through continuous economic and social transactions. By financing Jewish day schools, the Jewish Federation invests in the community and in the next generation of Jewish leaders because "strong Jewish day schools bring strong Jewish people to the community" (Interview with JF Board Member, Kopelman, 11/30/21). The Jewish Federation is further incentivized to continue investing in Jewish day schools because within Jewish Federation leadership, there is "an overrepresentation of Jews that had a formal Jewish education growing up in camps or Jewish day schools" (Interview with JF Board Member, Kopelman, 11/30/21). The strong correlation between Jewish day school education and future communal involvement highlights that the product being purchased from a Jewish day school, Jewish Cultural Capital, is a valuable resource that aids in the reproduction of Jewish continuity from a community perspective. In the 2015-2016 fiscal year, "73 Federations invested $52.3 million in 301 Jewish day schools" (Federation Jewish Day Schools Funding Models, 2018) and on average, Federations allocated "16% of their total local funding to day schools" (Jewish Federation Day Schools Funding Models, 2018) every year. The majority of Jewish Federations, including the Jewish Federation of Philadelphia, employ the "per capita model, a formula to set up how much money each Jewish day school is allocated" (Interview with JF Board Member, Kopelman, 11/30/21) based on the number of students and age of students attending a school. The more students a school has, and the older those students are, results in a larger amount of money a school is allocated. This substantial investment in Jewish day schools indicates that Jewish education is essential to the Jewish community's goals.

Though the Jewish Federation of Philadelphia is especially involved in the production of Jewish Cultural Capital through Jewish day school funding and support, the relationship is fragile and complex due to a history of debt and disagreement over the allocation of money. In Philadelphia, the Jewish Federation serves as both "landlord" and "bank" (Interview with JF Board Member, Kopelman, 11/30/21) to three of the area's Jewish day schools. Originally, the Jack M. Barrack Hebrew Academy was located on the border between Philadelphia and its western suburbs. In 2007, the Jewish Federation of Philadelphia bought a campus space farther west of the city because the "Federation envisioned that the Jewish population would be moving to the west… [because they] knew that wealthy people were moving that way" (Interview with Head of School, Levin, 11/29/21) and the Feder-

ation wanted to ensure that full tuition paying families would continue sending their children to Barrack. The Jewish Federation bought a campus for "34 million dollars" (Interview with Head of School, Levin, 11/29/21) and asked their constituent agent, Barrack, to move into that space and pay the Jewish Federation for the building's rent. Barrack has not yet "paid down the principal" (Interview with Head of School, Levin, 11/29/21) and still owes the Federation several millions of dollars. As a result of this position of indebtedness, there is an element of "friction" (Interview with Head of School, Levin, 11/29/21) between the Jewish Federation of Philadelphia and Barrack. Though the Jewish Federation recognizes that Jewish day school education produces engaged community members, in recent years, the Federation has "lowered the amount of money that they give per student" (Interview with JF Board Member, Kopelman, 11/30/21) because "many who sit on Federation boards give higher priority to social-service agencies or Jewish community centers" (Wertheimer, 2010) over Jewish day schools. Jewish day schools argue that the Federation should "look at the students that we are turning out" and the Federation responds by acknowledging that they "are not arguing [against a Jewish day school's] product, but [that] product is serving too few students" (Interview with Head of School, Levin, 11/29/21). Jewish Federations must balance conflicting priorities in order to promote the growth of the Jewish community at large. Though Jewish day schools are producing a valuable product, they serve only a small portion of the community, and the Federation recognizes that funds directed elsewhere may have a larger immediate impact.

Jewish day schools forge relationships of reciprocity with Jewish philanthropies and donors and promote government sponsored tax incentive programs in order to offset the cost of school maintenance and tuition. In recent years, the Jack M. Barrack Hebrew Academy has created a relationship of reciprocity with the Jewish National Fund, a Jewish philanthropy that raises funds for Jewish education and development in Israel. The philanthropy also owns AMHSI (Alexander Muss High School in Israel), the Israeli boarding school that many Jewish day schools (including Barrack) send their students to for a semester of high school. Several of Barrack's major donors created an endowment to subsidize the cost of a Barrack student's tuition to AMHSI. Each donor has "given a couple of million dollars. The other million has been raised by Barrack in gifts" (Interview with Head of School, Levin, 11/29/21) and as "Barrack raises funds within their networks" the Jewish National Fund has agreed to "match dollar for dollar any money that's raised and put that into endowment" (Interview with JNF Fundraiser, Pellish, 11/2/21) through money that has been raised from the Jewish National Fund's "general donation pool" (Interview with JNF Fundraiser, Pellish, 11/2/21). Through this relationship of reciprocity, Barrack, individual donors, and the Jewish National Fund promote their shared goal of enhancing Jewish continuity through education.

In order to incentivize donations, Jewish day schools and philanthropies market their fundraising by highlighting the tax incentives associated with donations and by promoting voucher programs to potential donors. The Jewish National fund "fundraises through outreach and engaging alumni" and by emphasizing to potential donors that "donating towards AMHSI counts towards tax benefits" (Interview with JNF Fundraiser, Pellish, 11/2/21). On the Jewish National Fund's website, it advertises to potential donors that they can "Save on your Taxes by Donating Crypto" because "donating cryptocurrency directly to a 501c3 nonprofit is more tax efficient and can save you money" (https://thegivingblock.com/donate/Jewish-National-Fund/). The Jewish National Fund promotes philanthropy by capitalizing on the tax incentives that allow donors to "deduct more on [their] tax return" (https://thegivingblock.com/donate/Jewish-National-Fund/). This conceptualization of donor relations is completely economized and is marketed as a logical economic transaction rather than an altruistic charitable donation. While philanthropies promote tax incentives through donating via cryptocurrency, Jewish day schools in Pennsylvania highlight EITC, a state tax program, to their prospective donors. The Earned Income Tax Credit (EITC) is Pennsylvania's approach to vouchers and works by allowing an individual or organization that paid over $15,000 or more state taxes to designate a portion of their state taxes towards a private educational institution, thereby allowing a donor to "almost painlessly give, by directing their state taxes, which they're going to have to pay anyway, to the institution that they really love" (Interview with Head of School, Levin, 11/29/21). The Jewish Federation, along with individuals and local businesses, support Pennsylvania's Jewish day schools by directing a portion of their state taxes towards EITC. This controversial policy "is perfectly legal" but one donor/board member of the Jewish Federation of Philadelphia feels that "it's somewhat immoral, instead of helping the state it goes to Jewish day schools but since it's legal [she] contribute[s]" (Interview with JF Board Member, Kopelman, 11/30/21) her state taxes towards Jewish day schools through EITC. Though it is recognized that donating through EITC is not the most "moral" route to supporting Jewish day schools, the opportunity is there and donors take advantage of it. Through these strategic and self-serving charitable mechanisms, Jewish day schools and all other private educational institutions are able to capitalize on their donors' financial motivations.

Conclusion

Jewish day schools serve the Jewish community by producing Jewish Cultural Capital and instilling this valuable product into their students, thereby producing a strong Jewish community that will remain culturally and religiously engaged with Judaism. A school's tuition symbolizes the value of the product being purchased, and even though the majority of Jewish day school students are on financial aid, elite Jewish day schools set higher tuitions than other religious schools

because it signals to prospective parents that an education attained at that institution is comparable to the product being purchased from an elite secular institution. Because of the resulting inaccessibility of this education and general school maintenance, however, Jewish day schools throughout the country rely heavily on financial support from their local Jewish Federation, individual donors, other Jewish philanthropies, and government issued tax incentives. Jewish Federation and other Jewish philanthropies/philanthropists choose to invest in Jewish day school education and create relationships of reciprocity because Jewish day schools create strong Jewish communities, educated Jewish leaders, and reproduce Jewish practice which all contributes to Jewish continuity, but there is also an observed shift in priorities amongst some Federation leaders who prioritize social and community engagement over the education.

About the Author: Samantha Becker

I got involved in my research through participating in the ANT 305, Advanced Seminars course. I chose to analyze the moral economy and web of social connections and financial transactions that work to support Jewish education.

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Featured in This Issue

The Gendering of Harmful Magic: The Process of Gendered Differences in Witchcraft, *Kirsten Bell '24*
Michael D. Bailey's innovative article "The Feminization of Magic and the Emerging Idea of the Female Witch in the Late Middle Ages" illustrates a feminization process that he claims culminated in the fifteenth century. However, magic as a whole was not just feminized, but gendered, which can be seen from sources as early as the ninth or tenth centuries. In this article, I demonstrate how this process actually started much earlier through analyzing sources from the ninth to the fifteenth century. Understanding the evolution of this phenomenon may help remove societal biases surrounding women and witchcraft, empower artists to make more conscious decisions, and can perhaps help propel us toward a more equal and unbiased society.

Data movement distance: An ordinal evaluation metric, *Aidan Goldfarb '22*
With the death of Moore's law, data movement has become the performance bottleneck of much large scale computation. However, the fine grained cost of data movement is lost in traditional algorithm analysis. Asymptotic function notation relates input size to the number of memory accesses, but does not account for the varying cost of individual memory accesses. We propose and evaluate a new, portable, ordinal, memory-centric metric, data movement distance (DMD), for program data movement evaluation. The saliency and extensibility of DMD is explored in the form of benchmarks and compiler additions.

Predicting Contraceptive Method Choice of Women Based on Demographic & Socio-Economic Characteristics, *Jose Luna Jr. '23*
The purpose of this paper is to predict the contraceptive method use of women based on socio-economic and demographic characteristics. The probability of women choosing to use contraceptives (i.e. no-use, long-term, short-term) given the predictor variables were found by interpreting the Baseline-Categorical Logit Model using log odds. By using standardized residuals, the data found that women who have two to three children were more likely to use contraceptives long-term (stdres = 4.2) whereas women with zero to one children were less likely to use contraceptives long-term (stdres = -8.03).

The Purchase of Virtue: The Commodification of Altruism in the Voluntourism Industry, *Julia Bergel '22*
Volunteer tourism is becoming one of the most profitable sectors of the tourism market, with an estimated worth of over 2.5 billion dollars every year. The ability of wealthy westerners to buy experiences of "helping" others while using the communities they are volunteering in as props in their facade of virtue is a direct consequence of commodifying something that is a human value. This paper explores the ways that the voluntourism industry allows for the purchase of virtue, among other criticisms, through previous scholarship, an interview, and a case study of a volunteer tourism company's website.

Color Polymorphism and Its Effects on the Substrate Preference of European Green Crabs (Carcinus maenas), *Regan Collins '23*
Crypsis, commonly known as camouflage, is a defense tactic against visual predators that relies on the morphological and physiological traits of prey organisms to avoid detection by blending into their environment. The primary goal of this study was to determine if the European green crab (C. maenas) will prefer a substrate that closely matches its polymorphic color pattern when given the choice between light and dark substrate in order to increase crypsis and avoid visual predation. Individual crabs (n=20) were photographed and caught in their natural environment to observe their substrate preference. It was found that though the crabs had little substrate preference when rock cover was available, when rock cover was removed, the majority of C. maenas (>80%) preferred the darker substrate regardless of carapace color (p<.01). This result highlights the interplay of both the behavioral and morphological components of crypsis as an anti-predator defense.

Olfactory Cues Guide Mate Search in Meloe blister beetles, *Atalanta C. Ritter & Federico Sanchez Vargas '21*
Reproductive success is the key to evolutionary success. As a result, organisms employ a wide repertoire of sensory mechanisms to find mates, but many of these mechanisms remain understudied. Such an organism is M. americanus, a local species of blister beetle, with a fascinating and complex life cycle. For this project, we investigated whether male beetles rely on olfactory or visual cues to find females. We found that they use olfactory cues to do so, a reasonable adaptation considering the physiology and ecology of these beetles.

Commodifying Jewish Culture and Identity, *Samantha Becker '23*
Though a connection to one's Jewish identity in Diaspora is perceived and internalized by the International Jewish community as "priceless" and essential to the continuation of Judaism, many Jews are denied access to Jewish education due to financial inabilities. How does the Jewish world ensure that the next generation of Jewish students remains religiously, ethnically, and culturally tied to Judaism when obtaining that education is economically exclusive? What is the value of a private education and how does it differ from a Jewish education? How do established Jewish institutions collaborate in order to maintain a Diasporic Jewish community?

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