VOLUME 17

Lucerna

UNDERGRADUATE RESEARCH JOURNAL

LUCERNA UNDERGRADUATE RESEARCH JOURNAL

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LETTER FROM THE EDITOR

Welcome to the seventeenth volume of *Lucerna*, the undergraduate research journal of the University of Missouri-Kansas City issued annually by the Honors Program. This volume features exemplary student research on topics ranging from notetaking to lactobacilli to language acquisition to xenolith analysis. The contributors and their faculty advisors devoted countless hours of hard work to produce this scholarship. In turn, the student editors, staff, graphic designers, and faculty advisors of *Lucerna* have spent a year preparing this publication. I have been involved with *Lucerna* since 2020, when I joined the staff as a student reviewer. I then worked as the Managing Editor with Editor-in-Chief Lee Francis (2021), whom I would like to thank for their guidance and patience. I would also like to thank Dr. Henrietta Rix Wood, our invaluable faculty advisor, as well as Dr. Gayle Levy, Honors Program Director, and Margo Gamache, Honors Program Director of Student Affairs for their support in producing *Lucerna* each year.

After confronting the challenges of the COVID-19 pandemic for two years, *Lucerna* has returned to in-person operations. By alternating virtual and in-person staff meetings, we were able to rekindle the excitement that research and its publication brings to the staff and student community. The *Lucerna* Symposium was held in-person on March 23, 2023, for the first time since 2020 and offered engaging presentations from our authors and an insightful question and answer session. Authors, mentors, and guests networked and discussed the exciting research presented this year.

This year, we completed some exciting projects and started new ones. *Lucerna* created its second promotional video, a professional production used for marketing and helping people learn about the journal. I'd like to thank Christian Dang and Tinh Nim for showcasing their research in the video and for their extensive efforts as veteran *Lucerna* staff members. I'd also like to thank Marisa McKay for restarting our in-person marketing with vigor, hosting tabling events in the library and encouraging student researchers at various events to submit their work to *Lucerna*. Finally, I'd like to thank Professor Zach Frazier and the talented students of the Ether design lab for *Lucerna*'s beautiful cover design and layout.

In addition to returning to face-to-face operations, we also made exciting changes in *Lucerna* this year. We organized the contents of the

journal according to three disciplines: Humanities, Social Sciences, and Science, Technology, Engineering, and Math (STEM). I am excited about this new categorization, as it will allow *Lucerna* to encourage students in all undergraduate programs to submit their research.

Lucerna, as its name suggests, illuminates student research. One of the goals of the journal is to encourage students across UMKC to pursue research. It is their hard work, passion, and dedication that makes this journal possible and signals the commitment and innovation of the next generation of scientists, mathematicians, journalists, geologists, physicians, psychologists, and literary analysts. I wish the contributors of this journal the best in their future endeavors and hope their work encourages us all to pursue and share new knowledge.

Sincerely,
Anuhya Dayal
2022 *Lucerna* Editor-in-Chief

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Editor-in-Chief: Anuhya Dayal

Anuhya Dayal (she/her) is a third-year student in the six-year BA/MD program, majoring in biology. Her medical research focuses on potential crosstalk mechanisms between bone and heart tissue. Anuhya joined *Lucerna* as a student reviewer in 2020. Her article, "From MMR to COVID-19: A Study of Vaccination Perception Over Time and the Modern Effects of Social Media," was published in *Lucerna* Volume 16. She has also published an article about the effects of MRI imaging techniques and field strength on image resolution in the *Journal of Neurology, Neurological Sciences and Disorders*. Anuhya will next enter a residency program and become a physician cardiologist, oncologist, or radiologist.

Managing Editor: Lauren Ferguson

Lauren Ferguson (she/her) is a junior majoring in environmental studies and Spanish. This is Lauren's first year with *Lucerna*, and she also is involved in other organizations on campus. After graduation, she is interested in working on environmental policy.

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SOCIAL SCIENCES

CO-SLEEPING VS. CRY-IT-OUT SLEEP TRAINING METHODS IN CONJUNCTION WITH ATTACHMENT STYLE AND EMOTIONAL REGULATION

Jessica L. Wise

The practice of co-sleeping has received a lot of media attention in the past few decades. Some people claim it is dangerous for the infant, can inhibit the infant's ability to self-soothe, or is otherwise "coddling" the baby. However, in many non-western cultures, co-sleeping is the norm. In the end, it is up to the parents to decide what works best for their family. When the parent's main goal is to form a secure attachment with their child and promote healthy emotional regulation, co-sleeping may be a better choice than the "cry-it-out" method. Dan Siegel, a clinical professor of psychiatry, has written several books on attachment, consciousness, and emotion theories. When applying Siegel's attachment model from *The Developing Mind: How Relationships and the Brain Interact to Shape Whoe We Are* to the cry-it-out and co-sleeping methods of sleep training, the co-sleeping method is associated with a more secure parent-infant attachment and better long-term emotional regulation ability.

INTEGRATION

Siegel (2020) discusses the term "integration" extensively. Integration is the connection between separate parts of a system. This connection is seen within every system, regardless of being embodied or relational (Siegel, 2020). "Embodied" and "relational" mean that there is integration within people and between people, respectively. Examples of embodied systems are emotional regulation systems and hormone levels. The primary example of a relational system is the infant-parent relationship, which breeds attachment style and the external methods of emotional regulation. A well-integrated system has many strong linkages between parts, and each part responds to one another. This integration leads to a healthier system and promotes growth. Poorly integrated systems will result in rigidity or chaos; the

parts are disorganized and not working productively with one another.

ATTACHMENT

Siegel (2020) defines attachment as "an inborn system" that influences and organizes "motivational, emotional, and memory processes with respect to significant caregiving figures." This system is what motivates babies to "seek proximity to parents" and "establish communication" (Siegel, 2020, p. 167). These behaviors allow babies to respond to their caregivers for their basic needs, such as protection, food, and hygiene. Attachments are extremely important for infants as they are completely dependent on the care of their parents or other guardians. This reliance includes the mental and physical stimulation required for healthy brain development at this volatile stage in life. Early attachment relationships have been "associated with characteristic processes of emotional regulation, social relatedness, access to autobiographical memory, and the development of self-reflection and narrative," according to Siegel (2020, p. 167).

Different Attachment Styles

There are multiple infant attachment styles, on a scale from secure to insecure, that can be measured by the organization of the attachment. The most important focus for the topic of sleep training is whether an attachment is secure or insecure rather than whether the attachment style is the "Strange Situation." This is a test in which an infant in a laboratory playroom with toys. The mother or other caregiver plays with the infant for a little while to get the infant comfortable with the room, then leaves the room. The caregiver later comes back into the room. The infant's attachment style is determined by their reaction to their caregiver leaving and their reaction to the caregiver returning. A secure attachment will lead a child to "seek proximity" from the caregiver but "quickly return to play" when the caregiver leaves (Siegel, 2020, p. 177). A child with secure attachment will also seek proximity when the caregiver returns but will not be overwhelmed by stress at either instance. Insecurely attached children will have elevated stress levels, whether externally visible or not, and will either not return to play because of preoccupation with the caregiver's absence or will not seek proximity with the caregiver at all. There are different attach-

ment styles under insecure attachment, but they are not relevant to the topic.

Affect Attunement

An important part of creating a secure parent-infant attachment is what Siegel refers to as "affect attunement." This attachment is described as the alignment of two separate mental states (Siegel, 2020). Affect attunement is nonverbal and generally shows that one person has a presence in another's mind, and each person's state of being affects the other: "feeling felt" (Siegel, 2020). This response happens when someone is sensitive to emotional signals from another person. In a parent-infant relationship, the parent needs to be responsive and sensitive to the infant's signals to communicate their needs, i.e., crying, yawning, attitude shifts, etc. This parental responsiveness will strengthen the connection and level of emotional communication between parent and infant (Siegel, 2020). Regarding relational emotional regulation, affect attunement is the key behavior that must be present in a parent-infant relationship. Since infants are not born with regulatory capacities, this responsiveness from a parent to regulate their emotions will give them practice with and understanding of emotional regulation, which will lead them to do it on their own in the future.

EMOTIONAL REGULATION

Parents model behavior. When a parent models emotional regulation for themselves or regulates the emotions of an infant, the infant learns to emotionally regulate for themselves, even if slowly. The parent also becomes a "safe haven" for the child as the parent continuously soothes the strong negative emotions that the infant may feel. Siegel notes these "repeated experiences become encoded in implicit memory as expectations and then as mental models or schemata of attachment," (2020, p. 167). Consequently, if the child continuously has these positive experiences with the parent, they will see them as the "secure" place to go when they are upset and learn the behavior of self-soothing. Siegel contends that an infant "uses an attachment figure's states of mind to help organize the functioning of its own states" (2020, p. 171). Without this modeling, it is difficult for infants to learn how to manage their emotions and trust their parents to be consistent and positive.

CO-SLEEPING

Positive Aspects

Elaine S. Barry explains "co-sleeping occurs when the mother-infant dyad shares the same sleeping surface with body contact for part or all of the night." One of the primary arguments against co-sleeping is that it puts infants at a higher risk of Sudden Infant Death Syndrome (SIDS) and suffocation. However, these risks are avoidable with proper co-sleeping practice. As will be discussed, co-sleeping also allows for much more awareness of the child's status throughout the night, which can help prevent serious health problems or death. Another common argument against co-sleeping is the worry that children will not learn to self-soothe, but his also is not the case. Co-sleeping infants tend to have "more robust sleep-wake rhythms at 1-3 months" than solitary sleepers, Barry notes (2019, N.PAG.). This aspect will be discussed in further detail below.

Attachment

Regardless of co-sleeping status, Barry contends mothers who pick up and soothe "their year-old old [sic] infants upon waking and fussing/crying/signaling during the night had infants who were much more likely to be classified as securely attached" (2019, N.PAG.). This result has a lot to do with affect attunement. When mothers are very emotionally responsive to their children consistently, the children have a better chance of forming a more secure attachment. When this responsivity is inconsistent, especially between day and night, infants may be more likely to lose trust that their parents will take care of them, hindering their abilities to learn how to regulate their emotions. Infants are not born with a circadian rhythm , so inconsistency in responsiveness and sensitivity from parents will likely be confusing and negatively affect the attachment relationship (Barry, 2019).

PROXIMITY SEEKING

Siegel observes "activation of the attachment system involves the seeking of physical proximity, which allows the infant to be protected from harm, starvation, unfavorable temperature changes, disasters, attacks from others, and separation from the group" (2020, P. 168). The level of physical proximity to caregivers that an infant seeks is one of the main

determinants of their attachment style. Barry maintains infants require proximity and physical contact for "normal physiological, socio-emotional, and cognitive development" (2019, N.PAG.). The main thing that co-sleeping provides is extended proximity between caregiver and infant. This proximity provides sensory input, which stimulates the infant's developing mind (Barry, 2019). Co-sleeping, Barry opines, provides "gentle, constant stimulation and proximity to the mother," which "is experience-expectant for the human infant and its developing brain" (2019, N.PAG.). Co-sleeping gives the infant near-constant responsiveness from the mother.

AFFECT ATTUNEMENT

Because of the physical proximity involved with co-sleeping, Barry reports mothers have "physiological synchrony in respiratory regulation, sleep-wake cycles, temperature regulation, and heart rate" of their infants (2019, N.PAG.). They feel small movements and are quick to respond when the infant wakes up crying. Co-sleeping parents checked on their infants "almost three times more per night," which gives more opportunities to respond to their infants' emotions (Barry, 2019). Barry explains this increased awareness of infant signals allows parents "to monitor, detect, and respond to life-threatening situations" (2019, N.PAG.). The proximity and attunement during co-sleeping means infant needs like hygiene and feeding are met more quickly as well. It is much more noticeable to parents when a diaper needs to be changed right next to them rather than down the hall from them. This awareness prevents the baby from discomfort and getting upset. Many people also choose to co-sleep because it makes breastfeeding more efficient (Barry, 2019). Breastfeeding mothers are more likely to co-sleep, and co-sleeping mothers are more likely to breastfeed for this reason. This proximity allows the mother and infant to lose less sleep by giving the infant access to breasts all night (Barry, 2019).

EMOTIONAL REGULATION

Parents who are attuned and sensitive to their infant's signals will form more secure attachments, and the infants will be better at regulating their emotions, particularly stress (Barry, 2019). Infants rely on their parents to regulate their cortisol (stress) levels and eventually learn to regulate them-

selves (Barry, 2019). The increased attunement achieved with co-sleeping will continuously regulate their cortisol levels. Barry observes around the age of "12 months, while behavioral responses to mild stressors remain similar (e.g., crying), securely attached children do not show cortisol increases to mild stressors while in the presence of their caregiver, while insecurely attached children show increased cortisol to these stressors" (2019, p. 6). The emotional regulation of children with secure attachments is superior to children with insecure attachments. Since co-sleeping may increase the likelihood of a secure attachment, it is also linked to improved emotional regulation. It has been shown that "infants with a history of co-sleeping (defined as bedsharing or room sharing) had less cortisol reactivity in the Strange Situation than solitary-sleeping infants" and "there is evidence that infants' normal stress response is developed through continuous mother-child contact during infancy," Barry writes (2019, p. 7). Maternal skin-to-skin contact (SSC) can balance the stress levels of newborns by lowering cortisol (Barry, 2019). According to Barry (2019),

> Early maternal responsiveness and interaction with human infants was related to male children's hormonal stress response two decades later, showing long-term changes in HPA-axis reactivity to an acute stressor. Specifically, their HPA-axis response was higher than solitary sleepers, demonstrating a more adaptive response to the serious stressor.

This finding shows that long-term emotional regulation and self-soothing are actually improved by co-sleeping, contrary to popular belief. Breastfeeding has an even greater ability to lower cortisol. General emotional availability was also important for lowering cortisol. These two items are amplified by co-sleeping, which shows that co-sleeping strongly correlates with affect attunement, attachment style, and emotional regulation.

NEGATIVE ASPECTS

In a study, "Sleep Arrangements, Parent-Infant Sleep during the First Year, and Family Functioning," by D.M. Teti et al. (2016) in the Journal of Developmental Psychology, their research started from the

idea that "persistent co-sleeping in cultures in which solitary sleep is the norm by the end of the infants' first year has been associated with family dysfunction and infant sleep disruption, both of which are predictive of cognitive and social developmental problems in early childhood" (p. 2). This study examined over 100 infants during the course of their first year who co-slept for different amounts of time, slept alone, or were inconsistent between the two. The parents and infants wore devices to track their sleep-wake rhythms, and the parents took marital satisfaction surveys at 1, 3, 6, 9, and 12 months. The parents also had weekly sleep journals to fill out for their infants, estimating how many times they woke up. In addition, t cameras were placed in the nursery to score emotional availability at bedtime, primarily of the mothers (Teti et al., 2016).

The results of this study did not reveal much new information about infant sleep patterns; however, they showed how the synchronization of mother-infant sleep patterns might negatively affect the mother. For mothers who co-slept after 6 months, this was especially true, as they lost the most sleep. It may have been for other reasons, but there is room to speculate on the association between a mother's sleep patterns, marital satisfaction, and emotional availability at bedtime. The mothers who lost more sleep reported lower marital satisfaction and were scored with lower emotional availability, which is a large part of forming secure attachments (Teti et al., 2016). If sleep deprivation and lack of cultural support for co-sleeping may affect the mother's behavior in this way, it is something to be aware of. However, this is not a causal relationship and does not seem to outweigh the benefits of co-sleeping.

SOLITARY SLEEPING: "CRY-IT-OUT"

Positive Aspects

Judy Beal (2017) defines the "cry-it-out" method as "a process whereby parents put their infant to sleep and then ignore their crying." There are two methods: the extinction method and the gradual extinction method (Beal, 2017). The extinction method ignores crying, and the gradual extinction method weans infants from parental responsiveness over time. This method is related to co-sleeping because it involves sleep training and responsiveness of parents, although it is not specific to night-time sleeping.

Gradual Extinction Method

The gradual extinction method has been shown to decrease "sleep latency, number of awakenings, and waking after sleep onset," according to Judy Beal in "Cry it Out: What is it and is it appropriate?" in the American Journal of Maternal/Child Nursing (2017). This method entails the parent entering the room when they hear crying, comforting the child, but not picking the child up or turning on the lights; they would then slowly decrease the number of times they respond until they stop completely (Beal, 2017). This would give parents better sleep, potentially decreasing their stress and increasing their emotional availability throughout the day. Using the graduated extinction method, the comfort is slowly weaned from the baby rather than a total inconsistency from previous responsiveness. One could argue that this weaning is sufficient to model emotional regulation in a way that the baby can replicate. If this occurs after 3-6 months of co-sleeping, it may be a sound way to transition to solitary sleeping for infants. However, when moving immediately to solitary sleeping from the hospital or brief room-sharing, infants may lack sensory stimulation.

Negative Aspects

According to Barry (2019, n.pag.), "solitary sleeping might even be considered a deprived sensory environment lacking the mutual exchanges that characterized the co-sleeping environment (and infant neurodevelopment) throughout human evolution." Circadian rhythms are not developed until infants are 3-4 months old, so if parents using the cry-it-out method are responsive in the daytime and unresponsive at night, it will feel confusing for the child (Barry, 2019). The main point that diminishes the effectiveness of the cry-it-out method comes from the observation of cortisol levels. While the cry-it-out method may reduce the crying behavior, infants still have much higher cortisol levels while sleeping than co-sleepers (Barry, 2019). Co-sleeping children have lower average baseline cortisol levels than solitary sleepers when separated from their parents at daycare (Barry, 2019). Solitary sleepers are more likely to be insecurely attached to their caregivers (Barry, 2019). This makes sense because they may receive less responsiveness and sensitivity from their parents, which leads to less external emotional regulation, ultimately leading to an insecure attachment and poor self-regulation.

CONCLUSION

Through increased physical proximity, co-sleeping allows more opportunities for deeper integration between the mental states of mother and infant than solitary sleeping. This increases parent-infant affect attunement by making infant signals more easily detectable and solvable. Affect attunement and emotional sensitivity to the child's needs externally regulate the child's stress. Without this, children will not learn effective ways to manage stress and likely be worse at self-regulation than solitary sleeping infants. These results directly contrast to the opposition claims that infants are "coddled" by co-sleeping and will not learn to self-soothe. The possible downfall of co-sleeping is the loss of sleep from the mother. However, if the purpose of parenting is their child's happiness and secure attachment formation, this sleep loss may not overshadow the need for the responsiveness of co-sleeping. Cry-it-out may be a method used after emotional regulation habits have been established, but it will not be effective in creating those regulation habits in the first place. Although it may decrease crying, there is still a high level of cortisol being produced, which is bad for the infant's brain development and shows the negative effect towards emotional regulation. It depends on the individual parent's goals, but emotional regulation and secure attachment can easily be listed as requirements for the "happy" and mentally "healthy" child. Overall, using affect attunement and emotional regulation to predict the likelihood of secure attachment, co-sleeping improves an infant's chance of being securely attached to their caregiver.

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STEM

XENOLITH STRUCTURES IN WELDED BASALT AGGLUTINATE ASSOCIATED WITH DOTSERO CRATER, COLORADO

Kyle C. Broley

ABSTRACT

The Dotsero maar volcanic crater formed through phreatomagmatic (interactions of lava with wet, unconsolidated sediment) and magmatic processes around 4,150 ± 300 years before present (B.P.) which erupted through sections of Pennsylvanian age sedimentary deposits. The field observations of the eruptive material showed various xenolith structures, or foreign rock fragments within the cooled magmatic material, which can be categorized into four specific groups based on the mineral grain size of the sediments and subtle color variation. The fieldwork focused on three sites located downslope from the southern crater rim of the Dotsero maar, accounting for all xenoliths ≥ 1 cm in size in selected agglutinate clasts and gathering samples of the localized surface sediments and xenolith structures. The surficial sediment samples and two groups of xenolith structures were examined through X-ray powder diffraction laboratory analyses. The results of this analysis demonstrate that field classifications of xenolith structures continue to be the most accurate form of identification and present grounds for further analyses through scanning electron microscopy (SEM) and thin section observations for differentiation and determination of thermal alterations created by the lava and sediment interactions.

KEYWORDS

Dotsero Crater, Volcanology, Maar-diatreme, Xenoliths, Lava/sediment interactions, X-ray powder diffraction

INTRODUCTION

The Dotsero maar volcano is one of the youngest volcanoes which formed far from a plate boundary in the United States and produced deposits of both magmatic and phreatomagmatic origin during its eruption event

Figure 1 - Elevation map displaying the region south of the Dotsero crater rim, highlighting the focus area of this study. The map was Generated in ArcGIS through the utilization of LiDAR data sets acquired from the United States Geological Survey (USGS).

4,150 ± 300 years B.P. (Sweeney et al. 2018). The combination of eruptive activity resulted in a 700 x 400-meter crater to form near the top of Blowout Hill in what is now Dotsero, Colorado, creating volcanic deposits of dense basaltic eruptive material, or welded agglutinate spatter, along the crater rim and the southern slope of Blowout Hill and a lava flow which filled a portion of the Eagle River valley. (Geologic and technologic terminology defined in Appendix A.) The crater cuts through and the eruptive deposits overlie evaporite, lithified sandstones of Pennsylvanian age (323 – 299 Ma.) (Leat et al. 1989). The petrography of these eruptive deposits displays a dominant phenocryst phase euhedral clinopyroxenes with plagioclase oxides and fresh olivine with an abundant cm-sized alkali feldspar-dominated xenocrysts showing partial melting textures (Leat et al. 1989).

Throughout the various welded basalt agglutinate deposits and spatter, xenolithic structures, or fragmented pieces of the local rock within the eruptive material, of the surrounding sediment layers are visibly present. While detailed geochemical and mineralogical analyses have been conducted on the eruptive material located at Dotsero, the xenolith structures and the impacts of the lava and sediment interactions have not been researched. This study provides a baseline into the identification of the specific xenolith clasts found downslope, south of the crater rim, to better understand the thermal interactions which occurred to the host sediments at the time of the Dotsero Holocene eruption. The questions to be answered: can X-ray Powder Diffraction reveal enough information to better categorize and identify any thermal alterations in the xenoliths found around Dotsero? If not, what types of future analyses are needed to examine the impacts of the lava and sediment interactions at the Dotsero maar volcano? Through the utilization of X-ray powder diffraction, for a deeper analysis of the Dotsero maar samples to both identify and understand the types of interactions that occurred at the time of the eruption is justified.

Geologic Setting

The crater rim of the Dotsero maar volcano sits 800 feet above the floor of the Eagle River Valley. The eruption occurred through a well-characterized suite of Pennsylvanian (323 – 299 Ma.) sedimentary rocks, primarily the Maroon Formation, the Eagle Valley Formation, and the Eagle Valley Evaporite Formation (Sweeney et al. 2018). Additionally,

the Minturn Formation occurs below the surficial deposits of this region and is visibly present as a xenolith within the welded agglutinate located across all three sites. The Maroon Formation, which is arkosic and very micaceous, consists of red beds of sandstone, siltstone, mudstone, a few thin beds of grey limestone, and some beds of conglomerate (Streufert et al. 2009). The Eagle Valley Formation is considered a transitional boundary between the Maroon Formation and the Eagle Valley Evaporite Formation and consists of interbedded, reddish-brown, gray, reddish-gray, and tan siltstone; shale; sandstone; gypsum; gypsiferous siltstone and sandstone; and carbonate rocks (Streufert et al. 2009). The Eagle Valley Evaporite Formation consists of a sequence of evaporitic rocks consisting mainly of gypsum, anhydrite, and halite, interbedded with light-colored, fine-grained clastic rocks and thin carbonate beds (Streufert et al. 2009). The Minturn Formation consists of a tan-to-brown lithic wacke, tan to reddish-brown, lithic subarkose, tan-to-brown medium-to-coarse-grained sandstone and lithic sandstone, and silty sandstone (Streufert et al. 2009).

Local Stratigraphy	**Description**	**Depth Beneath Crater (m)**
Maroon Formation	Very micaceous, dark-red sandstone; fine grained	0-125
Eagle Valley Formation	Reddish-Gray/Brown-to-tan slitstone and shale; fine-grained	125-475 625-675
Eagle Valley Evaporite	Gypsum, anhydrite, and halite; Fine-grained	475-625 675-750
Minturn Formation	Opaque-to-tan lithic structures; coarse-grained	750-1000
Quartz	Clear to opaque; brittle	greater than 1000

Table 1 - A description of the four major types of sediment layers within the local stratigraphy of the Dotsero maar volcano (Sweeney et al 2018). Sediment layers are listed with the Maroon Formation located at the surface to large, cm-sized quartz presumed to occur in the bedrock.

Upper Quarry

Figure 2. Photo from the southern edge of the Upper Quarry Site looking at the northern slope. Top right of the picture displays the agglutinate overlying the loose, unconsolidated material forming the slope. Down the slope towards the floor, you can see clasts of welded basalt agglutinate (Photo by author).

The Upper Quarry site consists of a 3.69-acre area located 0.33 kilometers southwest of the southern crater rim. The surrounding area consists of a flat region surrounded by a slope and is coved in unconsolidated lapilli tuff that overlies a portion of the Maroon Formation. Fractured pieces of welded basalt agglutinate can be found down the northern slope and the floor of the quarry, as wWell as overlying the top portion of the slope.

Lower Quarry

Figure 3 – Photo of the Lower Quarry Site, showing large quantities of welded basalt agglutinate and bomb clasts which fill the small valley floor. (Photo by author).

The Lower Quarry site consists of a 0.65-acre area located 0.24 kilometers southwest of the Upper Quarry. The lower quarry consists of a small valley of the Eagle Valley Formation covered in unconsolidated lapilli tuff. Variably welded basalt agglutinate overlies the top of the valley slopes and covers a large portion of the valley floor.

Southeastern Slope

Figure 4. Photo taken from the eastern edge of the Southeastern Slope showing a portion of the large are of this site with agglutinate on the right along the roadway and some intermittent clasts on the left. (Photo by author).

The Southeastern (SE) Slope site includes a large, 8.58-acre area located 0.28 kilometers southeast of the Lower Quarry. This site includes a section west of a service road that includes a transitional boundary between the Eagle Valley Evaporite and Eagle Valley Formation. Welded agglutinate spatter is located east of the main road beginning at the base of Blowout Hill along a moderately sloped section of the Eagle Valley Evaporite and the Eagle Valley Formation.

METHODS

Fieldwork

The fieldwork at the Dotsero maar volcano in Colorado examined and identified the impacts on localized host sediment created by the Holocene eruption (4,150 ± 300 years B.P.). During the week of August 1, 2021, three days were spent traversing a 0.41-kilometer squared area east and south of the crater rim at Blowout Hill. The focus area of this study was the selected Upper Quarry, Lower Quarry, and Southeastern Slope sites, based on the abundance of xenolith structures and location of the densely welded basalt agglutinated at these locations.

The field criteria consisted of selecting pieces of the welded agglutinate at each site, taking measurements of the agglutinate clasts, and notating the location through a handheld GPS unit and GPS logged photography. The identification and logging of the total number of xenolith structures within the agglutinate greater than 1 centimeter took place on each selected piece of agglutinate, with the largest xenolith structure within each piece of welded agglutinate clast measured and described as part of the field observations. Samples of the localized host sediment and available xenolith structures across all three sites were collected for laboratory analyses and experimentation as part of the field criteria.

Laboratory Analyses

Samples collected from the Dotsero sites were given a preliminary visual analysis through the utilization of a 40 x 25 mm magnification handlens to determine grain size and coloration patterns to better distinguish the four chosen classifications of the xenolith structures. These four groups were then divided into their respective sites using the acquired GPS points in the field. Given the similar visual sedimentary structure and coloration between the Eagle Valley Evaporite and Eagle Valley Formation samples, the classified Type B – White xenolith clasts were given priority for further analysis to provide more accurate identification of the samples.

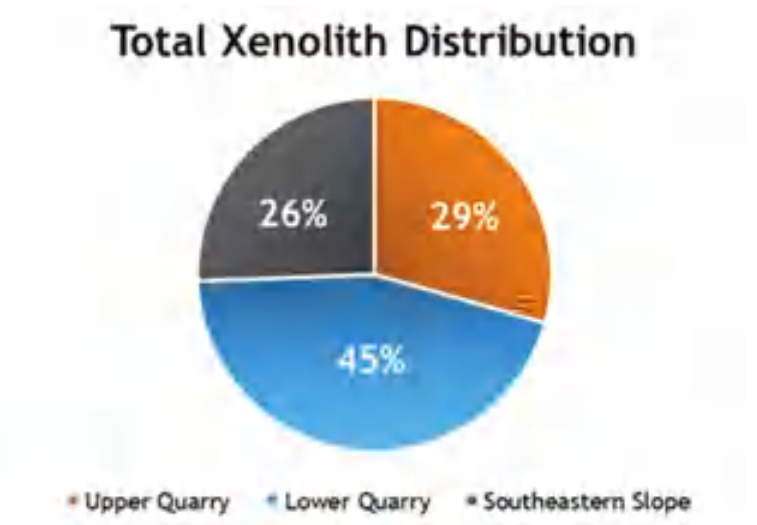
Further laboratory analysis for this phase of the study consisted of the utilization of X-Ray powder diffraction of the three localized sediment samples, the Type B – White xenolith structures, and the Type D – Minturn xenolith structures. Samples were examined at 1 degree per minute utilizing a copper diffraction tube to determine mineral struc-

ture to be used for more accurate differentiation and identification.

FIELD ANALYSIS

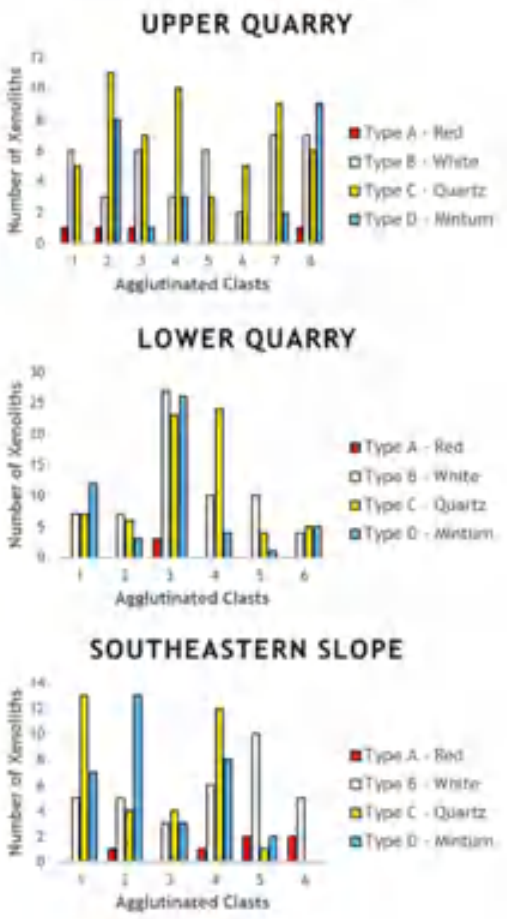
Xenolith Distribution

Twenty welded agglutinate clasts were examined across the three sites with eight located at the Upper Quarry, six located at the Lower Quarry site, and six located along the Southeastern Slope.



Graph 1 - A quantitative analysis displaying the total percentage of xenolith structures, which met the field criteria, distributed across all three sites.

Four samples of surficial host sediment layers were collected, including two samples of the Eagle Valley Evaporite, a sample of the Eagle Valley Formation, and a sample of the Maroon Formation, to be used in comparative analyses in the laboratory. A total of thirteen xenolith samples of all four classified types were collected from all three sites including a sample collected from scoriaceous breccia underneath a portion of the welded basalt agglutinate located at the Southeastern Slope site.



Graphs 2, 3, and 4 - Bar charts displaying the total number of field-classified xenolith structures examined in each piece of welded basalt agglutinate by site. Distribution data correlates with quatitative analysis in Graph 1.

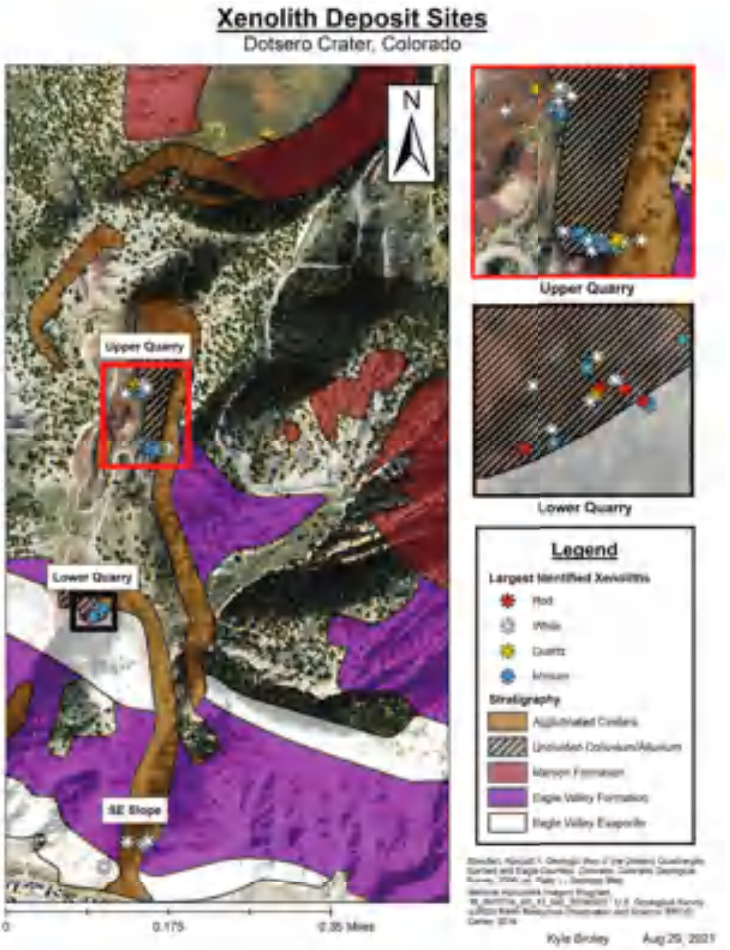


Figure 5 - A field map generated post field analysis displaying the correlating stratigraphic sedimentary layers with the locations of the largest identified type of xenolith at each site.

Type A – Red Classification

The Type A xenolith structures generally consist of a fine-to-medium grained red sandstone with occasional tan-brown banding found within some of the samples. The Type A xenolith samples maintain a general squared-to-elongate shape with a clearly defined margin between the welded agglutinate and sediment structure. Type A – Red accounts for a total of 3.1% of all xenolith structures which met the field criteria across all three sites. Multiple Type A structures can be found within four samples of lithic-rich spatter retrieved from the Lower Quarry site; however, due to the small size of the Type A – Red samples present, not enough could be used for X-Ray powder diffraction. Further analyses, such as thin section observations and scanning electron microscopy, are needed to identify the subtle variations of Type A – Red sediment structure and to detect any thermal alterations that may have occurred during the eruptive processes.

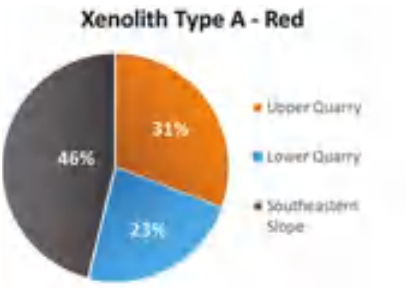


Figure 6 - Scaled photograph of a squared sample of Type A - Red xenolith displaying the tan-to-brown lithic banding.
Graph 5 - Total percentage of the distribution of the Type A - Red xenoliths across all three sites which met the specified field criteria.

Type B – White Classification

The Type B xenolith structures consist of a fine-to-medium grain white sediment that contains occasional dark, grey-to-black banding throughout most of the samples. Small black crystals and pore spaces are visible within the Type B – White xenolith structures through observations taken with a 40 x 25 mm hand lens. The general surficial shape of Type B xenoliths tends

to be rectangular-to-triangular consistently throughout all the collected samples, with clearly defined margins between the agglutinate and the sediment structure. Cutting through selected samples during laboratory analysis preparations revealed that the Type B – White xenoliths lose the identifiable surface shape deeper within the agglutinate clast but maintain the clearly defined margin throughout. Type B – White xenoliths account for 33.3% of all xenolith structures found across all three sites and tended to be larger in size than the other classified xenolith structures. Five samples of Type B were collected across all three sites, and Type B can also be found in the four samples of lithic rich spatter collected from the Lower Quarry site.

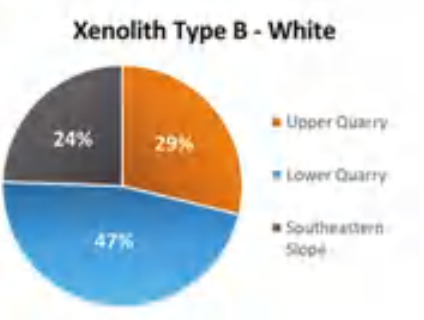


Figure 7 - Scaled photograph of a triangular sample of a Type B - White xenolith with the presence of dark-grey lithic banding.
Graph 6 - Total percentage distribution of the Type B - white xenolith structures across all three site locations which met the specified field criteria.

Type C – Quartz Classification

The Type C xenolith structures consist of a clear, brittle quartz crystal with occasional agglutinated material intermingled within visible void spaces. The general shape of the Type C – Quartz xenoliths tends to be squared-to-rectangular with a clearly defined margin or void between the crystal and the agglutinate. Due to the location of the Type C xenoliths within the welded agglutinate in the field, minimal collection of samples

could be completed with only one full sample and one shattered sample collected from the Upper Quarry site. The Type C – Quartz xenoliths account for 38.1% of all xenoliths recorded across all three sites. Small pieces of quartz are present within the four lithic-rich spatter samples collected form the Lower Quarry site; however, due to the size and limited number of samples, it was determined that additional analyses should be used in the future rather than the X-Ray powder diffraction analysis.

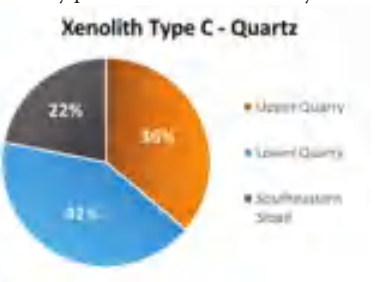


Figure 8 - Scaled photograph of a rectangular Type C - Quartz xenolith with a visible void space near the upper edge of the xenolith and between **sections of the xenolith and the agglutinate.**
Graph 7 - Total distribution percentage of the Type C - Quartz xenolith structures across all three sites which met the specified field criteria.

Type D – Minturn

The Type D xenoliths consist of a medium-to-coarse grained tan and opaque sediments with coarse grained black crystals intermingled throughout the xenolith structure. The general shape of the Type D – Minturn xenoliths tend to be round to oval throughout the samples collected and observations made out in the field. A notable thin, black-to-dark green alteration rind is observed in all the samples collected. The Type D – Minturn xenoliths account for 25.5% of all xenolith structures recorded across all sites. Two samples of the Type – D xenoliths were collected from the Upper Quarry site and one sample was collected from the Lower Quarry site.

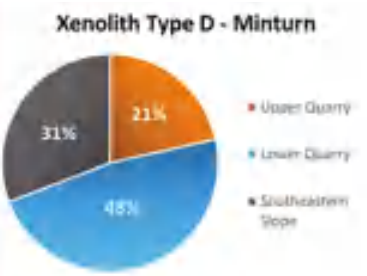


Figure 9 - Scaled photograph of the Type D - Minturn xenolith with an observable alteration rind around the contact margin between the xenolith and agglutinate.

Graph 8 - Total distribution percentage of the Type D - Minturn xenoliths across all three sites that med the specified field criteria.

X-Ray Powder Diffraction

Laboratory analyses of the samples collected from the sites at Dotsero primarily consist of X-ray powder diffraction to identify the mineralogical structure of the selected xenolith samples for better categorization and to detect any thermal alteration present. X-ray diffraction was chosen as the method for analyses of the xenolith and host sediment samples due to its rapid, reliable method for mineral identification (Chen 1977). Utilizing the X-ray diffraction patterns received from each sample, this analysis takes the three strongest reflection peaks from the 2-theta angles and converts this to d-spacing values, comparing the samples collected with specific mineral values for identification. These peak values are then run through a series of indexed, known mineral values to identify the mineral composition of the chosen samples (Chen 1977). This analysis is achieved through the comparison of two powdered sample portions of Type D – Minturn from the Upper Quarry site and one powdered sample portion from the Lower Quarry site, two powdered samples of Type B – White xenolith samples from the Upper Quarry, one powdered sample of Type B – White from the Lower Quarry site, and two powdered samples from the SE Slope site. A small portion of each host sediment sample was powdered and analyzed to create a baseline for determining the origin of the xenolith samples examined. Each sample was run using 1 degree

of rotation per minute from a 0° initial angle position to a final position of 60° in the X-Ray Powder Diffractor, utilizing radiation produced from a copper tube inside to create the d-spacing peak values which then are correlated with indexed mineral patterns used for identification.

Host Sediment Layers

The host sediment samples used for the X-Ray powder diffraction analysis consist of a small portion of the Maroon Valley formation taken from the northeastern edge of the SE Slope site, with samples of the Eagle Valley formation and the Eagle Valley Evaporite formation taken from a region west of a service road in the southern portion of the SE Slope site. Small portions of each sample were removed from the main host, ground to a fine powder, and analyzed.

The results of this analysis reveal that the Maroon Formation consists of a combination of quartz, albite, calcite, goethite, muscovite, and hematite. The analysis of the Eagle Valley Formation, the transitionary boundary, contains quartz, albite, calcite, and muscovite. The Eagle Valley Evaporite sample analyzed only contained gypsum. This portion of the analysis establishes the comparative baseline for the Type B – White xenoliths and Type D – Minturn xenoliths to attempt a better determination and definitive categorization beyond the current field-based identifications and to potentially identify any thermal alterations within the samples.

Type B – White

The preparation of the Type B – White samples consisted of taking scrapings away from the center of the xenolith structures to ensure no contamination from the basalt agglutinate appeared within the analysis. The scrapings were then ground into a fine powder to ensure randomization of the crystal alignments for an accurate comparative analysis to the host sediments for potential identification. The xenolith samples and a portion of the single sample from beneath a large portion of agglutinate in a section of scoriaceous breccia in the SE Slope site were examined by using JADE analysis software to compare the generated d-spacing values with the index of known values for specific minerals. The samples were grouped according to their acquired sites before comparison to identify variations and similarities within each sample and the host sediments.

Maroon Formation

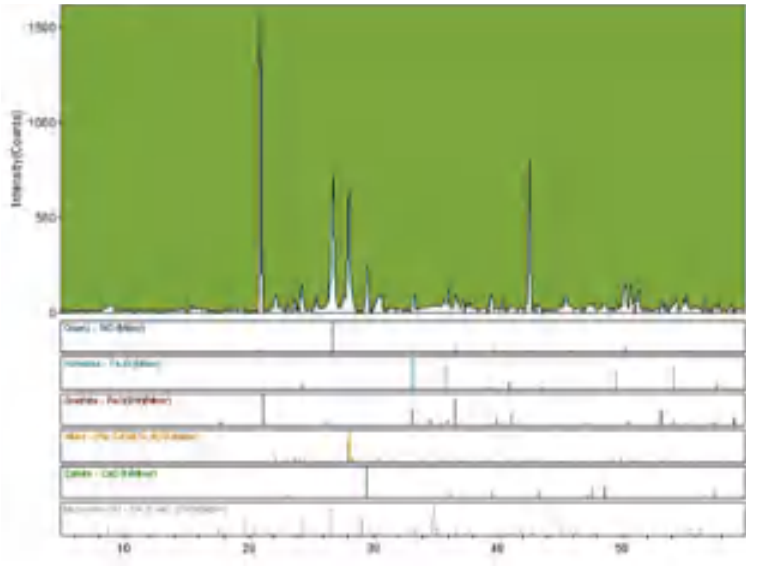


Figure 10a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the Maroon Formation sample. The analysis is presented after being smoothed through JADE analysis software to better distinguish the peaks and to create an accurate analysis of the peak intensity (y-axis).
Figure 10b (bottom) - The analysis of the Maroon Formation reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, albite, and muscovite in the major phase, with hematite, goethite, and calcite in the minor phase.

Eagle Valley Formation

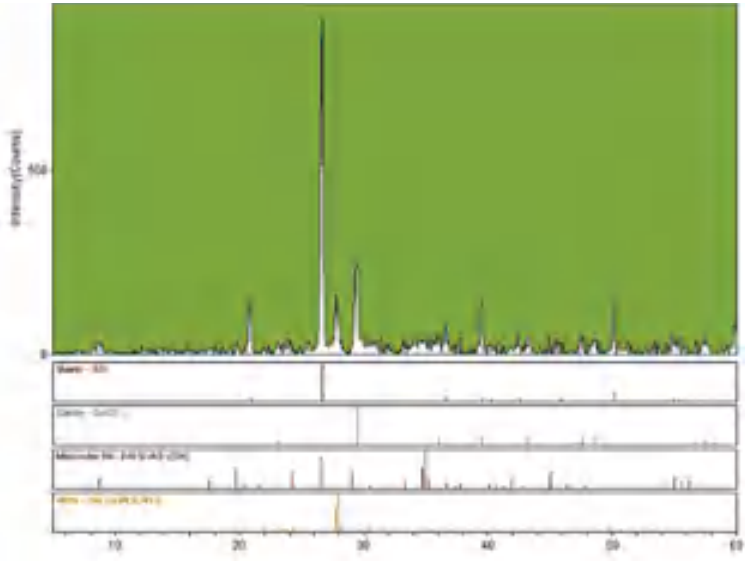


Figure 11a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the Eagle Valley Formation sample. The analysis is presented after being smoothed through JADE analysis software to better distinguish the peaks and to create an accurate analysis of the peak intensity (y-axis).
Figure 11b (bottom) - The analysis of the Eagle Valley Formation reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, calcite, muscovite, and albite.

Eagle Valley Evaporite

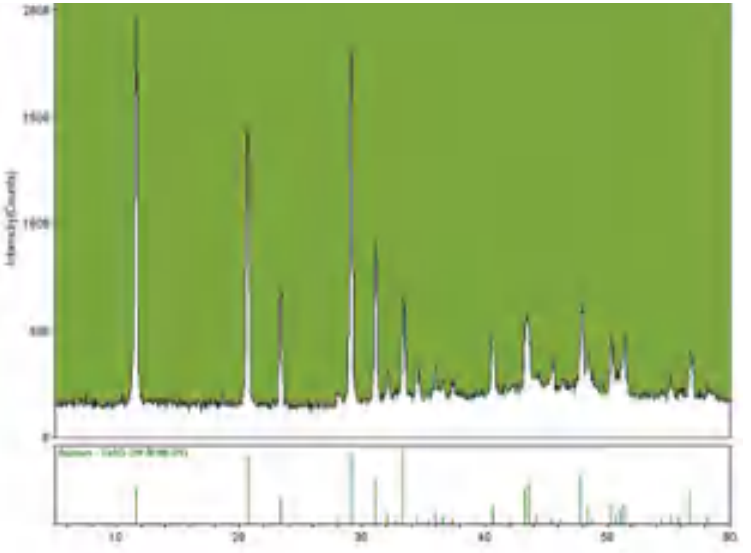


Figure 12a (top) - A visual analysis of the 2-theta angle values (x-axis] converted into d-value peaks from the Eagle Valley Evaporite sample. The analysis is presented after being smoothed through JADE analysis software to better distinguish the peaks and to create an accurate analysis of the peak intensity (y-axis)
Figure 12b (bottom) - The analysis of the Eagle Valley Evaporite reveals through the matching of indexed d-value peaks to have a mineral compositionm of gypsum.

From the analysis conducted both samples collected from the Upper Quarry site contain a combination of quartz, feldspars (anorthite, microcline, orthoclase, anorthoclase, sanidine, and albite), and pyroxenes (diopside and augite). Each sample had a subtle variation between the first sample containing magnetite and the second sample containing calcite. The xenolith sample from the Lower Quarry site shows a mineral composition like those from the first sample from the Upper Quarry site with a combination of quartz, feldspars (anorthite and anorthoclase), pyroxenes (diopside and augite), with a similarity between the second sample from the Upper Quarry by containing calcite. The xenolith sample from the SE Slope site also contained a similar mineral composition of quartz, feldspar (anorthite), pyroxene (augite), and contained calcite.

The sample acquired from underneath a section of welded agglutinate spatter in a section of scoriaceous breccia, which would have experienced lower temperatures compared to the xenolith samples examined, contains quartz, feldspar (microcline), pyroxenes (diopside and augite), calcite, and gypsum. The scoriaceous breccia sample is noted as the only xenolith sample acquired with any traces of evaporite (gypsum) in its composition.

Type D – Minturn

Due to the limited number of samples acquired during the fieldwork at the Dotsero maar sites, only three samples of the Type D – Minturn were analyzed by X-ray powder diffraction analysis. Two samples of the Type D xenoliths acquired from the Upper quarry site and one sample from the Lower Quarry site were analyzed in this portion of the study. Scrapping of the center surface area of the xenolith structure was powdered and tested utilizing identical settings used to the analyze the Type B – White xenolith samples and the sample of the Type B – White scoriaceous breccia. The first Type D – Minturn sample analyzed from the Upper Quarry site contains a mineral composition of quartz, feldspars (anorthite and albite), and pyroxene (augite). The second sample from the Upper Quarry site contains a similar composition of quartz, feldspar (albite), and pyroxene (augite), with the addition of the orthopyroxene ferrosilite. The Type D sample acquired from the Lower Quarry site revealed a mineral composition of quartz, feldspar (anorthite), and pyroxene (diopside), and contained the addition of iron oxides (goethite and maghemite) and dolomite (ankerite).

Upper Quarry Type B- White

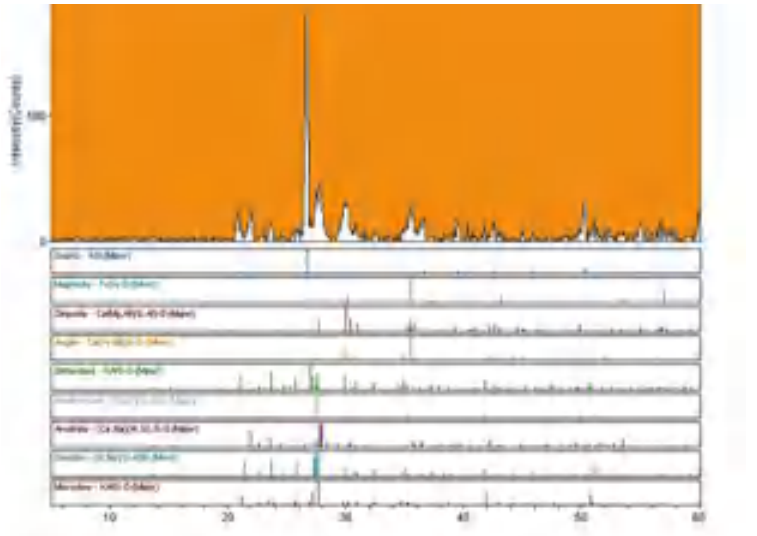


Figure 13a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from one xenolith sample collected from the Upper Quarry site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (y-axis). **Figure 13b (bottom)** - The analysis of the first xenolith sample examined from the Upper Quarry site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, magnetite, diopside, augite, orthoclase, anorthoclase, anorthite, sanidine, and microcline.

Upper Quarry Type B -White (Continued)

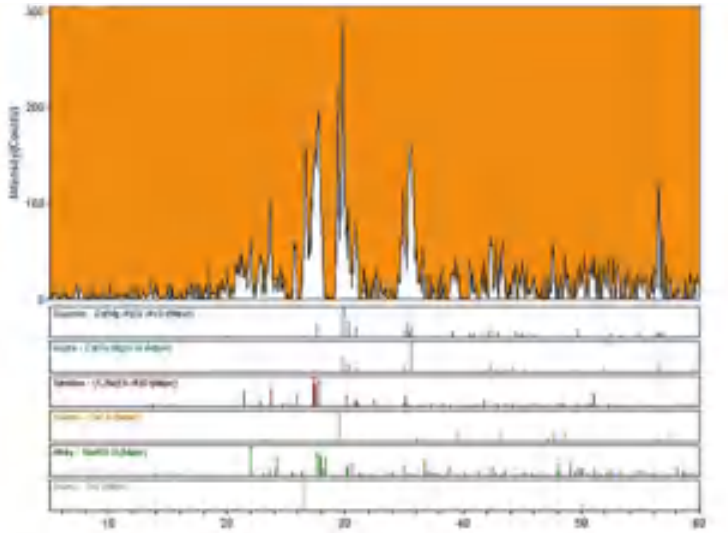


Figure 14a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the second xenolith sample collected from the Upper Quarry site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (y-axis).
Figure 14b (bottom) - The analysis of the second xenolith sample examined from the Upper Quarry site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, diopside, augite, sanidine, albite, and calcite.

Lower Quarry Type B- White

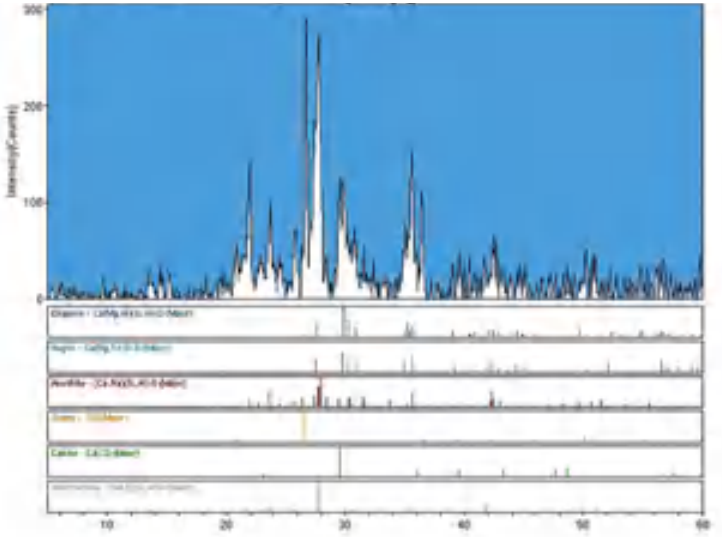


Figure 15a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from a sample collected at the Lower Quarry site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (y-axis).
Figure 15b (bottom) - The analysis of the xenolith sample from the Lower Quarry site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, diopside, augite, anorthoclase anorthite, and calcite.

SE Slope Type B- White

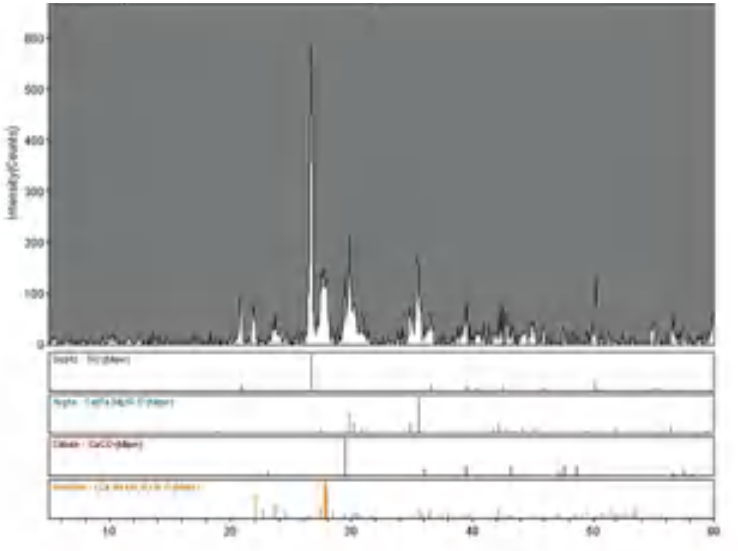


Figure 16a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from a sample collected at the SE Slope site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (v-axis)
Figure 16b (bottom) - The analysis of the xenolith sample from the SE Slope site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, augite, anorthite, and calcite.

SE Slope Type B - White (Scoriaceous Breccia)

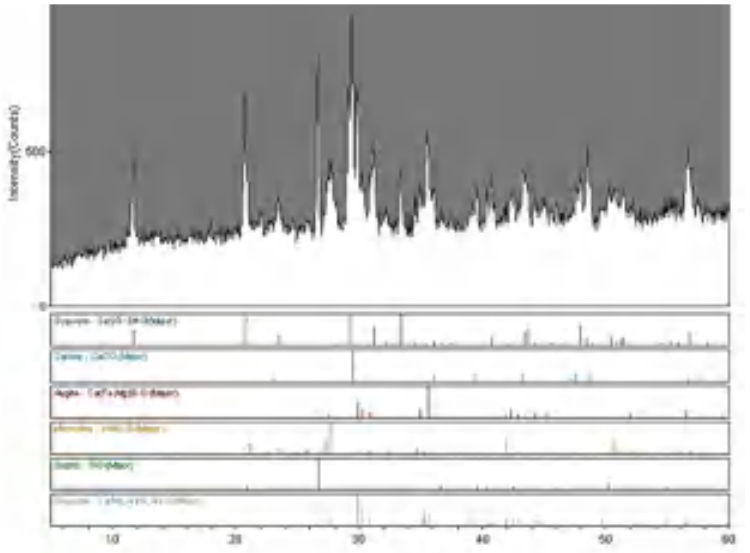


Figure 17a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the sample collected from a portion of scoriaceous breccia located at the SE Slope site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (y-axis).
Figure 17b (bottom) - The analysis of the sediment sample retrieved from the section of scoriaceous breccia from the SE Slope site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, diopside, augite, microcline, calcite, and gypsum.

Upper Quarry Type D - Minturn

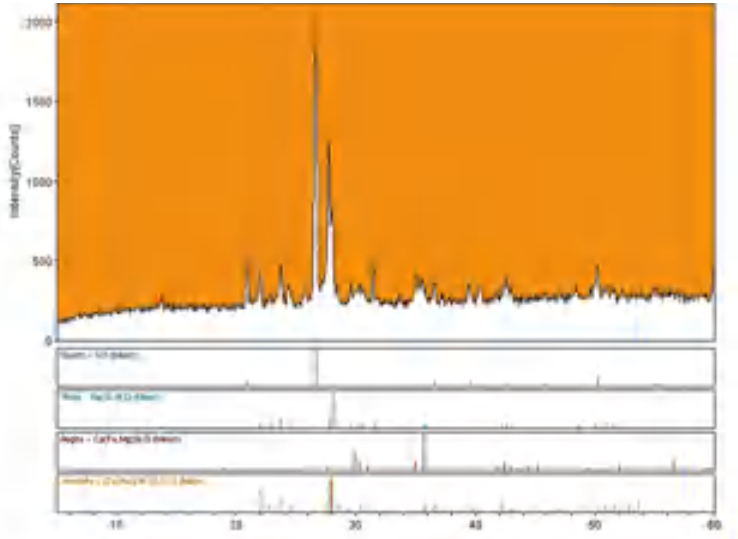


Figure 18a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the first sample of the Type D - Minturn acquired from the Upper Quarry site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (y-axis).
Figure 18b (bottom) - The analysis of the first xenolith sample from the Upper Quarry site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, anorthorite, albite, and augite.

Upper Quarry Type D - Minturn (Continued)

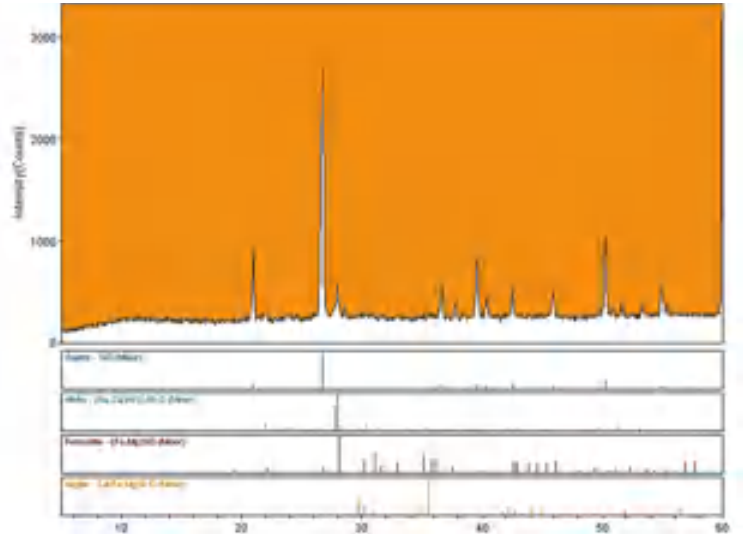


Figure 19a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the second sample of the Type D - Minturn acquired from the Upper Quarry site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (y-axis).

Figure 19b (bottom) - The analysis of the second xenolith sample from the Upper Quarry site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, albite, augite, and ferrosilite.

Lower Quarry Type D - Miniturn

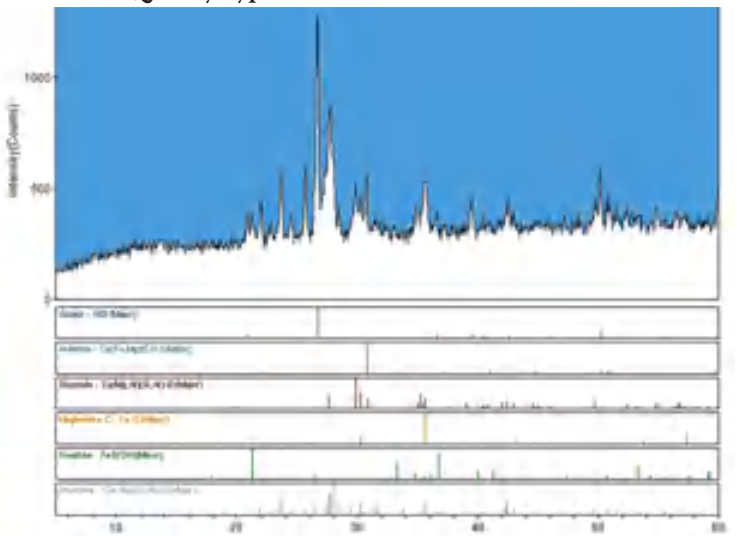


Figure 20a (top) - A visual analysis of the 2-theta angle values (x-axis) converted into d-value peaks from the sample of the Tvpe D - Minturn xenolith acquired from the Lower Quarry site. The analysis is presented after the peak values have been smoothed utilizing JADE analysis software to better distinguish the peak values before creating an accurate analysis of the peak intensities (v-axis).
Figure 20b (bottom) - The analysis of the xenolith sample from the Lower Quarry site reveals through the matching of indexed d-value peaks to have a mineral composition of quartz, anorthite, diopside, goethite, maghemite, and ankerite.

DISCUSSION

Acknowledging the limitations of this analysis in being unable to acquire a sample of the Minturn host sediment layer, the X-ray powder diffraction analysis reveals strong similarities between both the classified Type B – White xenolith samples and the Type D – Minturn xenoliths. While X-ray powder diffraction provides necessary information about the mineralogic composition of the xenolith structures the current observational classification of the sample types continues to be the most accurate form of differentiation between the xenolith structures found at the Dotsero maar volcano. This close mineral composition between the Type B and Type D xenolith structures at this level and type of analysis warrants further analysis to better distinguish between the xenolith categories and more accurately classify them using scanning electron microscopy and thin-section observational analysis. Future analyses would benefit from additional field work conducted at each of the three sites, including the collection of additional samples of each type of xenolith structure and host sediment layer samples.

CONCLUSION

The combination of fieldwork completed at the Dotsero maar volcano coupled with the analysis of the collected xenolith and host sediment samples through X-ray powder diffraction has shown that the mineralogic structure of each to be too similar for this type of analysis to better categorize the xenolith structures found at the Dotsero maar volcano. While unable to provide insight into whether thermal alterations of the sediment structures occurred during the Holocene eruption, this study has provided a strong baseline into the general composition of the xenolith structures compared to the mineral composition of the host sediment layers. This conclusion will encourage more accurate, deeper-level future analyses through scanning electron microscopy, which will facilitate detailed elemental analyses, elemental mapping, and observational thin-section analysis. Further analysis with SEM will help identify specific crystalline structures within each sample to better distinguish classifications of xenolith structures and to detect the thermal influences of the eruption on the host sediment layers.

APPENDIX A

Agglutinate
A welded eruptive deposit characterized by glassy material (vitric) binding the eruptive material; commonly used to describe bombs (eruptive material shaped while in flight) fused while hot and viscous.

Alkali
said of an igneous rock that contains more alkali metals or sodium and/or potassium than is considered average for the group of rocks to which it belongs.

Arkosic
A feldspar-rich sandstone, commonly coarse-grained and pink or reddish, that is typically composed of angular to subangular grains that may be either poorly or moderately well sorted and is usually derived from the rapid disintegration of granite or granitic rocks.

Breccia
A coarse-grained clastic rock, composed of angular broken rock fragments held together by a mineral cement or in a fine-grained matrix.

Carbonate
A rock consisting chiefly of carbonate minerals, such as limestone, dolomite, or carbonatite-; composed of more than 50% by weight of carbonate minerals.

Clastic
A consolidated sedimentary rock composed principally of broken fragments that are derived from preexisting rocks (of any origin) or from the solid products formed during chemical weathering of such rocks, and that have been transported mechanically to their places of deposition (e.g., sandstone, shale, or limestone).

Clinopyroxene
A group name for pyroxenes crystallizing in the monoclinic system and sometimes containing considerable calcium with or without aluminum and the alkalies (e.g., diopside, hedenbergite, or augite).

Conglomerate
A coarse-grained clastic sedimentary rock, composed of rounded to subangular fragments larger than 2mm in diameter (granules, pebbles, cobbles, boulders) typically containing fine-grained particles (sand, silt, clay) in the interstices, and commonly cemented by calcium carbonate, iron oxide, silica, or hardened clay.

Euhedral
A grain bound by perfect crystal faces; well-formed.

Evaporite
A sedimentary rock composed primarily of minerals produced from a saline solution as a result of extensive or total evaporation of the solvent (e.g., gypsum, anhydrite, halite).

Feldspar
A group of abundant rock-forming minerals of general formula: M Al(Si, Al)3O8, where M = K, Na, Ca, Ba, Rb, Sr, or rarely Fe.

Gypsiferous
Gypsum bearing calcium sulfate.

Holocene
The upper series of the Quaternary System of the Standard Global Chronostratigraphic Scale, above the Pleistocene, covering the time span between 11.5ka and the present; the term has replaced the earlier "Recent" as a formal name.

Lapilli Tuff
An indurated deposit that is predominantly lapilli, fragments of eruptive material defined within the limits of 2 and 64mm, with a matrix of ash; volcanic gravel.

Lithified
To change to stone, or to petrify, especially to consolidate from a loose sediment to a solid rock.

Maar Volcano
A low-relief, broad volcanic crater formed by multiple shallow explosive eruptions. It is surrounded by a crater ring and may or may not be filled with water.

Micaceous
Consisting of, containing, or pertaining to mica (e.g., a "micaceous sediment").

Petrography
Branch of geology dealing with the description and systematic classification of rocks, especially igneous and metamorphic rocks by means of microscopic examination of thin sections.

Phenocryst
A term used to describe a relatively large, conspicuous crystal in a porphyritic rock.

Phreatomagmatic
A volcanic eruption or explosion of steam, mud, or other material that is not incandescent; hydrovolcanic.

Plagioclase
A group of triclinic feldspars of general formula: $(Na,Ca)[Al(Si,Al)Si_2O_8]$.

Scoriaceous
Volcanic igneous vesicular texture involving relatively large gas holes such as in vesicular basalt, coarser than pumiceous.

Spatter
An accumulation of initially very fluid eruptive material, usually agglutinated, coating the surface around a volcanic vent.

Subarkose
A sandstone that does not have enough feldspar to be classed as an arkose, or a sandstone that is intermediate in composition between arkose and pure quartz sandstone.

Unconsolidated
A sediment that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth.

Wacke
A "dirty" sandstone that consists of a mixed variety of unsorted or poorly sorted mineral and rock fragments and of an abundant matrix of clay and fine silt.

Welded
A texture of pyroclastic rocks, especially those derived from ash flows, that is formed by the heat and pressure of still-plastic particles as they are deposited.

Xenocryst
Said of a sedimentary mineral, texture, or structure formed after the deposition of the sediment.

Xenolith
A fragment of country rock within a plutonic or volcanic rock.

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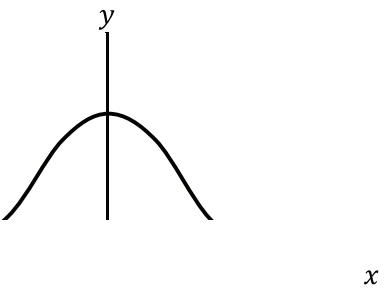
THE DEVELOPMENT OF THE NORMAL DISTRIBUTION

Allyson Jenkins

Consider the probability that even for a significantly large sample size, the number of successes and failures of an event are not in proportion to the true odds that the event does or does not occur. When proposing his solution to this problem, Abraham de Moivre (1667-1754) writes, “In answer to this, I’ll take the liberty to say, that this is the hardest Problem that can be proposed on the Subject of Chance, for which reason I have reserved it for the last, but I hope to be forgiven if my Solution is not fitted to the capacity of all Readers” (234). This idea, centered around binomials, is the basis of de Moivre’s formula for what would come to be known as the normal distribution. De Moivre was the first among many people to derive the formula for this curve. The normal distribution is used to represent data in certain populations, to determine the probabilities of events within that population, and to discuss errors of measurements.

The normal curve is of the form: $y = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$, where μ is the population mean and σ is the standard deviation (Stahl 96).
The normal curve has the general appearance:



For this reason, it is often referred to as the bell curve. It is especially helpful in the world of statistics for analysis methods such as correlations, regressions, hypothesis tests, and ANOVA (analysis of variance) (Altman and Bland 298). Though others had hypothesized some level of organization to the distribution of errors (a normal distribution), de Moivre was the first to successfully derive a formula. In this study, I will analyze de Moivre's argument, as well as those presented by two other mathematicians, Robert Adrain and Johann Carl Friedrich Gauss.

DE MOIVRE

De Moivre was a French mathematician who studied at the Collège de Harcourt in France and then moved to England for his mathematical career (O'Connor and Robertson, "Abraham De Moivre"). He worked mostly as a private tutor because he could not get a chair of mathematics at an English university due to discrimination against him as a French foreigner. He was eventually, however, elected a fellow to the Royal Society in 1697 (O'Connor and Robertson, "Abraham De Moivre"). His major contributions to the field of mathematics include his works on analytic geometry and the theory of probability, the latter of which includes his development of a formula for the normal distribution (O'Connor and Robertson, "Abraham De Moivre").

Below, I have explicated a portion of de Moivre's paper describing this formula, which was published in the 1738 version of his book The Doctrine of Chances: or, A Method of Calculating the Probabilities of Events in Play (which I obtained through the Linda Hall Library of Science, Engineering & Technology in Kansas City, Missouri), although the original paper was from November 12, 1733 (De Moivre 235-237). My comments are in [square brackets]. De Moivre uses the Old English version of the letter "s," such as in the word "some" in the title below. Each time it appears, I have replaced it with the modern version of the letter. I will also replace de Moivre's notation for a binomial with the modern notation (a+b)^n. The quote from de Moivre's work extends from page 235 to page 237.

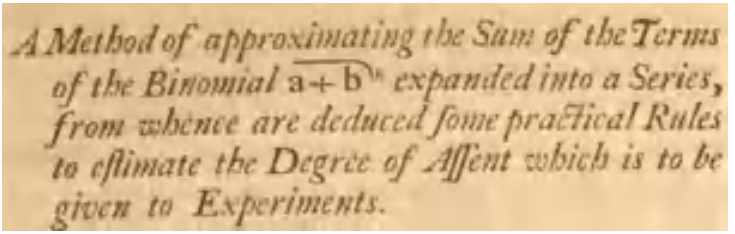

A Method of approximating the Sum of the Terms of the Binomial $\overline{a+b}^n$ expanded into a Series, from whence are deduced some practical Rules to estimate the Degree of Assent which is to be given to Experiments.

Figure 1. De Moivre 235

ALTHO' the Solution of Problems of Chance often require that several Terms of the Binomial (a+b)^n be added together, nevertheless in very high Powers the thing appears so laborious, and of so great a difficulty, that few people have undertaken that Task ; for besides James and Nicholas Bernoulli, two great Mathematicians, I know of no body that has attempted it ; in which, tho' they have shewn very great skill, and have the praise which is due to their Industry, yet some things were farther required ; for what they have done is not so much an Approximation as the determining very wide limits, within which they demonstrated that the Sum of the Terms was contained. Now the Method which they have followed has been briefly described in my Miscellanea Analytica, which the Reader may consult if he pleases, unless they rather chuse, which perhaps would be the best, to consult what they themselves have writ upon that Subject : for my part, what made me apply myself to that Inquiry was not out of opinion that I should excel others, in which however I might have been forgiven ; but what I did was in compliance to the desire of a very worthy Gentleman, and good Mathematician, who encouraged me to it : I now add some new thoughts to the former ; but in order to make their connexion the clearer, it is necessary for me to resume some few things that have been delivered by me a pretty while ago.

I. It is now a dozen years or more since I had found what follows; If the Binomial 1+1 be raised to a very high Power denoted by

$$n\,[(1+1)^n = \tbinom{n}{0} + \tbinom{n}{1} + \cdots + \tbinom{n}{n-1} + \tbinom{n}{n}],$$

the ratio which the middle Term has to the Sum of all the Terms, that is, to 2^n $\left[\text{the ratio is, for } n \text{ even, } \frac{\binom{n}{\frac{n}{2}}}{2^n}, \text{ and for } n \text{ odd } \frac{\frac{1}{2}\left[\binom{n}{\frac{n-1}{2}}+\binom{n}{\frac{n+1}{2}}\right]}{2^n}\right]$, may be expressed by some Fraction $\frac{2A\times(n-1)^n}{n^n\times\sqrt{n-1}}$, wherein A represents the number of which the Hyperbolic Logarithm is $\frac{1}{12}-\frac{1}{360}+\frac{1}{1260}-\frac{1}{1680}$, &c. [meaning a natural logarithm, or a logarithm with base e, so $\ln(A)=\frac{1}{12}-\frac{1}{360}+\frac{1}{260}-\frac{1}{1680}+\cdots$, or $A=e^{\frac{1}{12}-\frac{1}{360}+\frac{1}{260}-\frac{1}{1680}+\cdots}$ (Ayoub 1)] but because the Quantity $\frac{(n-1)^n}{n^n}$ or $\left(1-\frac{1}{n}\right)^n$ $\left[\frac{(n-1)^n}{n^n}=\left(\frac{n-1}{n}\right)^n=\left(1-\frac{1}{n}\right)^n\right]$ is very nearly given when n is a high Power, which is not difficult to prove, it follows that, in an infinite Power, that Quantity will be absolutely given, and represent the number of which the Hyperbolic Logarithm is -1 [as $n\to\infty, \ln\left(\left(1-\frac{1}{n}\right)^n\right)=-1$, meaning $\left(1-\frac{1}{n}\right)^n=e^{-1}$]; from whence it follows, that if B denotes the Number of which the Hyperbolic Logarithm is $-1+\frac{1}{12}-\frac{1}{360}+\frac{1}{1260}-\frac{1}{1680}$, &c. [$\ln(B)=-1+\frac{1}{12}-\frac{1}{360}+\frac{1}{1260}-\frac{1}{1680}+\cdots$, or $B=e^{-1+\frac{1}{12}-\frac{1}{360}+\frac{1}{1260}-\frac{1}{1680}+\cdots}$] the Expression above-written will become $\frac{2B}{\sqrt{n-1}}$

$$\left[\frac{2A\times(n-1)^n}{n^n\times\sqrt{n-1}}=\frac{2\left(e^{\frac{1}{12}-\frac{1}{360}+\frac{1}{260}-\frac{1}{1680}+\cdots}\right)e^{-1}}{\sqrt{n-1}}=\frac{2e^{-1+\frac{1}{12}-\frac{1}{360}+\frac{1}{260}-\frac{1}{1680}+\cdots}}{\sqrt{n-1}}\right.$$

$$\left.=\frac{2B}{\sqrt{n-1}}\right]$$

or barely [approximately] $\frac{2B}{\sqrt{n}}$, and that therefore if we change the Signs of that Series, and now suppose that B represents the Number of which the Hyperbolic

Logarithm is $1-\frac{1}{12}+\frac{1}{360}-\frac{1}{1260}+\frac{1}{1680}$, &c. that Expression will be changed into $\frac{2}{B\sqrt{n}}$.

$$\left[\ln(B_{new}) = 1-\frac{1}{12}+\frac{1}{360}-\frac{1}{1260}+\frac{1}{1680}+\cdots, \text{ so } B_{new} = e^{1-\frac{1}{12}+\frac{1}{360}-\frac{1}{1260}+\frac{1}{1680}+\cdots}. \text{ Hence, } \frac{2B_{original}}{\sqrt{n}} = \frac{2e^{-1+\frac{1}{12}-\frac{1}{360}+\frac{1}{260}-\frac{1}{1680}+\cdots}}{\sqrt{n}} = \frac{2}{e^{1-\frac{1}{12}+\frac{1}{360}-\frac{1}{260}+\frac{1}{1680}-\cdots}\sqrt{n}} = \frac{2}{B_{new}\sqrt{n}}.\right]$$

When I first began that inquiry, I contented myself to determine at large the Value of B, which was done by the addition of some Terms of the above-written Series ; but as I perceiv'd that it converged but slowly, and seeing at the same time that what I had done answered my purpose tolerably well, I desisted from proceeding farther, till my worthy and learned Friend Mr. James Stirling, who had applied himself after me to that inquiry, found that the Quantity B did denote the Square-root of the Circumference of a Circle whose Radius is Unity, so that if that Circumference be called c [$B = \sqrt{c} = \sqrt{2\pi}$], the Ratio of the middle Term to the Sum of all the Terms will be expressed by $\frac{2}{\sqrt{nc}}$ $\left[\frac{2}{B\sqrt{n}} = \frac{2}{\sqrt{nc}} = \frac{2}{\sqrt{2\pi n}}\right]$.

But altho' it be not necessary to know what relation the number B may have to the Circumference of the Circle, provided its value be attained, either by pursuing the Logarithmic Series before mentioned, or any other way; yet I own with pleasure that this discovery, besides that it has saved trouble, has spread a singular Elegancy on the Solution.

II. I also found that the Logarithm of the Ratio which the middle Term of a high Power has to any Term distant from it by an Interval denoted by l, would be denoted by a very near approximation, (supposing $m = \frac{1}{2}n$) by the Quantities $\overline{m+l-\frac{1}{2}} \times \log.\overline{m+l-1} + \overline{m-l+\frac{1}{2}} \times \log.\overline{m-l+1} - 2m \times \log.m + \log.\frac{m+l}{m}$.

$$\left[\left(\frac{n}{2}+l-\frac{1}{2}\right)\ln\left(\frac{n}{2}+l-1\right)+\left(\frac{n}{2}-l+\frac{1}{2}\right)\ln\left(\frac{n}{2}-l+1\right)-n\ln\left(\frac{n}{2}\right)+\ln\left(\frac{n+2l}{n}\right).\right]$$

De Moivre used this information to build his formula for what would eventually

come to be known as the normal distribution. Bob Rosenfeld explains the relation de Moivre discovers is a representation of the height at the center of the normal curve through a special case of the binomial distribution (4), which is $P_p(n|N) = \binom{N}{n} p^n q^{N-n} = \frac{N!}{n!(N-n)!} p^n (1-p)^{N-n}$, depicting the probability of observing n successes in N trials, with p the probability of a success and $q = 1 - p$ the probability of a failure (Weisstein). This distribution is approximated for large N by the normal distribution (Weisstein), and the special case used by de Moivre is when $p = \frac{1}{2}$ (Rosenfeld 4). Noting that the standard deviation for the binomial distribution is $\sigma = \sqrt{Np(1-p)}$ (the notation used by Rosenfeld has been changed to match that of the formula provided above), Rosenfeld explains that the de Moivre ratio $\frac{2}{\sqrt{nc}}$ under these conditions is equivalent to $y = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$ at $x = \mu$ (4). Therefore, through his work on binomials, Abraham de Moivre has made history as the first mathematician to derive this formula.

ADRAIN

After de Moivre published The Doctrine of Chances, other people continued to rediscover the curve to the normal distribution through different methods. The next mathematician to achieve this that I will discuss is Robert Adrain (1775-1843). Adrain started his life as a teacher in Ireland, but he fled to the United States after his participation in the failed Irish rebellion of 1798 (O'Connor and Robertson, "Robert Adrain"). He worked at a variety of U.S. universities and contributed to many of the first mathematics journals in the United States, even publishing some of his own journals. In 1808, Adrain published his paper Research concerning the probabilities of the errors which happen in making observations, etc. (Adrain 93-94), which approached the issue of the normal curve from the perspective of a distribution of errors (Stahl 110). His argument is the next argument I will closely examine. I begin by quoting Adrain's work.

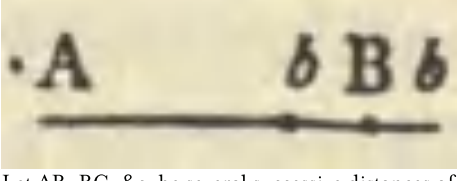
ARTICLE XIV.

Research concerning the probabilities of the errors which happen in making observations, &c.

BY ROBERT ADRAIN.

The question which I propose to resolve is this:
Supposing AB to be the true value [length] of any quantity, of which the measure by observation or experiment is Ab, the error being Bb [the position of b is either short or long of B]; what is the expression of the probability that the error Bb happens in measuring AB?

Figure 2. Adrain 93



Let AB, BC, &c. be several successive distances of which the values by measure [with error] are Ab, bc, &c. the whole [cumulative] error being Cc: now supposing the measures Ab, bc, to be given and also the whole [cumulative] error Cc, we assume as an evident principle that the most probable [true] distances AB, BC are proportional to the measures Ab, bc; and therefore the errors belonging to AB, BC are proportional to their lengths, or [in other words] to their measured values Ab, bc. If therefore we represent the values of AB, BC, or of their measures Ab, bc, by a, b [note that b now has two different meanings, depending on the context], the whole [cumulative] error Cc by E, and the errors of the measures Ab, bc by x, y, we must, for the greatest probability [that the measured distances accurately estimate the true distances AB, BC], have the equation $\frac{x}{a} = \frac{y}{b}$.

$$\left[\frac{\text{Error of measure Ab}}{\text{Value of measure Ab}} = \frac{\text{Error of measure bc}}{\text{Value of measure bc}}.\right]$$

Let X and Y be similar functions of $a, x,$ and of b, y, expressing the probabilities that the errors x, y, happen in the distances a, b [X(x) = Prob(x = error of measure Ab given a = value of measure Ab), and similarly Y(y)=Prob(y = error of measure bc given b = value of measure bc)]; and, by the fundamental principle of the doctrine of chance, the probability that both these errors happen together will be expressed by the product XY. If now we were to determine the values of x and y from the equations $x + y = E$ [cumulative error], and XY = maximum [probability that both events happen together], we ought evidently to arrive at the equation $\frac{x}{a} = \frac{y}{b}$: and since x and y are rational functions of the simplest order possible of a, b, and E, we ought to arrive at the equation $\frac{x}{a} = \frac{y}{b}$ without the intervention of roots, in other words by simple equations; or, which amounts to the same thing in effect, if there be several forms of [the probability functions] X and Y that will fufil the required condition, we must choose the simplest possible, as having the greatest possible degree of probability.

Let X', Y', be the logarithms of X and Y, to any base or modulus e [for convenience we choose the natural base $e \approx 2.718$, meaning $X' = \ln(X)$ and $Y' = \ln(Y)$]: and when XY = max. its logarithm $X' + Y' =$ max. [$\ln(XY) = \ln(X) + \ln(Y) = X' + Y' =$ maximum value] and therefore $\dot{X}' + \dot{Y}' = 0$ $\left[\frac{d}{dt}(X' + Y') = \frac{d}{dt}(\ln(X)) + \frac{d}{dt}(\ln(Y)) = 0\right]$, which fluxional equation we may express by $X''\dot{x} + Y''\dot{y} = 0$ $\left[\frac{d}{dx}(\ln(X)) \cdot \frac{dx}{dt} + \frac{d}{dy}(\ln(Y)) \cdot \frac{dy}{dt} = 0\right.$, so $X'' = \frac{d}{dx}(\ln(X(x))$, which is a function of x, and likewise Y'' is a function of $\left.y\right]$; for as X' involves only the variable quantity x [$X' = \ln(X(x))$], its fluxion $\dot{X}'$ [= $X''\dot{x}$] will evidently involve only the fluxion of x; in like manner [$Y' = \ln(Y(y))$, so] the fluxion of Y' may be expressed by $Y''\dot{y}$; and from the equation $X''\dot{x} + Y''\dot{y} = 0$, we have $X''\dot{x} = -Y''\dot{y}$: but since $x + y = E$ we have also $\dot{x} + \dot{y} = 0$ $\left[\frac{dx}{dt} + \frac{dy}{dt} = 0\right.$, since E is a constant$\left.\right]$, and $\dot{x} = -\dot{y}$[,] by which dividing the equation $X''\dot{x} = -Y''\dot{y}$, we obtain $X'' = Y''$.

Now this equation ought to be equivalent to $\frac{x}{a} = \frac{y}{b}$; and this circumstance is effected in the simplest manner possible, by assuming $X'' = \frac{mx}{a}$, and $Y'' = \frac{my}{b}$; m being any fixed number which the question may require.

Since therefore $X'' = \frac{mx}{a}$, we have $X''\dot{x} = \dot{X}' = \frac{mx\dot{x}}{a}$, and taking the fluent [integral with respect to t], we have

$$X' = a' + \frac{mx^2}{2a}\left[\int\left(\frac{mx}{a}\cdot\frac{dx}{dt}\right)dt = \frac{m}{a}\int x dx = \frac{m}{a}\cdot\frac{x^2}{2} + a'\right].$$

The constant quantity a' being either absolute, or some function of the distance a.

We have discovered therefore, that the logarithm of the probability that the error x happens in the distance a is expressed by $a' + \frac{mx^2}{2a} = X'[= \ln(X(x))]$, and consequently the probability itself is $X = \left[e^{X'}\right] = e^{\left(a' + \frac{mx^2}{2a}\right)}$.

Such is the formula by which the probabilities of different errors may be compared, when the values of the determinate quantities $e, a',$ and m are properly adjusted. If this probability of the error x be denoted by u, the ordinate of a curve to the abscissa x, we shall have $u = e^{\left(a' + \frac{mx^2}{2a}\right)}$, which is the general equation of the curve of probability.

Adrain developed his general equation for "the curve of probability," or the normal distribution, independently of de Moivre. In fact, many of the mathematicians who worked with the normal distribution did so without knowledge or application of previous discoveries. As seen, de Moivre focused on binomials and series throughout his development of the curve. Adrain, however, utilized calculus. The number of mathematicians who worked on and developed their own methods for representing the normal curve is a testament to its importance within mathematical and scientific fields.

GAUSS

Shortly after Adrain's work was published, Johann Carl Friedrich Gauss (1777-1855) published his work on the normal curve in his book, Theory of the motion of the heavenly bodies moving about the sun in conic sections (1809). Gauss was

a brilliant and well-known mathematician from the Duchy of Brunswick (modern-day Germany). He made many contributions to various topics in both mathematics and physics during his career. Among these topics were number theory, differential equations and geometry, the least squares method, and planetary orbits (O'Connor and Robertson, "Johann Carl Friedrich Gauss"). He published numerous papers and books of his work and even won the Copenhagen University Prize in 1822 (O'Connor and Robertson, "Johann Carl Friedrich Gauss"). Gauss was interested in non-Euclidean geometry, but he was hesitant to publish on this topic out of concern for his reputation since proposing its existence would have been controversial (O'Connor and Robertson, "Johann Carl Friedrich Gauss"). One of his many mathematical contributions is his derivation of the formula for the normal distribution. For this reason, the normal distribution is also known as the Gaussian distribution. I will explicate sections 175 (253-255) and 177 (257-259) from the translation of Gauss's book by Charles Henry Davis from 1857. Section 175 sets up the requirements for building the normal curve and defines most of the quantities used in section 177, in which Gauss develops the formula for the normal distribution.

175.

[Statement of Problem]

To this end let us leave our special problem, and enter upon a very general discussion and one of the most fruitful in every application of the calculus to natural philosophy. Let V, V', V'', etc. be functions of the unknown quantities p, q, r, s, etc., μ the number of those functions, ν the number of the unknown quantities; and let us suppose that the values of the functions found by direct observation are $V = M, V' = M', V'' = M''$, etc. Generally speaking, the determination of the unknown quantities will constitute a problem, indeterminate, determinate, or more than determinate, according as $\mu < \nu$ [fewer functions than variables], $\mu = \nu$, or $\mu > \nu$* [more functions than variables].

*If, in the third case [$\mu > \nu$], the functions V, V', V'' should be of such a nature that $\mu + 1 - \nu$ of them, or more, might be regarded as functions of

the remainder, the problem would still be more than determinate with respect to these functions, but indeterminate with respect to the quantities $p, q, r, s,$ etc.; that is to say, it would be impossible to determine the values of the latter, even if the values of the functions $V, V', V'',$ etc. should be given with absolute exactness: but we shall exclude this case from our discussion.

We shall confine ourselves here to the last case, in which, evidently, an exact representation of all the observations would only be possible when they were all absolutely free from error. And since this cannot, in the nature of things, happen, every system of values of the unknown quantities $p, q, r, s,$ etc., must be regarded as possible, which gives the values of the functions $V - M, V' - M', V'' - M'',$ etc., [each difference representing (true value)−(observed value)] within the limits of the possible errors of observation; this, however, is not to be understood to imply that each of these systems would possess an equal degree of probability.

[Requirements of the Curve]
Let us suppose, in the first place, the state of things in all the observations to have been such, that there is no reason why we should suspect one to be less exact than another, or that we are bound to regard errors of the same magnitude as equally probable in all. Accordingly, the probability to be assigned to each error Δ will be expressed by a function of Δ which we shall denote by $\varphi\Delta$ [$\varphi(\Delta)$, the normal curve]. Now although we cannot precisely assign the form of this function, we can at least affirm that its value should be a maximum for $\Delta = 0$ [when the error $\Delta = 0$, the probability the observed value is correct is the maximum possible], equal, generally, for equal opposite values of Δ [an error of $\Delta < 0$ should be as likely as $\Delta > 0$, so $\varphi(\Delta) = \varphi(-\Delta)$], and should vanish, if, for Δ is taken the greatest error, or a value greater than the greatest error: $\varphi\Delta$, therefore, would appropriately be referred to the class of discontinuous functions [a function not defined by a single formula], and if we undertake to substitute any analytical function in the place of it for practical purposes, this

must be of such a form that it may converge to zero on both sides, asymptotically, as it were, from $\Delta = 0$, so that beyond the limit it can be regarded as actually vanishing [the limit as $\Delta \to \pm\infty$ is 0]. Moreover, the probability that an error lies between the limits Δ and $\Delta + d\Delta$ differing from each other by the infinitely small difference $d\Delta$, will be expressed by $\varphi\Delta d\Delta$ [$= \varphi(\Delta) \cdot d\Delta =$ height · width $=$ area of infinitely small rectangle]; hence the probability generally, that the error lies between D and D', will be given by the integral $\int \varphi\Delta.d\Delta$ extended from $\Delta = D$ to $\Delta = D'$. This integral taken from the greatest negative value of Δ to the greatest positive value, or more generally from $\Delta = -\infty$ to $\Delta = +\infty$ must necessarily be equal to unity $\left[\int_{-\infty}^{\infty} \varphi(\Delta) d\Delta = 1\right]$. Supposing, therefore, any determinate system of the values of the quantities $p, q, r, s,$ etc., the probability that observation would give for V the value of M, will be expressed by $\varphi(M - V)$, substituting in V for $p, q, r, s,$ etc., their values; in the same manner $[\varphi(M' - V')], \varphi(M'' - V'')$, etc. will express the probabilities that observation would give the values M', M'', etc. of the functions V', V'', etc. Wherefore, since we are authorized to regard all the observations as events independent of each other, the product $\varphi(M - V)\varphi(M' - V')\varphi(M'' - V'')_{\text{etc.}} = \Omega$, will express the expectation or probability that all those values will result together from observation.

Gauss has proposed the beginning of his argument for the derivation of the equation of the normal curve. He continues some of this development in section 176 and states a theorem worth noting:

> "If, any hypothesis H being made, the probability of any determinate event E is h, and if, another hypothesis H′ being made excluding the former and equally probable in itself, the probability of the same event is h′: then I say, when the event E has actually occurred, that the probability that H was the true hypothesis, is to the probability that H′ was the true hypothesis, as h to h′" (255).

This theorem states that $\frac{\mathrm{H}_{\text{true probability}}}{\mathrm{H}'_{\text{true probability}}} = \frac{\mathrm{h}}{\mathrm{h}'}$. In his argument, Adrain starts with the proportional $\frac{x}{a} = \frac{y}{b}$, where x and y represent the errors in a measurement

and a and b represent the respectively measured lengths. By rearranging this proportional, we obtain $\frac{x}{y} = \frac{a}{b}$. Gauss's argument, then, appears to utilize similar logic to the argument that Adrain published a year earlier. This foundational similarity still allows for great differences between each work, so we will continue to examine Gauss's paper. Since Gauss's argument can still be easily followed by omitting section 176, I have chosen to jump to the analysis in section 177. Here, Gauss is prepared to derive a formula for $\varphi(\Delta)$.

177.

Now it readily follows from this, that the most probable system of values of the quantities $p, q, r, s,$ etc. is that in which Ω acquires the maximum value, and, therefore, is to be derived from the v equations

$\frac{\mathrm{d}\Omega}{\mathrm{d}p} = 0, \frac{\mathrm{d}\Omega}{\mathrm{d}q} = 0, \frac{\mathrm{d}\Omega}{\mathrm{d}r} = 0, \frac{\mathrm{d}\Omega}{\mathrm{d}s} = 0,$ etc.

[Ω acquires the maximum value here since each derivative equal to 0 can indicate a maximum, minimum, or flattening of the curve. Through his construction, Gauss has assumed that only a maximum will exist.]

These equations, by putting [note that v now has a new meaning]

$$V - M = v, V' - M' = v', V'' - M'' = v'', \text{ etc.}, \text{ and } \frac{\mathrm{d}\varphi\Delta}{\varphi\Delta \mathrm{d}\Delta} = \varphi'\Delta \left[\frac{1}{\varphi(\Delta)} \cdot \frac{d\varphi(\Delta)}{d\Delta} = \varphi'(\Delta)\right],$$

assume the following form:

$$\left[\frac{d\Omega}{dp} =\right] \frac{\mathrm{d}v}{\mathrm{d}p}\varphi' v + \frac{\mathrm{d}v'}{\mathrm{d}p}\varphi' v' + \frac{\mathrm{d}v''}{\mathrm{d}p}\varphi' v'' + \text{etc.} = 0,$$

[Recall $\varphi(\Delta) = \varphi(-\Delta)$, so here $\varphi'(\Delta) = \varphi'(-\Delta)$, and recall Ω from the end of section 175. We will illustrate only the case of three factors in Ω.

$$\Omega = \varphi(M - V)\varphi(M' - V)\varphi(M'' - V'') = \varphi(-v)\varphi(-v')\varphi(-v'') = \varphi(v)\varphi(v')\varphi(v'').$$

So, for example, $\varphi(v')\varphi(v'') = \frac{\Omega}{\varphi(v)}$ and so on. Using first the derivative product rule, and later the chain rule,

$\frac{d\Omega}{dp} = \frac{d\varphi(v)}{dp}\varphi(v')\varphi(v'') + \frac{d\varphi(v')}{dp}\varphi(v)\varphi(v'') + \frac{d\varphi(v'')}{dp}\varphi(v)\varphi(v') = \frac{\Omega}{\varphi(v)} \cdot \frac{d\varphi(v)}{dp} + \frac{\Omega}{\varphi(v')} \cdot \frac{d\varphi(v')}{dp} + \frac{\Omega}{\varphi(v'')} \cdot \frac{d\varphi(v'')}{dp}.$

$\frac{1}{\Omega} \cdot \frac{d\Omega}{dp} = \frac{1}{\varphi(v)}\left(\frac{d\varphi(v)}{dv} \cdot \frac{dv}{dp}\right) + \frac{1}{\varphi(v')}\left(\frac{d\varphi(v')}{dv'} \cdot \frac{dv'}{dp}\right) + \frac{1}{\varphi(v'')}\left(\frac{d\varphi(v'')}{dv''} \cdot \frac{dv''}{dp}\right)$

$= \frac{dv}{dp}\varphi'(v) + \frac{dv'}{dp}\varphi'(v') + \frac{dv''}{dp}\varphi'(v'').$

Where $\frac{d\Omega}{dp} = 0$, we have $\frac{dv}{dp}\varphi'(v) + \frac{dv'}{dp}\varphi'(v') + \frac{dv''}{dp}\varphi'(v'') = 0.$]

$$\left[\frac{d\Omega}{dq} =\right] \frac{\mathrm{d}v}{\mathrm{d}q}\varphi' v + \frac{\mathrm{d}v'}{\mathrm{d}q}\varphi' v' + \frac{\mathrm{d}v''}{\mathrm{d}q}\varphi' v'' + \text{etc.} = 0,$$
$$\left[\frac{d\Omega}{dr} =\right] \frac{\mathrm{d}v}{\mathrm{d}r}\varphi' v + \frac{\mathrm{d}v'}{\mathrm{d}r}\varphi' v' + \frac{\mathrm{d}v''}{\mathrm{d}r}\varphi' v'' + \text{etc.} = 0,$$
$$\left[\frac{\mathrm{d}\Omega}{\mathrm{d}s} =\right] \frac{\mathrm{d}v}{\mathrm{d}s}\varphi' v + \frac{\mathrm{d}v'}{\mathrm{d}s}\varphi' v' + \frac{\mathrm{d}v''}{\mathrm{d}s}\varphi' v'' + \text{etc.} = 0.$$

Hence, accordingly, a completely determinate solution of the problem can be obtained by elimination, as soon as the nature of the function φ' is known. Since this cannot be defined a priori [beforehand], we will, approaching the subject from another point of view, inquire upon what function, tacitly, as it were, assumed as a base, the common principle, the excellence of which is generally acknowledged, depends. It has been customary certainly to regard as an axiom the hypothesis that if any quantity has been determined by several direct observations, made under the same circumstances and with equal care, the arithmetical mean of the observed values affords the most probable value, if not rigorously, yet very nearly at least, so that it is always most safe to adhere to it. By putting, therefore, $V = V' = V''\text{etc.} = p,$

[From the work prior since now $p - M = v, p - M' = v', p - M'' = v'', \ldots$, we need to obtain

$0 = \frac{\mathrm{d}\Omega}{\mathrm{d}p} = \frac{d(p-M)}{dp}\varphi'(p-M) + \frac{d(p-M')}{dp}\varphi'(p-M') + \frac{d(p-M'')}{dp}\varphi'(p-M'') + \ldots = \varphi'(M-p) + \varphi'(M'-p) + \varphi'(M''-p) + \ldots]$

we ought to have in general,

$$\varphi'(M-p) + \varphi'(M'-p) + \varphi'(M''-p) + \text{etc.} = 0,$$

if instead of p is substituted the value

$\frac{1}{\mu}(M + M' + M'' + \text{etc.})$,

[The arithmetic mean of the observations $M, M', M'', \ldots$ since μ represents the number of functions V, V', V'', etc. which correspond to M, M', M'', etc.] whatever positive integer μ expresses. By supposing, therefore,

$$M' = M'' = \text{etc.} = M - \mu N \; [N = \text{any positive constant}],$$

$[M' = M'' = \ldots = M - \mu N$

$$\frac{1}{\mu}M' = \frac{1}{\mu}M'' = \ldots = \frac{1}{\mu}M - N.$$

So, $\frac{1}{\mu}(M + M' + M'' + \ldots) = \frac{1}{\mu}\cdot M + \left(\frac{1}{\mu}M - N\right) + \left(\frac{1}{\mu}M - N\right) + \ldots$

$= \mu\left[\frac{1}{\mu}\cdot M\right] + (\mu-1)(-N) = M - (\mu-1)(N) = (M-\mu N) + N$

$= M' + N = M'' + N = \ldots$

Thus, replacing p with the average,

$$\begin{aligned} 0 &= \varphi'(M-p) + \varphi'(M'-p) + \varphi'(M''-p) + \ldots \\ &= \varphi'(M-(M-(\mu-1)N)) + \varphi'(M'-(M'+N)) \\ &\qquad + \varphi'(M''-(M''+N)) + \ldots \\ &= \varphi'\big((\mu-1)N\big) + \varphi'(-N) + \varphi'(-N) + \ldots \\ &= \varphi'\big((\mu-1)N\big) + (\mu-1)\varphi'(-N).] \end{aligned}$$

we shall have in general, that is, for any positive integral value of μ,

$\varphi'(\mu-1)N = (1-\mu)\varphi'(-N)$,

whence it is readily inferred that $\frac{\phi'\Delta}{\Delta}$ must be a constant quantity, which we will denote by k [Rewriting the equation above, $\frac{\phi'(\mu-1)}{\mu-1} = \frac{\phi'(-N)}{-N}$. Since the left side

is a constant, while on the right side N is arbitrary, we conclude that all values $\frac{\phi'(\Delta)}{\Delta}$ are the same, say equal to k. So, $\phi'(\Delta) = k\Delta$]. Hence we have

$$\log \varphi\Delta = \frac{1}{2}k\Delta\Delta + \text{Constant},$$

[Recalling the definition of the natural (hyperbolic) logarithm as an integral,

$$\ln \varphi(\Delta) = \int \frac{1}{\varphi(\Delta)} d\varphi(\Delta) = \int \left(\frac{1}{\varphi(\Delta)} \cdot \frac{d\varphi(\Delta)}{d\Delta}\right) d\Delta = \int \varphi'(\Delta) d\Delta = \int k\Delta \, d\Delta = k \cdot \frac{\Delta^2}{2} + \text{Constant.}]$$

$$\varphi\Delta = xe^{\frac{1}{2}k\Delta\Delta}.$$

denoting the base of the hyperbolic logarithms by e and assuming

$$\text{Constant} = \log x.$$

[Writing Constant $= \ln(x)$, we have $\varphi(\Delta) = e^{\ln\varphi(\Delta)} = e^{k\frac{\Delta^2}{2} + \ln(x)} = e^{k\cdot\frac{\Delta^2}{2}} \cdot e^{\ln(x)} = xe^{\frac{1}{2}k\Delta^2}$.]

Moreover, it is readily perceived that k must be negative, in order that Ω may really become a maximum [if $k > 0$, $e^{\frac{1}{2}k\Delta^2}$ grows without bound as $\Delta \to \pm\infty$, so $\varphi(\Delta)$ has no maximum, hence neither does Ω], for which reason we shall put

$$\frac{1}{2}k = -hh; \text{ [So, } \varphi(\Delta) = xe^{-h^2\Delta^2}.]$$

and since, by the elegant theorem first discovered by LAPLACE, the integral

$$\int e^{-\mathrm{hh}\Delta\Delta} \mathrm{d}\Delta \text{ from } \Delta = -\infty \text{ to } \Delta = +\infty \text{ is } \frac{\sqrt{\pi}}{h},$$

(denoting by π the semicircumference of the circle the radius of which is unity)

$$\left[\int_{-\infty}^{\infty} e^{-h^2\Delta^2} d\Delta = \frac{\sqrt{\pi}}{h}\right], \text{ our function becomes } \varphi\Delta = \frac{h}{\sqrt{\pi}} e^{-\mathrm{hh}\Delta\Delta}.$$

$$\left[1 = \int_{-\infty}^{\infty} \varphi(\Delta) d\Delta = x \int_{-\infty}^{\infty} e^{-h^2\Delta^2} d\Delta = x \cdot \frac{\sqrt{\pi}}{h}. \text{ So } x = \frac{h}{\sqrt{\pi}}.\right]$$

Gauss explains the reasoning behind many of his assumptions, but, as we have seen, he often leaves out quite a bit of the actual mathematics. Like Adrain, Gauss also relies on calculus, but his methods clearly differ from those of the former. Gauss uses logic to construct the basis of the distribution before creating a formula, and he uses this logic to guide his derivation. Adrain relies more on direct computations.

CONCLUSION

De Moivre, Adrain, and Gauss each approached this problem in different ways. None of them replicate the exact formula that is used today, though all versions are valid. Ironically, although Gauss was the last out of these three men to find the formula to the normal distribution, it is identified as the "Gaussian Distribution." Despite the fact Adrain's work preceded Gauss', Adrain often is omitted from discussions of the derivation of the normal curve. At times even de Moivre, despite being the first to discover the curve's formula, is overlooked as a result of Gauss' fame.

The multiple discoveries and lacking attributions of the curve's origins demonstrate communication failures of this era. Perhaps there were many other mathematicians who discovered this formula only for their efforts to be lost. None of these men were the first, nor the last, to take on problems related to the normal curve. Many mathematicians had previously theorized a need for this curve, and many in the future would expand upon its uses within a variety of fields. The formula of the normal distribution came to be known through the efforts of multiple mathematicians who often referenced and utilized works by previous mathematicians. The normal distribution may have been developed by individuals, but it was anything but an individual effort.

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THE WALKING ECOSYSTEM: HOW GUT PSYCHOBIOTICS BIFIDOBACTERIA AND LACTOBACILLI ALLEVIATE SYMPTOMATOLOGY OF DEPRESSION AND ANXIETY

Lauren Melton

ABSTRACT

Exacerbation of mental health disorders such as depression and anxiety due to the global COVID-19 pandemic has emphasized the need for better mental healthcare. The microbiome, a diverse community of microorganisms living within and around the human body, may have therapeutic properties that could solve the mental health crisis. Multiple studies suggest mechanisms by which two important bacterial species, Bifidobacteria and Lactobacilli, impact symptoms of anxiety and depression. Results of these studies indicate an impact on mental health by detailing how probiotic species have been shown to down-regulate the hypothalamic-pituitary-adrenal axis, increase the biosynthesis of GABA (a principal neurotransmitter), and upregulate tryptophan production, the precursor to serotonin. These physiological mechanisms have been found to alleviate depression and anxiety, suggesting that Bifidobacteria and Lactobacilli can be used to help treat symptoms of Major Depressive Disorder (MDD) and Generalized Anxiety Disorder (GAD).

INTRODUCTION

Waking up each morning to stare at a groggy figure in the mirror is not a unique experience for the average college student, but a common misconception is that the reflection glaring back is only human. The human body includes approximately 10 trillion human cells and a conglomerate of about 100 trillion bacteria (Dekaboruah et al., 2020). The microorganisms colonizing the body outnumber human cells 10 to 1. The inhabitants are small in size, so this community remains invisible to the naked eye, but its effect on human health is undeniable (National Institutes of Health, 2012). The human body is a walking ecosystem of microorganisms, a diverse com-

munity of bacteria, fungi, protozoa, and viruses that make up the human microbiome (Barko et al., 2018). This group of native organisms, highly concentrated in the gastrointestinal tract, has a serious impact on human health, influencing bodily processes such as defense against infection and metabolism regulation (Al Bander et al., 2020). Many studies show that the enteric nervous system, a neural communication system between the digestive organs and brain, also referred to as the gut-brain axis, shows a precise link between intestinal functions and cognitive functions (Carabotti et al., 2015). Emerging research has emphasized the gut microbiome's important role in these communications. Two organisms that inhabit the gut, Bifidobacteria and Lactobacilli, are key to unlocking our knowledge of how the gut microbiome acts on the hypothalamic-pituitary-adrenal axis (HPA), a major regulator of hormonal release, and thereby influence mental health. By examining this interaction, as well as the action of probiotics in the biosynthesis of GABA (an inhibitory neurotransmitter) and upregulation of tryptophan production (the precursor to serotonin) how Bifidobacteria and Lactobacilli alleviate the symptoms of mental health disorders such as anxiety and depression can be elucidated.

Major depressive disorder (MDD), a mood disorder that causes a person to exhibit feelings of emptiness, despair, and cognitive dysfunction, debilitates many people and has affected even more people during the COVID-19 pandemic. In 2017-2018, prior to the onset of the global pandemic, the average percentage of adults diagnosed with depression in the United States was 8.7%. This number rose in March 2020, the same month the US began to recommend and later enforce stay-at-home orders, to 10.6%. Young adults, aged 18-34, experienced a larger increase than all other age groups at a rate of 13.4 percentage points. In April 2020, just one month later, this number rose again to 14.4%, almost double the rate that had been reported prior to the pandemic (Daly et al., 2021).

Young people are most susceptible to MDD and generalized anxiety disorder (GAD), which causes extreme feelings of nervous unrest. College students reported suffering from moderate to severe anxiety at rates of about 44% and moderate to severe depression at rates of 36% during the early stages of the COVID-19 pandemic (Lee et al., 2021). A study of 1,074 college students found moderate prevalence of depression and stress symptoms among the group, explicitly concluding that interventions aimed at promot-

ing mental health among college students are needed (Ramón-Arbués et al., 2020). These mental health disorders can be crippling, putting excess strain on a population that is not only undergoing immense academic pressure, but also beginning to live their lives as independent adults and creating long-term habits that stay with them through their personal and professional lives. Implementing mental healthcare for students is important, and the key to a healthier and happier life is living inside and around them.

THE HUMAN MICROBIOME

The human microbiome is a complex and diverse conglomerate of organisms that has adapted to the human body throughout an individuals' lifespan. These organisms are specialized to survive and thrive within the unique conditions of each body. These bacteria are known as commensal bacteria or indigenous microbiota, defined by Helena Tlaskalová-Hogenová et al. as "microorganisms which are present on body surfaces which are covered by epithelial cells and are exposed to the external environment such as the gastrointestinal and respiratory tract, vagina, and skin" (Tlaskalová-Hogenová et al., 2004) These bacteria share a positive relationship with the human body where each party benefits from the presence of the other. This relationship is referred to as commensalism (Singh and Christina, 2021). Though dutifully at work with bodily processes, these microbes are not created by human genetic material the way that somatic cells are. The human body is slowly exposed to these indigenous microorganisms the same way new settlers find a country to call their own.

The colonization of a newborn begins with a fair amount of conjecture. It is hypothesized that the fetus is first exposed to microorganisms within the mother's womb, the uterus, an organ that was once considered undoubtedly devoid of bacterial life (Cresci and Bawden, 2015). A study, "The Not-so-Sterile Womb: Evidence That the Human Fetus Is Exposed to Bacteria Prior to Birth," details methods of collecting data that may indicate the womb as the first site of colonization. Using a sample of fifty pregnant women preparing for non-emergency cesarean sections, during which their newborn babies are surgically removed in a sterile environment, researchers collected samples of amniotic fluid and meconium, fecal waste created by a fetus in utero, in the womb (Stinson et al., 2019).

The samples revealed the presence of bacterial DNA; extensive

gene sequencing detected the presence of diverse microbiota throughout meconium and amniotic fluid. Of those species detected, 32.7% were found overlapping in both meconium and amniotic fluid samples, supporting past studies claiming that these substances are alike in colonization when compared to maternal feces or even infant feces. This overlap of shared organisms can be attributed to the swallowing of amniotic fluid by fetuses that contributes to meconium production (Stinson et al., 2019). This view of the beginning of colonization suggests the sterile womb hypothesis is no longer as accurate as once thought.

The emergence of a fetus from the womb, however, undoubtedly begins the bloom of microbiota within the infant. During vaginal birthing, where the infant exits the uterus by passing through the vaginal canal, an infant is exposed to the diverse community of microorganisms that maintain vaginal health. Due to this process, a newborn will have a microbiome that very closely resembles that of the vagina. When babies are born by cesarean section, however, their newborn microbiota resembles that of the skin's surface. The first bacterial exposures of a child's life will inoculate them with many new microorganisms, some of which will become part of their indigenous population while others that are pathogenic are fought off by the infant's immune system, recruiting assistance from these commensal microorganisms (Cresci & Bawden, 2015).

Breast milk is another agent of exposure to hundreds of species of important gut bacteria that aid digestion, immunity, and the overall health of the host (Al Bander et al., 2020). Two vital microorganisms make contact with the infant in the birth canal, and possibly even in utero, according to emerging research. Multiple species of Lactobacilli and Bifidobacteria are found throughout the vagina, finding a new host during a baby's delivery in about one-fourth of cases (Matsumiya et al., 2002) Although naturally born fetuses will see this bloom of Lactobacilli and Bifidobacteria, babies born via Cesarean section will have a much lower number of these microorganisms as their original microbiota will closely resemble that of their mother's skin instead of her vaginal canal.

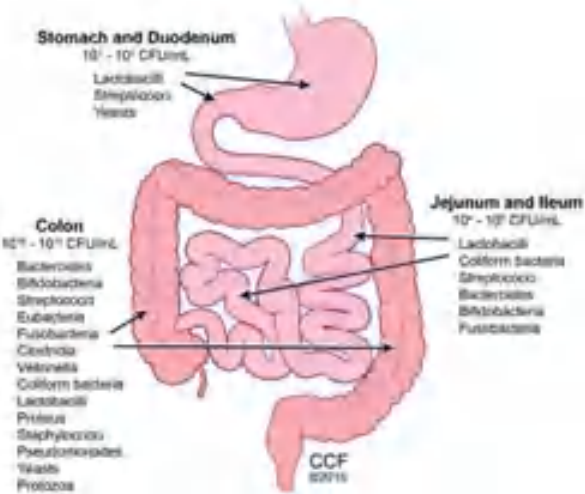

Figure 1. (Cresci and Bawden, 2015)

Colonization is only just beginning in the delivery room, as breast milk has also been found to have strains of both Lactobacilli and Bifidobacteria, repeatedly exposing the infant to their beneficial properties and eventually becoming members of the newborn's gut microbiome (Soto et al., 2014). They provide many benefits throughout life as a layer of protection for the vulnerable infant e exposed to the potential pathogens of the outside world for the first time.

Lactobacilli, ubiquitous members of the gut microbiome, are rod-shaped bacteria that find their home throughout the entire human gut from the stomach down through the duodenum, small intestine, and colon. Probiotic Lactobacilli provide a large array of benefits throughout the gut and the rest of the body. Extensive research into species such as Lactobacillus acidophilus and Lactobacillus rhamnosus has been conducted to study the effect they may have in preventing human and animal diseases. This research into disease prevention extends into cancer, diabetes, liver disease, and inflammatory bowel disease (Azad et al., 2018), providing a strong base for the possible medical applications of Lactobacilli as a probiotic.

Another probiotic gut bacteria is Bifidobacteria, found primarily in the ileum and jejunum of the small intestine as well as the colon. This organism has long been used as a probiotic, ingested to change the composition of the host gut microbiome, altering and even alleviating symptoms of multiple diseases (Azad et al., 2018). Bifidobacteria functions similarly to Lactobacilli in its ability to suppress inflammation, fight potential pathogens, and increase the protective functions of the gastrointestinal barrier through prominent species Bifidobacterium bifidum and Bifidobacterium breve (Azad et al., 2018). The mental health benefits seen in correlation with Lactobacilli and Bifidobacteria can be explained by understanding the function of these organisms and by examining the physiological presentation of depression and anxiety in the human body.

THE PHYSIOLOGY OF DEPRESSION AND ANXIETY

Understanding the physiological processes that influence the onset and progression of depression and anxiety begins with the immune system. The human body's natural defense system has two main components: the innate immune system and the adaptive immune system, the former being the faster responder, always patrolling for possible threats. Components of the innate immune system, including myeloid cells such as macrophages and dendritic cells, are triggered by threats to the body's health like injury or illness. These triggers are presented as PAMPs (pathogen-associated molecular patterns) or DAMPs (damage-associated molecular patterns), also known as alarmins. PAMPs are present on infectious pathogens, alerting myeloid cells to an intruder; DAMPs are released by human cells following injury or cell death to alert the innate immune system of damage that has occurred (Beurel et al., 2020). Alarmins are not only triggered by physical injury, but also stress, genetic factors, and even a change in microbiome bacterial composition. In response to these triggers, macrophages and dendritic cells produce signaling molecules called cytokines.

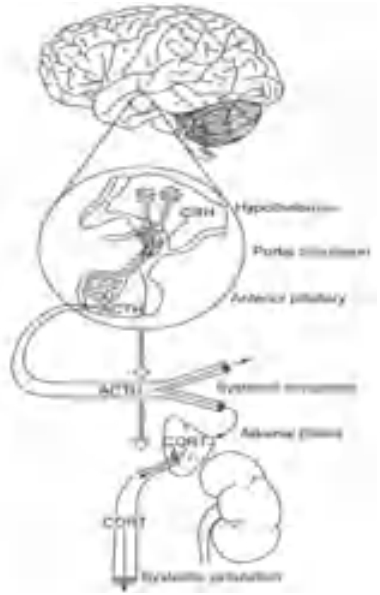

Figure 2. (Herman et al., 2016)

There are two main types of cytokines, inflammatory and anti-inflammatory. Inflammatory cytokines correlate with depression; their purpose is to recruit other immune cells and initiate inflammation, a condition that disturbs many physiological processes (Beurel et al., 2020). Inflammation is commonly associated with physical injuries like bruises or cuts, but inflammatory cytokines inside the body also communicate with the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. The SNS is responsible for the body's unconscious response to danger, while the HPA axis describes the communication between the hypothalamus and pituitary gland, located superior to the brainstem, and the adrenal glands, located on the superior portion of the kidneys (Beurel et al., 2020).

These inflammatory cytokines influence the HPA axis by triggering it to release hormones such as adrenocorticotropic hormone (ACTH) from the anterior pituitary gland, a trophic hormone that causes release

of cortisol from the zona fasciculata of the adrenal cortex. Cortisol is a glucocorticoid that decreases inflammation because of HPA axis stimulation. Studies show that stress encountered in early childhood, or even maternal stress during gestation, decreases the body's sensitivity to the hormones regulating inflammation, meaning that the HPA axis has to work at a higher rate to resolve inflammation (Beurel et al., 2020).

Similarly, patients with depression are often found to have hypercortisolemia and resistance to glucocorticoids, meaning that their HPA axis is working at an abnormally increased rate of stimulation, possibly due to low sensitivity levels caused by stress. The direct link between these factors and the onset of depression is not yet fully understood, but errors in communication between the immune system and the HPA axis lead to a higher rate of depression in those who have experienced early childhood stress or abuse (Beurel et al., 2020). GAD symptomatology is also consistent with elevated inflammation, but there are three major ways that probiotics such as Lactobacilli and Bifidobacteria can work to decrease symptoms of depression and anxiety (Beurel et al., 2020).

Studies on probiotic use to decrease symptoms of depression and anxiety focus mainly on three different mechanisms: the down-regulation of the HPA axis, the increased biosynthesis of Gamma-aminobutyric acid (GABA)(the brain's main inhibitory neurotransmitter utilized as a relaxant following stressful impulses), and upregulation of tryptophan production, (the biological precursor to serotonin, found in low levels in depression). Bifidobacteria and Lactobacilli alleviate the symptomatology of GAD and MDD through the down-regulation of the hypothalamic-pituitary-adrenal (HPA) axis, increased synthesis of GABA neurotransmitter, and upregulation of tryptophan production. By influencing these mechanisms, probiotics can be used to help treat mental health disorders.

PROBIOTICS AND THE DOWN-REGULATION OF THE HPA AXIS

A study in the Journal of Physiology provided deeper insight into the role that indigenous microbiota may play regarding brain development and physiological response. The goal of this study was to observe the HPA axis reaction to stress in mice colonized with three different microbiomes, testing the hypothesis that altering the microbial colonization early in lives would alter the development of HPA responsiveness (Sudo et al.,

2004). One category of mice was maintained in a germ-free environment having no exposure to microorganisms (GF); one was raised with a normal functional microbiota without specific pathogens (SPF); and the last group was raised with specifically chosen organisms (gnotobiotic) (Sudo et al., 2004). The gnotobiotic group in this study was specifically inoculated with Bifidobacterium infantis, an indigenous member of the infant gut. The individual groups of 9-week-old males were maintained separately in plastic containers with sterile food and water, and their fecal matter was examined periodically for any contamination by extraneous bacteria. They were then subjected to two different stress-inducing protocols.

In the first stress protocol, the mice in each group were held in a 50 mL conical tube for 1 hour to act as an acute stress restraint. They were then euthanized by cervical dislocation either immediately, 30, 60, or 120 minutes following their 1 hour of stress restraint. The second stress protocol involved subjecting the mice to ether by lining a glass container with ether-soaked absorbent paper and containing the animals inside for 2.5 minutes. Following the protocol, the mice were euthanized by cervical dislocation either immediately, 30, 60, or 120 minutes following their stress protocol. A control group was also obtained by euthanizingmice via cervical dislocation without subjecting them to the stress protocols. Blood samples were then taken via cardiac puncture and stored at freezing temperatures before assays were conducted to screen for adrenocorticotropic hormone (ACTH) and corticosterone, two hormones released by the HPA axis in the stress response (Sudo et al., 2004).

Upon examination of hormone levels, GF mice who were raised in an environment completely devoid of microorganisms had a higher level of ACTH and corticosterone in response to restraint stress (Sudo et al., 2004). In response to ether stress, there was no significant difference in hormone levels of GF mice and SPF mice. This difference in hormone levels during restraint stress can be concluded as a difference in HPA axis activity, showing a down-regulated response in mice with normal microbiota devoid of specific pathogens (SPF) (Sudo et al., 2004). The mice that were inoculated with the specifically chosen Bifidobacterium infantis showed a down-regulated HPA stress response following their restraint stress protocol as well, showing an even stronger correlation to down-regulated HPA axis activity (Sudo et al., 2004).

A similar study conducted by the American Neurogastroenterology and Motility Society observed stress responses in mice. By inoculating these mice with a probiotic solution containing Lactobacillus helveticus R0052 and Bifidobacterium longum R0175 and then subjecting them to a water-based stress test, the researchers determined the effect of these probiotics on the physiological stress response of the mice via HPA axis hormonal release and the autonomic nervous system (ANS) (Ait-Belgnaoui et al., 2014).

Male mice between 6 and 8 weeks old were separated in two groups, one that received the probiotic solution every day for two weeks and one that was given saline for the same length of time (Ait-Belgnaoui et al., 2014). After the two-week period, the mice were subjected to water avoidance stress (WAS) protocols where the animal was placed in a plexiglass tank filled with water. Instead of free-floating, they were placed on a brick that rose only about 1 cm above the water, exacerbating their innate fear of water. This test is commonly used and well researched with a history of being effective in inducing the release of stress hormones like ACTH and corticosterone within half an hour (Ait-Belgnaoui et al., 2014). The mice were left in the apparatus for 1 hour daily over 4 consecutive days. The mice were also subjected to a control procedure, or "sham" as it is referred to in the study. Sham consisted of the same procedure as WAS but the tank did not contain water (Ait-Belgnaoui et al., 2014).

Following the chronic stress procedures experienced by the four mice groups, blood was taken from the animals to assess stress hormone levels, including corticosterone, noradrenaline, and adrenaline. The animals were then euthanized and organs such as the hypothalamus and colon were analyzed. In the second conglomerate of mice groups subjected to chronic stress, the brain was removed and observed following euthanization (Ait-Belgnaoui et al., 2014).

After statistical analysis, it was determined that mice exposed to probiotic inoculation before their stress protocols released a lower amount of corticosterone, a glucocorticoid part of the HPA axis and released by the adrenal cortex (Ait-Belgnaoui et al., 2014). Mice inoculated with Lactobacilli and Bifidobacteria were also found to release lower levels of adrenaline and noradrenaline, two hormones also released by the adrenal gland, as compared to those that did not receive the probiotic solution (Ait-Belgnaoui et al., 2014).

PROBIOTICS AND THE BIOSYNTHESIS OF GAMMA-AMINOBUTYRIC ACID (GABA)

Gamma-aminobutyric acid (GABA) is the primary inhibitory neurotransmitter in the mammal brain and has key implications in the perpetuation of mental health disorders. It is a relaxant that allows for recovery after stress impulses and low levels of this molecule are often associated with depression and anxiety. A 2020 study examining the correlation between probiotics and the production of GABA investigated if some gut microbiota are capable of synthesizing GABA (Duranti et al., 2020). This idea correlates to the newly devised term "psychobiotics," referring to members of the microbiota, such as Lactobacilli and Bifidobacteria, that are capable of influencing the central nervous system. Based on previous studies, Bifidobacterium adolescentis was designated as a primary model for the study of GABA production.

To investigate this further, three rat animal model groups were provided with a B. adolescentis supplement over the course of 5 days. They received strains of this probiotic that had previously been isolated from the human gut microbiome. To provide a control group, a fourth group of rats was given a sugar solution entirely devoid of any bacterial strains over the same perio. To measure the proliferation of the Bifidobacteria strains in these first three groups of rat models, fecal samples were collected and tested using quantitative polymerase chain reaction (qPCR) to detect the genetic presence of the bacteria. The fecal matter was also examined for transcription levels in specific genes associated with GABA production. The expression of these genes was observed, positively confirming that B. adolescentis was capable of producing GABA (Duranti et al., 2020).

Additionally, B. adolescentis strains were isolated from human fecal samples and colon biopsies where they were then cultured in an anaerobic atmosphere on MRS broth, a medium used to grow bacteria. They were incubated at 37 degrees Celsius for 48 hours in order to promote growth, and the colonies were then analyzed for the presence of GABA production through multiple derivation processes (Duranti et al., 2020). Seventy-nine % of the tested strains showed activity in which monosodium glutamate (GMS), the GABA biological precursor, transformed into GABA. Ultimately, 23% of all tested strains of B. adolescentis were considered high

GABA producers as they transformed a significant amount of GMS to GABA, a promising finding in psychobiotics (Duranti et al., 2020). These results suggest that probiotics are capable of alleviating the symptomatology of anxiety and depression through the increased biosynthesis of GABA.

PROBIOTICS AND THE UPREGULATION OF SEROTONIN PRECURSOR TRYPTOPHAN

A recent study explored the possible correlation between probiotics, specifically Lactobacillus helveticus, Lactobacillus paracasei, and Bifidobacterium bifidum, and their impact on the mouse microbiome. A specific portion of this study focused on the main gene involved in serotonin synthesis, the TPH1 gene. This gene codes for tryptophan hydroxylase-1, an enzyme required for the synthesis of serotonin, a chemical neurotransmitter produced by neurons mainly associated with mood modulation (Taverniti et al., 2021).

This study began with the preparation of the probiotic formulas containing multiple strains of L. helveticus, L. paracasei, and B. bifidum. The strains were cultured and then suspended in phosphate buffered saline (PBS) in order to be administered to the mice. These mice, two-month-old females, were housed in groups of 5 and allowed one week of adaptation before the administration of either the bacterial suspension or sterile PBS to act as a control (Taverniti et al., 2021). Each group received the same amount of PBS whether it was sterile or inoculated, and their dosing took place for 5 days. At the end of the 5-day period, the mice were euthanized 4 hours after they received their last dose. Biopsies of the distal small intestine, proximal colon, and cecum were collected and DNA extraction procedures were performed (Taverniti et al., 2021).

The extracted DNA was analyzed by qPCR in order to confirm the presence of these B. bifidum, L. helveticus, and L. paracasei strains. The mice who received sterile PBS did not appear to present any of the strains, as expected, but the mice that received the bacterial gavages showed significant bacterial colonization in their cecum and colon (Taverniti et al., 2021). The distal small intestine was colonized by these bacteria, but at a less significant amount. Additional testing was performed on

many different genes within the gut cells of the mice including the TPH1 gene and the serotonin reuptake transporter (SERT) that functions in the reuptake of serotonin after it is released (Taverniti et al., 2021).

This study found that the administration of B. bifidum, specifically strain MIMBb23sg, caused a significant upregulation in the TPH1 gene, directly increasing the production of tryptophan hydroxylase-1. This strain also had an attenuating effect on SERT in the ileum, a part of the small intestine (Taverniti et al., 2021). Both of these findings show that probiotics, specifically Bifidobacteria, promotes the upregulation of tryptophan hydroxylase-1which directly increases the formation of serotonin.

By observing evidence obtained by many researchers, it is clear that Bifidobacteria and Lactobacilli not only have therapeutic effects on the human body, but that through the specific mechanisms of HPA axis attenuation, synthesis of GABA, and upregulation of tryptophan, these probiotics may alleviate symptoms of depression and anxiety.

DISCUSSION AND CONCLUSIONS

By learning about the microbiome and its various members and characteristics, it is clear that the human body is holding an entire world inside of it, a world that has yet to be evaluated for its full potential. Journeying through the painful effects of depression and anxiety not only on the individuals they affect, but the entire community, it is shockingly evident that mental healthcare must be significantly improved. Learning how these mental illnesses present themselves in the human body through physiological processes is vital in understanding the people who are impacted by them and useful in finding a way to bring therapeutic relief on a biological level. Knowing that these connections are already being made by the brain and the gut, it is up to future research to continue taking advantage of this communication. Fortunately, a foundation has been laid as therapeutic measures based on the microbiome are already current practice in many hospitals in the United States and elsewhere.

The most prevalent therapeutic measure utilizing the healing properties of the microbiome is known as a fecal microbiota transplant (FMT). An odd-sounding procedure, FMT is defined as, "the transfer of stool from a 'healthy' donor to a recipient believed to harbor an altered colonic microbiome resulting in disease" (Czepiel et al., 2019).

FMT procedures are done with the idea that the host-microbiome will be returned to normal, healthy concentrations following the transfer of these commensal microbes. Donor fecal matter is scanned thoroughly for pathogens, or harmful bacteria, and the standards for donor health are quite high (Czepiel et al., 2019). Multiple gut health issues are currently treated by FMT, and the effect has been quite positive in practice.

Currently, FMT has been clinically utilized in the treatment of patients with C. diff infections. Research surrounding the impact of FMT on C. diff is incredibly promising as the link between gut health and mental health is explored. Clostridium difficile, commonly known as C. diff, is a bacterium notorious for causing nosocomial infections contracted within a hospital setting. There are many risk factors for contracting C. difficile infection (CDI), such as being a patient in a nursing home or taking part in antibiotic therapy (Vindigni & Surawicz, 2017). Symptoms can range from uncomfortable to deadly with bouts of diarrhea that can escalate to colitis, a rare but potentially deadly inflammation of the colon. Current treatments for CDI include antibiotic therapy, even though most drugs used to treat C. difficile have also been found to exacerbate it (Vindigni & Surawicz, 2017). This difficulty with antibiotics has led to the recent rise in using FMT as a therapy for this often- recurring nosocomial infection.

In a study where FMT was used to prevent recurrent CDI, 81% of FMT patients experienced resolution while only 31% of patients treated solely with Vancomycin, an antibiotic, found relief (Vindigni & Surawicz, 2017). There are multiple different ways that FMT can be administered, but the most common involves the formation of donor fecal components into capsules taken orally. Upwards of 20 capsules are often prescribed to be taken within a short period. There are also upper gastrointestinal procedures where the transplant occurs through a tube placed in the nose and into the GI tract, and lower gastrointestinal procedures where an enema or colonoscopy would act as the means of transplantation (Vindigni & Surawicz, 2017).

The success that has been found in microbial therapy via FMT gives hope for what is to come with the future of medicine. Research focused on the microbiome has exploded in recent years, with constant discoveries. As research progresses, further investigation of these particular physiological processes is vital to understand how the microbial bloom of flora

inside the human gut can help heal patients from the inside out. Human beings have been colonized by these microscopic populations since birth, yet the whole world teeming with life is almost entirely ignored by modern Western medicine. By recognizing them, not only for their existence but for their benefit, looking in the mirror will never again be the same.

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STRANGE MATING BEHAVIORS AND MAXIMIZING REPRODUCTIVE SUCCESS

Madison Pope

INTRODUCTION

Imagine you have gone back in time to when you were ten years old. You get home from school, drop your backpack on the floor, and head directly to the television to watch one your favorite shows before your mom comes downstairs to remind you to do your homework. As you flip through the channels, you become fascinated by the colorful birds you see performing strange dances on Animal Planet. Why do they behave in such an odd way?

If you are anything like me, then you've likely had a similar experience with a television show, documentary, or book about unique and uncommon animal behaviors. You've been captivated by elephants who have learned how to paint or dolphins performing new tricks. You may also have questioned why animals, such as the dancing birds, perform these strange behaviors. In the case of the comical and well-documented mating dances of birds, how do behaviors like this actually benefit the animal and increase their ability to find a mate? Through this paper, I will be introducing some of the most bizarre animal mating behaviors and discussing how these behaviors improve the chances of reproductive success for the creatures that engage in them.

Research of this nature has captivated scientists since long ago. Charles Darwin himself was interested in the role of sexual selection and decision-making in the process of evolution (Garefalaki et al). Before we begin to analyze the peculiar reproductive behaviors of specific animals, there are a few key concepts to understand. Reproductive success is determined by the number of offspring an individual produces during its lifetime. This allows that individual's genes to continue on through subsequent generations (Garefalaki et al.). Sexual selection occurs when animals view particular traits as more beneficial, and thus select for those traits when mating (Garefalaki et al). As a result, natural selection, evolution, and speciation can occur (Garefalaki et al). In M.E. Garefalaki et al.'s study into the impact of sexual selection on the reproductive behaviors of

snails, "Intraspecific Variation in Reproductive Characters Is Associated with the Strength of Sexual Selection in the Hermaphroditic Land Snail Cornu aspersum," they note that "sexual selection is now considered a pervasive evolutionary agent across the animal tree of life… acting along pre-copulatory (i.e., in terms of "Darwinian" competition for mates and/or mate choice) and post-copulatory episodes of selection (i.e., in terms of sperm competition… and/or cryptic female choice)" (2).

As you will see in the examples ahead, animals can go to great lengths in order to create or optimize an opportunity to have offspring and thus ensure reproductive success. Beyond the basic human curiosity and desire to understand such unconventional behaviors, studying the behaviors in which these animals engage gives us valuable information about evolution and the nature of sexual selection and speciation. Three fascinating mating behaviors in three different animals will be discussed here. First is the sexual cannibalism (consumption of mates) of the praying mantid, followed by the intertwined nature of functional hermaphroditism (can possess both female and male gonads) and social hierarchy in the clownfish, and finally the unusual parabiosis (anatomical joining) seen in certain species of deep-sea anglerfish.

PRAYING MANTID/MANTIS

If you are a collector of animal fun facts, there is a good chance you know that the female praying mantid will bite off the head of the male when they mate. This fascinating reproductive behavior certainly makes for a good conversation starter, but how does this behavior benefit the praying mantid's reproductive success and overall survival as a species? Though it may seem contradictory that eating a potential mate could benefit a species, studies conducted into the sexual cannibalism of the praying mantid have discovered interesting ways in which this behavior is beneficial.

Scientists have been studying this bizarre behavior, termed sexual cannibalism, for decades. In Ruth E. Buskirk et al.'s 1984 article, "The Natural Selection of Sexual Cannibalism," sexual cannibalism is defined as when "a female kills and feeds upon her mate during or following copulation" (612). This definition has been expanded upon in more recent research and now also includes cannibalism which occurs even before mating can begin (Barry et al). Surprisingly, this behavior extends far

beyond the praying mantid and can be found in many species of spiders and elsewhere in the animal kingdom (Buskirk et al.). Such a widespread behavior must have some benefit that outweighs such a fatal risk.

As sexual cannibalism obviously comes at a high cost for the male, the reasons why this behavior might be favored are of great interest. Buskirk et al note that sexual cannibalism "is seldom observed except for species in which males can expect few potential matings and cannibalism is likely to increase the number of offspring resulting from a mating" (613). In addition, it has been observed that a male can continue to engage in sexual behavior with the female even after the male has been decapitated (Buskirk et al). The increased chance of producing offspring could potentially explain why males are willing to risk their lives, as they can successfully reproduce regardless of if they survive the mating itself.

In a 2012 study entitled "Low Mate Encounter Rate Increases Male Risk Taking in a Sexually Cannibalistic Praying Mantis," William D. Brown et al. investigated the decision-making process of the male praying mantid in such a precarious situation. The investigators were particularly interested in the impacts of level of risk and frequency of encountering a potential mate on male praying mantid reproductive behavior. They hypothesized that males would play it safe and avoid mating encounters that may lead to sexual cannibalism when the risk of being cannibalized was higher due to female hunger and when in an environment where there is an increased likelihood of coming across a potential mate. To test this hypothesis, the rate of mating encounters and the amount of food given to females was manipulated by the investigators. Females were broken into two categories, high and low risk, based upon the amount of food they were given; females were considered high risk when food had been kept from them for five days and when they were oriented to face directly at the male for a potential mating encounter. Potential mating encounters were carefully watched to record courtship behaviors and the response of the male mantid specifically.

The results of this study showed that males who had limited exposure to females moved quickly toward the females regardless of risk. Thus, males who were set up to have limited reproductive success took greater risks to increase the likelihood of continuing their bloodline. The decision of these males to engage in risky mating behavior led to "high rates of sexual cannibalism" (Brown et al, 1). However, if males were given more frequent

chances to mate and were then subsequently put into a high-risk situation with a hungry female, they reacted more cautiously "by slowing their rate of approach and remain[ing] a greater distance from a potential mate" (Brown et al, 1). This example illustrates that male mantids do not take the risk of sexual cannibalism lightly. They evaluate their likelihood of producing offspring given their current environment and make their mating decisions based upon analysis of cost versus the ultimate reward: reproductive success.

On the flip side of our previous discussion, it is also critical to consider why female mantids engage in sexual cannibalism. Studies such as Katherine L. Barry et al.'s "Female Praying Mantids Use Sexual Cannibalism as a Foraging Strategy to Increase Fecundity" and T.R. Birkhead et al.'s "Sexual Cannibalism in the Praying Mantis Hierodula Membranacea" analyze the risk and reward of sexual cannibalism from the female mantid's perspective. Both studies were particularly concerned with the effect of sexual cannibalism on the female's fecundity, or fertility. Increased fertility and overall chances of survival due to the nutrients gained during consumption of the male could be motivating female mantids engage in sexual cannibalism (Barry et al.; Birkhead et al.). The amount of food given to females in these studies was manipulated, but the variables measured differed between the two studies. In Birkhead et al.'s study, the weight of the eggs produced by female mantids was recorded along with the frequency of cannibalism; in Barry et al.'s work, the weight of egg sacs and occurrences of sexual cannibalism were also recorded, but the data included additional information on the size of the females themselves before and after cannibalism occurred.

Ultimately, females who were kept well-fed were better primed for reproductive success, produced more offspring, and consumed their mating partner at a lower frequency (Birkhead et al.). On the other hand, the data collected in both studies indicated that hungry females who cannibalized had bigger egg sacs compared to those who did not engage in this behavior. Barry et al. stated that "the difference in ootheca [egg case] mass between the groups [of the study] indicates that sexual cannibalism could increase females' reproductive output by up to 40%" (Barry et al, 713). It was also found that females who were emaciated and thus more desperate for nutrients were more likely to engage in cannibalism than females who were healthy. For the females who were starved, eating their mate improved their health condition (Barry et al.). As with the males,

female mantids are carefully evaluating their needs as they participate in mating encounters and make decisions about sexual cannibalism.

Another facet to consider when evaluating praying mantid mating behavior is that of the potential role of female deception in order to attract male mates. Hungry females could benefit nutritionally by communicating that they are looking for a mate when, in reality, they are only looking for a meal. In a study entitled "Mate Attraction by Females in a Sexually Cannibalistic Praying Mantis," Jonathan P. Lelito and William D. Brown utilized this angle in their research of sexual cannibalism in praying mantids. This study used honest and deceptive signaling theories. Honest signaling theory focuses on honest communication between animals, and thus when "a signal is reliably linked to the true motivation of the sender" (Lelito and Brown, 314). The alternative, deceptive signaling, utilizes dishonest methods of communication demonstrated in examples such as animals who convey that they are stronger than they actually are to scare off a potential predator or predators using the traditional mating signals of their prey to lure prey in (Lelito and Brown). It is important to note that dishonesty can result in punishment and thus comes with risk.

Lelito and Brown wanted to know if honest or deceptive signaling was used by females when attempting to attract a mate. They separated females into different categories: hungry and fed, and virgin or mated. Cages of female mantids were set up in a field, and observations of wild mantids approaching the cages were recorded. Their data showed that previously mated females attracted less males, as did hungry females (Lelito and Brown). These results align with honest signaling theory and tell us that females are not aiming to deceive potential mates in their efforts to reproduce.

Further research is required to explain the intricate details that are involved in this cannibalism act. In the particular species of praying mantid Barry et al. investigated, *Pseudomantis albofimbriata*, the size of the males is around 40% of the total size of the females (Barry et al.). Barry et al posit that this size ratio contributes to the occurrence of sexual cannibalism as a meal of this size could positively impact both the reproductive and survival success of a female mantid, particularly when a female is lacking nutritional resources. However, they also note that in other species that demonstrate sexual cannibalism, a comparable size ratio does not ultimately benefit

the female (Barry et al.). Observations such as this warrant more study to uncover what benefit sexual cannibalism confers to the female in these scenarios. The evolution of such a behavior is also of interest, as the impact of this behavior on a population as a whole can be monumental (Buskirk et al). Studies into the reproductive success of males who have been cannibalized versus those who have not could add valuable data to this field of study.

CLOWNFISH

For the next two mating behaviors of interest, we move from the fields and forests of the praying mantid to the fascinating environment that is the ocean. In the sea anemone world of the clownfish, there is a tightly regulated social hierarchy that exists among communities of clownfish living in coral reefs (Casas et al.). Their hierarchy is organized based upon size and contribution to the overall community, with the smallest fish being the most subordinate while the largest two fish compose the "dominant breeding pair," according to Lucy M. Fitzgerald et al. (3). There is only one female in the entire community; she is the largest and most dominant of the group (Fitzgerald et al). When the dominant female dies, the community shifts, with each fish moving up within the hierarchy (Fitzgerald et al). Surprisingly, the male from the dominant breeding pair moves up in the social hierarchy by undergoing biological changes in order to become the dominant female (Casas et al). This reproductive strategy is known as functional hermaphroditism (Casas et al). It seems counterintuitive that such a complicated process within the clownfish community could be advantageous for the species. How do clownfish accomplish the change in sex biologically, and how does this behavior affect them socially?

Once the dominant female is gone from the clownfish community, it takes approximately fourteen days for the sex change process to begin (Casas et al.). The male begins this process with gonads consisting of a mature set of testes but immature ovaries (Casas et al.). As they transition, the testes degenerate until they are completely broken down, and the ovaries take over as the fully functioning gonadal tissue (Casas et al.). Changes in gene expression within the clownfish who changes from male to female were investigated by Laura Casas et al in their 2016 article, "Sex Change in Clownfish: Molecular Insights from Transcriptome Analysis". They found that differential expression of particular genes

in the brain causes changes in hormonal expression, which eventually cause differential expression within the gonads themselves. Genes like CYP19A1, also known as aromatase, are key as they are critical in regulating the amount of estrogen in the fish, thus facilitating the change from male to female (Casas et al.). They also identified two other genes that regulate expression of the aromatase gene and the hormonal pathway.

The social behavior surrounding this change in hierarchy is equally as regulated. In "Rank Change and Growth Within Social Hierarchies of Orange Clownfish, *Amphiprion Percula*," Fitzgerald et al. found that at each level of the hierarchy, the fish on the level above maintained a size "approximately 1.26 times the size of its immediate subordinate" (4). Maintaining this specific ratio protects the fish and allows it to stay within the safety of the community without conflict; if the hierarchy is challenged, this could mean death or eviction for fish who broke rank (Fitzgerald et al.). Once the hierarchy is shifted, the fish who move up in rank seize the opportunity to capitalize on the change in resources and grow (Fitzgerald et al.).

You may be wondering if clownfish ever choose to leave their communities or fight the norm, as there are clear benefits to being higher up within social ladder. In fact, as Branconi notes, "Individuals that forgo their own reproduction in animal societies represent an evolutionary paradox because it is not immediately apparent how natural selection can preserve the genes that underlie non-breeding strategies" (Branconi et al, 1). Branconi et al. show that, in fact, clownfish do leave their groups or contest the hierarchy when a suitable opportunity presents itself. In their 2020 article, "Ecological and Social Constraints Combine to Promote Evolution of Non-Breeding Strategies in Clownfish," Branconi et al. studied populations of clownfish in the wild to determine when clownfish will opt go against the rules of the community. Clownfish will either leave the group or contest their position within the group when the risks of such behaviors are reduced. In such a scenario, it is less likely for the clownfish community to either attack or kick out a clownfish that violates the social order.

Based on these findings, why would clownfish evolve to create a system where they will likely be in a subordinate role within their group? In Peter Buston's article, "Size and Growth Modification in Clownfish," Buston studies the social hierarchy of the clownfish and how this unique social system benefits both the individual clownfish and the group as a whole.

He studied clownfish communities in Papua New Guinea by recording their growth and analyzing their social structure. Buston's data reiterates the findings of Fitzgerald et al.; clownfish do regulate their size to stay within a very particular and well-defined ratio (Buston; Fitzgerald et al.). Buston also goes a step further and discusses how the regulation of growth is a unique conflict avoidance strategy, as most animals actively engage in conflict when threatened by others within their group. Thus, the social system used by the clownfish is a beneficial strategy for mediating potential evolutionary conflicts and keeps members secure within the group as they regulate their size and are not perceived as a threat. Branconi et al. also note that "it is a combination of ecological and social constraints that promote the evolution of non-breeding strategies" (5).

There are additional questions that need to be answered in regards to this fascinating clownfish behavior. In other species of fish living within coral reefs, the males prefer to wait to see if a new, dominant female will arrive before initiating the sex change process (Casas et al.). Because the process of changing from male to female requires much energy and time, the male would rather save these resources until it is evident that a new female will not be joining the community (Casas et al.). This begs the question of why clownfish opt to immediately begin the transition without a waiting period. What additional advantage does this bring them that outweighs the investment of resources required for the sex change?

It is also important to consider the effects of climate change on these populations of clownfish and how the environmental changes may impact their behavior in the future (Fitzgerald et al.). Fitzgerald et al. found that the type of anemone that a clownfish community lived in influenced the growth rate of the hosted fish. It will be important to evaluate what changes may occur as the types of anemones available to clownfish are impacted by global warming and to prevent harm to this species and many others while we still can.

ANGLERFISH

If a species living in a wide-spread and challenging environment struggles to find a mate, sometimes biological creativity must come into play to ensure the species can reproduce and survive. The deep-sea anglerfish, otherwise known as ceratioids, is an interesting example of such biological

creativity (Swann et al). Living in the dark depths of the ocean, it is rare for the deep-sea anglerfish to come across a mate. While this environmental factor could potentially create issues in the anglerfish's ability to produce enough offspring for species survival, evolution has allowed for a strange solution to this problem in some anglerfish species. It is through a form of sexual parasitism known as parabiosis that these anglerfish are able to ensure reproductive success (Isakov; Swann et al). Jeremy B. Swann et al. define parabiosis as "a form of naturally occurring anatomical joining" (1).

The first official case of sexual parasitism in a species of anglerfish was documented in Sofia Vieira et al.'s article, "Sexual Parasitism in the Deep-Sea Ceratioid Anglerfish Centrophryne Spinulosa Regan and Trewavas (Lophiiformes: Centrophrynidae)." Vieira et al. observed and measured a conjoined male and female anglerfish. The male was observed to be much smaller than the female to which it was attached, and degeneration in the male form was observed. Diagrams were drawn to show the size difference as well as the manner in which the anglerfish were attached. It is clear that the investigators were captivated by this finding, and the avenues for future research were flooded with new questions.

Since this original study, the reproductive behavior of anglerfish has been carefully studied and documented, and much more extensive knowledge has been gained. To find a mate, the dwarf male anglerfish follows pheromones released by the female (Isakov). When he finally happens upon a female in the depths of the ocean, he uses his teeth to grab the female and attach himself to her (Isakov). The length of time over which this attachment occurs varies depending on the species of anglerfish, but in some species, this attachment becomes permanent (Swann et al.). To become permanent, proteins from the male cause the female tissue at the site of attachment to eventually dissolve (Isakov). A fusion then occurs between the male and female anglerfish; eventually, all that remains of the male is the testes, which get nutrients via the circulatory system that was joined with the female (Isakov). In some species of anglerfish, females are even known to be attached to multiple males at the same time (Swann et al.). Due to this arrangement, sperm can be supplied many times to the female, and offspring can be continually produced in an otherwise reproductively challenging environment (Isakov).

In vertebrates such as the anglerfish, an event like this would usually initiate an immune response. This would ultimately lead to the destruction of the foreign tissue (Swann et al.). In a typical immune response, foreign antigens known as major histocompatibility complex (MHC) are targeted by antibodies (Swann et al). In Swann et al.'s article "The Immunogenetics of Sexual Parasitism", their whole genome sequencing studies showed that anglerfish exhibiting this sexual parasitism behavior had undergone major changes involving the genetic systems. Variation in two major histocompatibility genes, *MHC1* and *MHC2*, was identified, as well as several other genes associated with the immune system. Arseny Dubin et al. continued this field of study by sequencing genomes in a particular species of anglerfish, *Lophius piscatorius*, in their article "Complete Loss of the MHC II Pathway in an Anglerfish, *Lophius Piscatorius*." Three elements of the MHC II pathway, namely CD4, CD74 A/B, and MHC II α/β, were not found to have genes present in Lophius piscatorius; therefore, the MHC II pathway was completely non-functional in this species. In order for the MHC II pathway to become non-functional, multiple genetic deletions in many locations must have happened over time.

The immune system's ability to attack antigens not belonging to itself is compromised or lost entirely in these species of anglerfish; however, what we would anticipate as being a deadly loss of adaptive immunity incredibly does not affect the ability of the anglerfish to survive (Isakov; Swann et al.). How has evolution played a role in allowing the deep-sea anglerfish to practice this bizarre reproductive behavior without eliciting such an immune response? Martin Malmstrøm et al. investigated one part this critical question in their article, "Evolution of the Immune System Influences Speciation Rates in Teleost Fishes." They aimed to trace the evolutionary lineage of the loss of adaptive immunity in anglerfish species. The genomes of sixty-six different species were analyzed, and both MHC I and MHC II genes were evaluated and contrasted between the species. Three known ortholog genes, or genes found in common ancestors, were used as controls and could be found in each of the species studied. MHC II gene loss was discovered within these species. However, the copies of MHC I genes were found to have increased within most of the species studied. When looked at evolutionarily, it was found that the increase in MHC I genes occurred after the loss of MHC II genes (Malmstrøm et

al.). The data collected in this study leads to the suggestion that MHC I genes are important for speciation and speciation rate in anglerfish.

Many questions remain about the anglerfish. It is still unknown how the anglerfish can survive and protect itself from disease with such a major loss in its adaptive immune system (Isakov). Swann et al. hypothesize that the innate immune system has been restructured to compensate for the losses in adaptive immunity. They suggest comparative studies into the evolution of innate and adaptive immunity to test this hypothesis. It is also unknown how the current sexual parasitism behavior came into existence. Did the immune system of anglerfish change first to allow for parabiosis to occur, or was this reproductive behavior favored and then followed by the adaptation of the immune system (Swann et al.)? Further research is required in this area.

Beyond the behavior and evolution of the anglerfish, these findings could lead to invaluable knowledge in the world of immunology for other vertebrates. In "Histocompatibility and Reproduction: Lessons from the Anglerfish," Noah Isakov notes that in mice and humans, loss of adaptive immunity, like that which has occurred in these anglerfish, severely compromises the immune system. Perhaps if we can learn more about how the anglerfish evolved in this way, we can begin to address issues like that of organ rejection during surgeries and the need for medications the suppress the function of the immune system (Isakov). Future studies into the anglerfish could yield answers that benefit human medicine for years to come.

CONCLUSION

Though bizarre, mating behaviors like these have given us more information about the world we live in and the adaptation that occurs to facilitate life. The sexual cannibalism of the praying mantid, the social hierarchy and functional hermaphrodism of the clownfish, and the sexual parasitism of the deep-sea anglerfish teach us much about evolution and how animals have found ways to optimize reproduction under a variety of challenging and changing circumstances. This field of research also gives us new information about and a new lens with which we can evaluate issues ranging from global warming all the way to organ rejections during transplants. Much work has been done, but new doors for further investigation have been opened too. It is up to future scientists to continue on this path toward knowledge which will continue to teach us about the past and help us improve our future.

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HUMANITIES

GRIEVING THROUGH PARTICIPATORY ART: ALTERNATIVE SPACES AND RITUALS

Evie Cross

Grieving across cultures is a participatory practice. Artists David Best and Nene Humphrey use their bodies of work to allow for participation in alternative grieving practices. Best is most well-known for his wooden temples built and then burned at Burning Man, an annual arts and cultural festival in the Black Rock Desert, Nevada. Humphrey is known for her work in performance art and installation. In different ways, these artists both work with grief and grieving practices. Best and Humphrey open up spaces within their works to allow visitors or participants to grieve by encouraging communal remembrance, public grieving, and the infusion of memory into physical objects. This investigation into grief will begin with an overview of traditions, especially those relevant to understanding Best's and Humphrey's work. It will focus on specific works by both artists: Best's *Temple* (2015) in Londonderry, Ireland and Humphrey's installation, *The Plain Sense of Things* (2007-2009). *Temple* is a seventy-two-foot wooden structure built in Northern Ireland to mark the end of a decades-long period of violence between Catholic and Protestant groups in the region. *The Plain Sense of Things* is a longitudinal work, beginning as an amalgamation of wires in patterns and shapes similar to the nervous system and evolving into a performance of singing, braiding, and presenting images of the brain. Best's work will be analyzed through existing scholarship while Humphrey's will be primarily analyzed through personal interview. Finally, these artworks will be compared to show how they individually allow for alternative grieving practices. Through this comparison, the differences in practice and the effect on participants will highlight the importance of multiple alternative grieving methods and spaces in a progressively secular and transcultural society.

A group of nurses conducted interviews with grieving families to record data on grieving practices across different ethnicities and countries. The nurses found that after the death of a person, people in mourning practice rituals of all kinds to honor and remember the dead and to support those left behind. Rituals and traditions are essential to the grieving

process and are to facilitate emotional healing by providing a safe space to express emotions and community support (Hidalgo et al.). Grieving rituals also offer a way to stay connected with family and friends. Many grieving traditions are tied to religious practices; therefore, there is also a wide range of different grieving approaches, considering the great number of religions. Despite this range, there are still a few shared characteristics of grieving practices across cultures. Most grieving practices include music, singing, food, and gatherings for close family and friends (Hidalgo et al.). These commonalities help show how *Temple* and *The Plain Sense of Things* can serve as grieving spaces and rituals. In both artworks, people gather with the intention of mourning. Both Best and Humphrey create spaces where emotions of grief are allowed, and those emotions can be expressed or understood through gathering with others or participating in the works.

It is essential to look at a few ways people from different cultures grieve beyond their shared traditions; however, this history is in no way complete nor broad. Some cultures encourage the outward portrayal of emotions. For example, funeral wailers, are women designated to cry loudly at funerals. Wailing occurs at Jewish funerals and in Romania. East Asian countries also expect weeping and wailing. In China, if one does not show their grief, it is seen as a failure to fulfill one's family duties. One interesting aspect of wailing and outward grief is that people who choose to wail can often feel a unique connection with the deceased not felt at other times in the grieving process. On the other end of the spectrum, some cultures do not support the outward emotions of grief and even discourage it. For example, Japanese Buddhists believe crying for deceased loved ones will stop them from entering the afterlife. In many grieving rituals practiced by white Americans, those with outbursts of emotion are often taken away from the rest of the group during mourning gatherings (Hidalgo et al.). These examples show that the emotional processing of grief can look very different depending on the culture, despite often including a group gathering. Best and Humphrey create new environments with their artworks that are participatory and accepting of bereavement. This setting allows for alternative grieving that does not require the close following of tradition, such as including close family or friends.

Alternative spaces and rituals for grieving are necessary as cultures become more integrated and mixed over time. Traditions are important

and can provide constancy, but it is also important to provide ways to express grief under nontraditional circumstances. These nontraditional expressions are especially important as death is continuously more medicalized. Medicalization is a way of treating nonmedical problems, such as death, as medical problems. One example of the medicalization of death is hospitals barring families from visiting sick family members face to face during the height of the COVID-19 pandemic (Garber). Another example is the transition of end-of-life care from the home by the family to a care setting like a hospital by medical professionals. As medicalization in Western cultures has increased, there has also been an increase in the secularization of death. Society sees death as less of a spiritual event requiring community and connection and more as a medical event requiring medical treatment. Some sociologists believe that living people need to connect to the past to feel secure in their future (Walter 36-38).

With growing secularization and the intermingling of cultures and traditions, there is a new need for alternative methods and spaces of grieving to connect to the past yet still fitting the values and preferences of people today. Sara McDowell and Elizabeth Crooke noted that by creating a new space with *Temple*, not owned by one political group, there was much more freedom to mourn, gather, and express emotions (McDowell and Crooke). Nene Humphrey herself had a similar observation about her work. She said that the loss of someone very close to them entirely changes one's perspective on life. Humphrey observed "once you start thinking about death as we are all born, we all die . . . When you really experience a deep loss that sense becomes heightened . . . I'm not sure you can understand that any way besides experiencing the loss" (Humphrey). She contends anyone can point to a time of significant change in their life, and it is often linked to loss. She also notes each participant in her work, from the collaborators to the performers, was working through their own grief. Though the performers did speak to each other while braiding, they each had opportunities for introspective exploration to understand their role in the project and their place in the grieving process (Humphrey).

Temple in Londonderry, Northern Ireland, was a memorial marking the end of a long period of violence between Unionists/Loyalists and Irish Nationalists/Republicans. It was made in collaboration with Artichoke, a group known for making public art, especially temporary participatory

works. *Temple* was a 72-foot-tall wooden structure with pieces of wood intricately cut by Nerve Centre's Fablab, a creative media arts center in Northern Ireland (*Temple*: David Best). The cuts of wood are comparable to the most intricate paper snowflakes. In fact, children from surrounding schools were asked to cut paper designs that would later be used to adorn the temple as wood pieces and their designs resembled snowflakes. The temple is unlike an ordinary temple or building. It is an open structure not meant to house or shelter. The wood pieces used in the temple are thin and have more cut-out spaces than wooden spaces; it is impressive that the structure can remain standing. Light also streams into the interior of *Temple* through the cut-outs. The wood is light-colored, unfinished wood. While the architecture and decoration are intricate and unique, the material is simple and humble. Architecture critic Phineas Harper notes that the architecture of *Temple* opposes the rigid and more plainly decorated architecture typical of the area (McDowell and Crooke). This ornate yet humble nature makes the structure wondrous and approachable. It is light and airy, not heavy and stoic. It is welcoming and unassuming.

Each step of *Temple*'s construction was participatory. Nuala Ernest describes Best's temple designs as "90 percent intuitive and ten percent planned in advance" (39). The funding for the project was crowd-sourced. Volunteers within the Londonderry community constructed this building in early 2015. After its building, over 60,000 people visited the temple. Some visitors brought notes, letters, pictures, or objects owned by loved ones who had passed. Visitors were also given wooden boards to decorate and add to the structure the week before it was intentionally set on fire. In its final stage, the people of Londonderry watched as *Temple* was burned. The burning was especially important because violent groups in Londonderry had previously used bonfires as a symbol of Nationalism and exclusion (McDowell and Crooke).

Temple addresses grief and memory in many ways. It is first important to consider the origin of Best's temples. His first temple was built at Burning Man in remembrance of a friend who was killed in a motorcycle accident. Festival goers brought mementos of their dead loved ones, and the temple was eventually burned. Best sees the burning of his temples as a way to protect and release feelings of grief (Ernest). Londonderry's *Temple* evokes a history of violence and division that made it difficult for different groups

to have one shared space to grieve and gather. *Temple* is a type of site-specific installation that allows participants and visitors to consider not just the temple but the temple in the environment of Londonderry. It is a communal space for opposing groups to process their emotions, remember loved ones, and heal from decades of communal trauma (McDowell and Crook). *Temple* as an installation has the power to erode art space to create a social space (Reiss). The temporary nature of *Temple* is different from traditional grieving practices and permanent memorials. Memorials around Londonderry were often for one political side or the other, so they never bridged different communities to help them heal. These memorials were permanent markers of separation and condemnation for the opposite side (McDowell and Crooke). *Temple* had the unique quality of impermanence. McDowell argues that this impermanence encouraged visitors and participants to be more personal with their messages and more open to remembering and healing.

Nene Humphrey's *The Plain Sense of Things* is an installation work of multiple mediums focused on grief's internal and individual processing. It is made of an interconnected, tangled mass of crinkled black wire, wool, and red Epoxy-Sculpt spanning a wall. Humphrey used Victorian Era mourning-braid techniques to manipulate the wire and wool. Traditionally, in the nineteenth century in countries such as England and the United States, hair was cut from dead loved ones and braided to be worn by mourners as jewelry (Carey Dunne). Humphrey acknowledged how the braid was given a new context and meaning: "It's not the same ritual in this century. I don't have those same patterns of thought that they had. It was new based [yet] based on something very directly" (Humphrey). She engages participants by teaching them the mourning-braid techniques so they can add to her installation. Participants are taught the braiding before they perform, but they can come from any background. She taught musicians, professional singers, and former students for her stemming projects, such as *If you were to peer into the mourner's skul*l. In that work, Humphrey had participants braid red wire while reciting braiding instructions. This performance also features an audio portion, playing Tom Sleigh's poem *Circling the Center* (Albu).

The Plain Sense of Things and its resultant performances stem from Humphrey's personal journey through grief after the loss of her husband in 2006. She was researching grieving and mourning practices and came across Victorian mourning braids. Here, she saw a connection between the

crossing over of hair and the crossing over of neurons in the amygdala, the brain's emotional powerhouse. Working as the Artist in Residence at the LeDoux neuroscience lab at New York University, she found an additional meaning for Victorian mourning braiding. By teaching braiding to others and explaining its background, each fellow artist, performer, or audience member could apply the ideas and practices of braiding to their own personal experiences. Humphrey sees the braiding as an important visualization and acknowledgment of grief in a culture that focuses more on moving on from grief than talking about it. *The Plain Sense of Things* creates a space and environment where personal grief is materialized and visible. The expression and processing of grief is encouraged. Importantly, Humphrey notes braiders whisper instructions but do not really talk to each other. While the performances and braidings are communal events, the emotions and the physical braiding with the hands are individualized (Humphrey). In this, there is no expectation of how a person should braid or feel. Participants are free to feel and braid with whatever personal touches they choose.

Both Best and Humphrey encouraged participants to build or add to their visual works physically. This contribution results in the materialization of grief and emotion of the artists and the participants. Both Best and Humphrey direct the work to a degree: Best created the general design of *Temple*, and Humphrey researched and taught the braiding for performances of *The Plain Sense of Things*. However, the physical presence of their artworks would not be completed without the work of participants. *Temple* could not be built by Best alone, and *The Plain Sense of Things* would look very different without singers, projections, video work, and braiding from Humphrey's participants and collaborators. Collaboration is essential to complete both works and is often a necessary component of participatory art, as pointed out by Tom Finkelpearl's writings (4).

By requiring participants to complete the work centered around grief, participants have the open opportunity to infuse their personal emotions into the physical works while also leaving personal touches. One specific example of a personal touch in *Temple* is the adornment of personalized planks and photos to the structure (McDowell and Crooke). Similarly, an element of personal creative input is present in Humphrey's work as she noted how each person's braid was slightly different, and she could pick out who braided which strand. Each hand had a personal

touch on the final appearance of the physical artwork (Humphrey).

Another important similarity between Best and Humphrey's work is the sense of temporality. Best creates a unique sense of temporary space, as *Temple* was burned seven days after completion. MacDowell notes that the temporary, transitioning space of *Temple* created a more open space for expression and remembrance. Many permanent memorials around Londonderry were created for one political movement or the other; they rarely commemorated loss on both sides. The temporary nature of *Temple* allowed it to be a grieving space for anyone, transcending the usual connotations of permanent memorials with partisan causes and losses (McDowell and Crooke). The temporariness also promised a release of emotions that may not have been previously processed or felt. Humphrey also works with ideas of temporality. From her personal perspective, she sees the use of ritual as a means of creating something that feels eternal: "In the performance you just come into something that's been going on for a long time and it will go on for a long time . . . Anything ritualistic has a sense of more than just the making of a thing. It becomes a whole process that has deeper meaning" (Humphrey). The objects may be ephemeral, but the ritual can be enduring. This temporality is also seen in Best's work as he continues the ritual of temple building and burning, but no temple remains standing today. The practice and ritual of braiding make *The Plain Sense of Things* meaningful and timeless. On top of this, Humphrey works with the ideas of grief and how grief can pass and change the human mind. The human body is temporary, but so is the state of emotion and memory. However, she also sees life and death as a greater cycle, once again referencing an eternal process beyond human control or understanding (Humphrey).

Best also uses the idea of eternal cycles. While his work is temporary and offers a more immediate release, he creates quasi-holy spaces. At his temples at Burning Man, people go seeking and expecting spiritual realizations. His architecture resembles church design while being socially ambiguous, so it is inviting to all. Christopher Langley notes that the temples represent transition and self-identity construction (22). At Londonderry's *Temple*, visitors are grieving an entire time period of militarized violence that began in the late 1960s (McDowell and Crooke). They are also looking to the future, marking a time of transition into a more peaceful period. Here too, Best deploys this idea

of cycles and the important aspect of impermanence in human nature. Humans have the ability to grow and change, even through grief, and are part of a greater cycle of life and death. In different ways, both Best and Humphrey are pointing to the impermanence of the human body and experience while also acknowledging the passing of time as constant.

While there are significant similarities that highlight the importance of new, alternative spaces and methods of grieving, it is also important to note the biggest difference between the works and how it affects the grieving process of participants. It is clear that Best's *Temple* is a social project meant to bring healing to individuals united by the tragedies of Londonderry. Humphrey's *The Plain Sense of Things* is less about uniting a group to focus on a single reason for grief and more about gathering to grieve independently. As mentioned, participants did not talk to each other while braiding and thus simulated isolation. This isolation is in contrast to Best's work since visitors were all gathering to grieve a specific period that occurred in a specific place. *Temple* provides space for communal healing of shared traumas. *The Plain Sense of Things* provides communal healing for individuals and varying traumas. Both artworks and spaces created are important because grief can be caused by many circumstances and may require various methods for healing. By offering more than one alternative for different types of grief, Best and Humphrey are individually working to shape a culture more open to expressing, processing, and discussing grief. As time goes on, societies and cultures are becoming more intermingled. Some groups long for tradition and other groups long for better methods. *The Plain Sense of Things* and *Temple* both combine traditions of public gathering into alternative spaces in an increasingly hybridized world. Hybridized grieving rituals such as Victorian mourning braiding and singing or visiting and adorning a wooden temple reminiscent of a holy structure that is later burned combine tradition and new practices to create new rituals for new or intermingled cultures.

Temple and *The Plain Sense of Things* are two participatory works of art focused on the emotion of grief. By being a part of the physical creation of the works, participants can work through their own grief and infuse it into the physical work. Both works show the temporary and constant aspects of life, providing comfort and understanding to participants. It is important to study these works together, as *Temple* focuses on shared events while *The Plain Sense of Things* focuses on individual experiences. Despite this

difference, Best and Humphrey are open about allowing grieving processes, which creates a safe space to process and emote. In a world increasingly secularized and blending, the alternative spaces and rituals for grieving created by Best and Humphrey provide new opportunities to process grief for people who may be navigating how to blend grieving traditions or find contemporary substitutes for them. Especially in Western cultures that focus on the quick recovery from losing a loved one, Best and Humphrey's work is essential in creating a culture more open to discussing and processing grief.

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EVERYDAY LANGUAGE ACQUISITION: A NON-NATIVE SPEAKER'S PERSPECTIVE

Gabriela D. Díaz Leguillú

Growing up on the beautiful island of Puerto Rico, I never thought the day would come when I would move and leave everything and everyone I knew and loved behind. I did not think that I would find myself in a situation where the extra conversational English classes my mom made my sister and me take in elementary school would be crucial to my everyday life. Yet life happened, and in 2016, my sister, mom, dad, and I had to take on a new challenge that many immigrant families face: moving to an unfamiliar country with a different culture and language.

While I admit that my fears could never compare to those of my parents when it came to encountering a language barrier, I did not realize how big of a role vernacular language fluency played until I began interacting with English speakers daily. My sister, Adriana, and I were lucky to have had an early bilingual education, but my parents had learned English mostly during their college years. This key factor influenced our ability to communicate efficiently with native English speakers. Adriana and I had often used English in casual settings—in conversations with our friends and watching Disney shows in English. In contrast, my parents spoke English mainly in academic, professional settings where most of their interaction with the second language was written and predictable. This difference led me to reflect on the importance of vernacular language acquisition for any language learner, as it contributes to one's ability to easily communicate with native speakers.

As I researched this topic, I did not find much academic scholarship about the way non-native speakers become familiar with colloquial, casual language, or slang of a second language. This essay will explore how I and other non-native speakers acquired, or are acquiring, vernacular literacy. The research method for this paper is ethnography, as I document my experience as a non-native speaker of English and compare it to that of my acquaintances. I conducted interviews with people who have attained slang fluency and compared the data. This paper aims to fill a gap in the

study of language acquisition. Many academic studies have been conducted about the way people learn a second language, but not many studies have been conducted about how people become fluent in slang. Because slang and everyday expressions are so intertwined with language and culture, non-native speakers acquire vernacular literacy primarily through immersion. Furthermore, the speaker's motivation to learn out of desire or out of necessity plays a key role in the process of this acquisition.

LEARNING LANGUAGE

Primary language acquisition is a fundamental skill learned at a young age. Magazine writer Melanie Howard notes the language acquiring process begins when one is in the womb. She further explains how an infant's brain functions as a learning sponge and how "we are wired to learn language" (Howard). To support this claim, she refers to a National Academy of Science study in which babies' brains exhibited blood flow in the left hemisphere, which processes speech in adults, when the babies heard a recording of a woman reading played both forwards and backwards. Conversely, adults only exhibited this blood flow while listening to the forward reading (Howard). She also talks about the multifaceted nature of language acquisition and how, even for babies, interactions with their parents are more helpful for their learning process than putting them in front of a screen. This interaction could arguably be the case for second language acquisition as well, because immersion is a multifaceted process and is more successful at teaching language than the typical process of language instruction in a classroom.

Second-language acquisition is vastly different from first-language acquisition. By the time a second language is learned, one's first language has been established, influencing the ability to achieve native-like proficiency. Research has shown that the same area of the brain processes first and second languages. Using a second language activates more neurons in the brain, indicating that the second language is not processed as efficiently as the first (Vance). Younger learners of a second language show a similar degree of brain activity between their first and second language, showing how the age of acquisition can play a role in language proficiency. However, the rate at which one acquires the language and the degree of fluency varies among individuals and the rate is

dependent on various factors due to the multifaceted nature of language acquisition (Vance). For example, someone exposed to a second language solely in its written form may consider themselves fluent in reading but may have difficulty understanding the language when spoken.

DEBATES ABOUT TEACHING SLANG IN THE CLASSROOM

Including slang in a class curriculum, where most foreign languages are first learned, is controversial. Spanish teacher Melissa Ann Barra contends the controversy stems from the belief that slang may be used inappropriately in a classroom setting (Barra 8). In her article "Teaching Spanish Slang, Familiar Language, and electronic Language in the Classroom," she argues that slang, a key feature of language and culture, should be taught in school because it allows students to communicate more efficiently in real-life scenarios and adds an element of authenticity to the course (Barra 10). Barra explores both oral and written slang used on social media among native Spanish speakers. Given the impact of technology, she believes that the neglect of teaching slang used in the electronic world is a disservice to students because language teachers should "teach them to learn to use it to learn and communicate" (Barra 9). Despite slang's evolution and variability, Barra proposes teaching students colloquial words and expressions can get their attention in the classroom, allow them to communicate proficiently with native speakers, and expose students to various cultures. One of the reasons she supports teaching slang in the classroom is that "language and culture cannot be separated" and that "to learn such informal language is to learn an aspect of a culture and people from which it comes" (Barra 11-12). As a non-native Spanish speaker, Barra was unfamiliar with many colloquial terms and had to learn them from coworkers who were native Spanish speakers. Learning these expressions via Internet sources was hard because she found few sources that provided definitions. She mentions a time when she traveled to Spain and realized she knew grammatically correct Spanish but not commonly used Spanish (Barra 14). While not comparable to learning through immersion, learning slang in a classroom could enhance the student's ability to connect and communicate in the second language to gauge how immersion influenced non-native speakers, Jasmin Hernandez Santacruz and Tamar H. Gollan tested English-speaking students before and after an eight-week study abroad program in Rome.

Santacruz and Gollan predicted t one of the reasons why immersion is successful at increasing second language proficiency is because it "[inhibits] the first language" of the speaker and encourages a degree of fluency in the second language (29). Despite this theory, the study concluded that the primary reason why immersion is successful is the "frequency" of exposure to the second language (29). The students' Italian fluency increased during the period of immersion. Their first language proficiency was temporarily impacted in an insignificant way; however, the benefit of on second language acquisition far outweighed the momentary inhibition.

METHOD AND FINDINGS

I interviewed several people who are either undergoing or have undergone the process of learning a second language. I drafted fifteen questions that would help me grasp how they learned a second language and how they became familiar with its vernacular features. These questions included prompts such as "What is your first and second language? What motivated you to learn this language? When did you start learning this second language?" etc. (The complete list of questions is in the appendix). Although my original plan was to look only at the transition from Spanish to English, I discovered that expanding my initial focus to include the opposite, English to Spanish, helped answer my question.

I conducted four interviews: two people whose first language was English and two whose first language was Spanish. In comparing the data, I noticed certain patterns. One of these patterns was the person's motivation for learning the language played a big role in the learning process. For example, I interviewed my boyfriend, Timothy, and my friend Janelle, both native English speakers. Timothy learned some Spanish in high school at an academic level; he believes that this established a mediocre foundation of the language and did not help him when using it to communicate with members of my family who are native Spanish speakers. Nevertheless, his desire to connect with my family and participate in my culture motivated him to learn more about the language. Now he is learning by "hearing people speak," which helps him to "understand context through repetition and culture" at an increased pace making him able to communicate better in Spanish. Janelle, who is half Cuban, also mentioned that forming connections with her dad's family was one of her biggest motivations

for learning Spanish. Janelle's learning experience looked different from Timothy's because she attended an "immersion school" where the classes were all taught in Spanish since she began her education. Janelle shared that many of her classmates who had the same experience did not become fluent in Spanish because they lacked the motivation to learn. Both Timothy and Janelle wanted to form connections through communicating authentically with the people who speak Spanish in their lives.

In contrast, when I asked my parents, who are native Spanish speakers, about their motivation to learn English, they both answered it was necessary to succeed in college and their professional careers. Their experience with learning English was different from Timothy's and Janelle's. Denisse, my mom, and Duaen, my dad, both took English classes throughout their school career, but they learned most of their English in college and their jobs. They think the English classes offered in elementary and secondary schools in Puerto Rico often do not help students truly gain a comprehensive understanding of the language. Like Timothy, Denisse and Duaen learned that an academic foundation for a second language was not helpful when they had to use the language practically. Because most of their English was learned in post-secondary education, they both feel their "best English" is jargon used within their professional fields. In comparison, Janelle and Timothy believe that they have a better understanding of conversational Spanish.

I also asked the participants about their knowledge of colloquial expressions and slang in their second language. I asked if they have gained a level of fluency when it comes to the vernacular aspect of the language and how they achieved it. When comparing all the interviews, I noticed that they all agreed their vernacular literacy was very low. None of them considered themselves "slang fluent." Furthermore, in most cases, they believed this to be one of the obstacles to communicating efficiently with native speakers of the second language. They also agreed that immersion was the best way to acquire vernacular literacy because it directly exposed them to the authentic language. The participants mentioned other things that helped their learning process, like music and television, but they did not play as big of a role as immersion in the acquisition process. Janelle pointed out that she has learned colloquial expressions through listening to Spanish music, but she does not understand their meaning because this method does not provide the cultural context of such expressions. My parents

explained that while they are both fluent in the English language, they feel like outsiders in casual settings because of the constant use of informal language, which often hinders their ability to follow a conversation.

Finally, I asked the participants if they believe it is important to be familiar with the colloquial aspects of a language. The answers to this question resulted in two important elements. First, while the participants believed it is essential to know colloquial expressions and slang to fully participate and understand a specific community and culture, slang is not necessary to successfully communicate or be considered fluent in the second language. For example, Janelle has always lived in the United States and explained that she interacts with Spanish speakers from many different countries. Because of her diverse interactions, it is almost impossible for her to become completely slang fluent in Spanish since vernacular expressions are often specific to a country or region. Attaining a high level of vernacular literacy is not necessary for Janelle because these interactions are short-term and often only require a general understanding of the language to achieve successful communication. In contrast, Duaen, Denisse, and Timothy stressed the importance of having vernacular fluency as their situations differ from Janelle's. Timothy seeks to become thoroughly familiar with colloquial Puerto Rican expressions and slang because he wants to engage specifically with my family. Since he is learning Spanish that is specific to a region; he believes it is essential to attain vernacular literacy to truly understand my culture and language. Denisse and Duaen are adversely affected by their lack of familiarity with colloquial language. Since they live in a country where the primary language spoken is their second language, their inability to participate in many informal exchanges with their peers often prevents them from establishing meaningful relationships outside of their professional sphere. They both think they lack a lot of the vocabulary needed to communicate proficiently in a casual setting, which often results in restraining themselves from engaging in casual conversations with native English speakers.

CONCLUSION

Learning a second language can be challenging for many people. A language learner's interest in studying the language plays a big role in determining how fluent they may become in the second language. The

method through which they learn also prepares them to interact with native speakers in different, often limited settings. After conducting interviews with second-language learners and researching the topic of vernacular language acquisition, it is clear that immersion is the most successful teaching method. Due to the multifaceted nature of the learning process, direct exposure to the language and culture of native speakers provides a context for colloquial terminology and slang that a textbook cannot explain to non-native speakers. Establishing connections with people seemed to be a more successful driving force to attain fluency in comparison to learning out of necessity. Familiarity with colloquial expressions and slang was more important to the participants who found themselves excluded and wanting to participate in informal exchanges with a specific group of people. Immersion is the best way to attain vernacular literacy, and the speaker's motivation often contributes to the level of fluency they attain in the informal aspects of the language.

APPENDIX A: LIST OF INTERVIEW QUESTIONS

1. What is your first language?
2. What is your second language?
3. When did you start learning this language?
4. What motivated you to learn this language?
5. How did you learn this language?
6. Would you consider yourself fluent or not?
7. Are you mostly familiar with an academic level of the second language, or a more conversational one?
8. Are you exposed to the second language often?
9. Do you feel like you are able to follow casual conversations in the second language? Why?
10. Do you feel like you have a good understanding of colloquialisms in the second language? Why?
11. What have been the methods that have helped you familiarize yourself with casual, conversational [insert language]? Which of these was most effective?
12. Would you consider yourself slang fluent in your second language? Why?
13. Did you learn slang while you learned the second language or after?
14. How do you think the timing above impacted your ability to communicate with native speakers of that second language?

a. If you learned it after/while, how and why?

15. Do you believe it is important to be familiar with the colloquial aspects of a language?

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TEMPORARY REPRESENTATION IS NOT REPRESENTATION: THE BLACK EXPERIENCE AT THE NELSON-ATKINS MUSEUM OF ART

Symone Franks

I have visited the Nelson-Atkins Museum of Art in Kansas City many times and always had a pleasant experience. A couple of months ago, I visited the museum again and expected to find a new appreciation for the art, as I had not been in three years and had matured quite a bit. The experience was much different from the previous times. As I browsed the museum, I expected to be met with the familiar feeling of sophistication, but something had changed. I walked through the long corridors and could not see myself reflected in any of the pieces. I expected an upstanding establishment like the Nelson-Atkins Museum of Art to validate my experiences as a Black woman just as they would validate any other group of people, but the Nelson-Atkins could not deliver. It was as if I had opened my eyes for the first time. In the American exhibit, there were a couple of pieces that featured African American experiences, but even those were pictures of pain and suffering or white people's perception of Black people in America. Where else was there to look? I obviously would not be represented in Asian, European, or Native American art collections. In the African Art collection, there was little to no connection at all. I wish that I did feel connected, but that privilege was stolen from me. I felt alone and isolated; I started to wish I would have just kept my eyes closed.

The Nelson-Atkins Museum has been pushing a narrative of inclusivity and diversity. Recently, the museum hosted a temporary exhibit titled "Testimony" that was intended to celebrate local African American artists. It was open from June 5, 2021, to March 27, 2022 (African American Artists Collective featured in Nelson-Atkins Exhibition). This exhibit was created in collaboration with the African American Artists Collective (AAAC). The AAAC consists of around 150 members and was formed in 2014. According to the Nelson-Atkins informational page for "Testimony", the goal of the AAAC is to "identify and catalyze their practice as a means to support the African American and Black Arts movement in Kansas City, throughout

the country, and across the globe" (African American Artists Collective featured in Nelson-Atkins Exhibition). "Testimony" features thirty-five talented artists representing the multifaceted nature of the Black experience. *Survivor* and *DeadDeadNDead* are great examples of the exhibit's emotional range. *Survivor* by Jason Wilcox carries the theme of Black female empowerment and the will to survive, while *DeadDeadNDead* by Alton "AT" Webb carries a theme of trauma related to lynching in America. I viewed this exhibit in the fall of 2021 and thoroughly enjoyed my experience. Finally, I could enjoy a museum visit again without feeling invisible. However, I quickly realized that this exhibit was temporary and that feeling quickly faded. In a couple of months, when this exhibit is gone, everything would return to "normal," as if my representation only mattered for a short period of time.

The Nelson-Atkins exhibit "Testimony" is a step in the right direction, but it is not adequate in addressing the problematic behavior perpetrated by the museum and the extensive issue of underrepresentation in their collections. A temporary exhibit will not erase these problems, and it is ignorant to believe that it will. The Nelson-Atkins website briefly describes the mission of the museum: "The Nelson-Atkins Museum of Art invites all people to explore art in its care, and through its broad collection, the depths and complexities of human experiences" (The Nelson-Atkins Museum 2021 Strategic Plan). In this paper, I will explore instances in which the Nelson-Atkins Museum has contradicted its mission statement and how there must be more serious efforts to truly be an inclusive and diverse space.

THE RACIST ROOTS OF THE NELSON-ATKINS MUSEUM OF ART

When the Nelson-Atkins Museum opened on December 11, 1933, its purpose provided an aesthetic outlet to the people of the community and allow them to learn about different time periods, cultures, and experiences. As historian Kristie Wolferman observes, "The idea that viewing art was an almost religious experience was typical of the times. Art represented an advancement of mankind to a higher level of moral values" (121). Because the Nelson-Atkins was seen in this religious respect, there are still some remnants of this ideology in the way we currently experience this museum. It's important to acknowledge this to understand the importance of representing many different cultures and ethnic groups. If some groups are not represented, it sends

a message that these groups are not worthy of aesthetic attention.

Mary Atkins and William Rockhill Nelson founded the museum. William Rockhill Nelson was a well-known businessman in the Kansas City area. He owned *The Kansas City Star* and was known for being the mentor of J.C. Nichols, a known segregationist. Kansas City journalist Mike Hendrick comments, "Nelson was one of Nichol's best supporters and also built neighborhoods with deed restrictions forbidding the sale of houses to Black people. While Nelson was also known as a reformer who employed the newspaper as a bullhorn for community betterment and focused a spotlight on public corruption, he was an unapologetic segregationist . . ." (6a). In response, the museum considered changing its name and diversifying the board of directors, but it has not taken action on returning a Nigerian sculpture, as I discuss in the next section. I will further investigate into these situations and provide an in-depth assessment of their American Art Collection.

NAME CHANGE

During the winter of 2020, the Board of Trustees discussed changing or modifying the name of the museum because of cofounder William Rockhill Nelson's racist behaviors. *The Kansas City Star* published an article denouncing the paper's relationship with William Rockhill Nelson and called on the museum to make a similar statement. Julián Zugazagoitia, director of the museum, released a statement, ". . . an attempt to expunge a portion of the museum's history is not the answer to fighting racism or advancing our community. The better approach is to ensure and demonstrate that the Nelson-Atkins is a model for inclusivity and that our programs have a profound reach" (qtd. in Karash par. 13). The museum's hesitance to change its names as been tied to the large financial support that the William Rockhill Nelson Trust provides. One of the stipulations of this financial assistance is that the museum must bear Nelson's name. Kansas City reporter Savannah Hawley notes: "The Trust's financial contributions amounted to just under $1.8 million in both 2020 and 2019 for program fees, a large portion of its budget . . . motivation to right the wrongs of its racist history should not come second to finances" (par. 6,7). The sacrifice of losing that funding would have demonstrated the museum's commitment to the community it serves. Ultimately, the museum

chose money over removing the name of a person who would have directly opposed their supposed mission of inclusivity. Hawley comments further:

> Nelson cannot be remembered as a reformer and community advocate when he did not advocate for the whole community. In fact, he actively harmed our Black and Brown Kansas Citians. Our art museum is a fixture for all in the community, one that claims to be anti-racist. Upholding the name of a man who worked to disenfranchise and exclude people on the basis of race is fundamentally not anti-racist, and the museum can't claim to be until their past is dealt with (par. 10).

MAKING THE BOARD OF TRUSTEES MORE DIVERSE

Instead of a name change, the Nelson-Atkins Board of Trustees proposed the addition of five new members to promote diversity. The board added two White women, two White men, and one Black woman (Karash). Before these additions, the board room was mostly White men and women with the exception of one Black man. This is an absolutely laughable attempt at activism and is barely strategic enough to qualify as performative activism. The first step in changing the bias ingrained in the culture of the Nelson-Atkins is to truly diversify the board of trustees. How can these efforts for inclusivity be genuine if when we look at the boardroom, we see exclusivity? The authors of *Activating Diversity and Inclusion: A Blueprint for Museum Educators as Allies and Change Makers* explain this concept: "Museum leaders must analyze their institutional compositions, identifying the gaps, and recruiting board members from local community organizations, businesses, and sectors to ensure that their team reflects the diversity of the communities in which they are situated" (Ng et al.). Based on this information, it is evident that black voices are not being heard or amplified in the Nelson-Atkins boardroom.

THE NELSON-ATKINS' "COMMEMORATIVE HEAD OF AN OBA"

The "Commemorative Head of an Oba" is a rare Nigerian sculpture that the museum acquired in the 1980s. It belongs to a group of sculptures in museums around the world called "Benin Bronzes.". Many museums in

Europe and the United States have started repatriating sculptures in their collection to the places of their origin (Paul). When the Nelson-Atkins was asked if it had any plans to return the bronze sculpture, a museum representative replied, "To date, we have not received any specific inquiries or claims about these works" (qtd. in Paul par. 24). The repatriation movement posed an amazing opportunity for the museum to show that they truly care about the people they allegedly strive to represent. The unwillingness to respect the opinions of the people to whom the sculptures belong makes me question if their quest for diversity and inclusivity is authentic.

AMERICAN ART COLLECTIONS

The American Art collection includes 116 works of art on view in the museum. Of those 116 works, only three pieces feature African American people ("Works of 'American Art'"). *Crapshooters* was painted by White artist Thomas Hart Benton and depicts African American men playing a game of craps. *Lynch Family* was painted by White artist Joseph Hirsch and depicts a mother in distress, holding her baby. It alludes to the fact that her husband was lynched. *Goodnight Irene* was painted by Black artist Charles Wilbert White and depicts a man strumming a guitar and singing to his wife. Of those three pieces of art, only *Goodnight Irene* was made by an African American artist. African American people are only truly represented in the American Art exhibit one time. It's crucial that American art reflects the composition of people that live in America. There are so many beautiful cultures that have influenced American life and American art and it's a shame that they are not being represented in this collection.

COUNTERARGUMENTS

Some people believe the Nelson-Atkins Museum is diverse because its collections include African, Asian, American, and Native American art. This perspective is flawed because museumgoers should feel deliberately represented. Deliberate representation creates an experience that is unique to the viewer. The art presented feels genuine, and in turn, you connect with the intention behind the piece. On the other hand, partial representation creates an initial interest, but you leave feeling unfulfilled because there is a disconnect. For example, I experienced this disconnect when

viewing the African art exhibit. I enjoy looking at all of the pieces, but I feel no connection because I am not African. Even though the Nelson-Atkins displays a wide range of cultures, each one needs to be diversified. Being African American does not mean you identify with the American exhibit and the African exhibit. Racial identities are not one-dimensional. For this reason, there is a pressing need for an expansion of these collections.

Several individuals argue that "Testimony" adequately represents African Americans despite being temporary. They debate that it is admirable that the Nelson-Atkins is including any representation at all and that it is "better than nothing." This argument is dense and insensitive to those advocating for the bare minimum. It is not overdramatic to want equality in a public institution. Other collections get the privilege of permanency. Does African American art not deserve that same privilege?

CONCLUSION

"Testimony" itself is an exceptional exhibit that displays the varied experience of African Americans. The impact is short-lived, however, because the exhibit is temporary. The museum recently has found itself in problematic situations and has handled them poorly. While William Rockhill Nelson's racist past is not what I take issue with, I take issue with the way the museum is attempting to redeem itself. To truly redeem itself, there must be diversification of the board of trustees, the addition of art that represents marginalized groups, and the willingness to listen to constructive criticism. "Testimony" is an effort by the museum to acknowledge the gap in their collections, but it's not enough to acknowledge a problem if you're not going to fix it.

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PERFECTING THE ART OF NOTE-TAKING FOR MEDICAL STUDENTS

Arkadeep Ghosh

Many people use notes to journal about emotions, learn new material for classes, conduct business with peers, document sports teams, and remember what groceries to pick up that day. Note-taking is one of the most effective ways to retain information or reflect over ideas (Bloch and Piolat 101). Therefore, it is vital that people who need to learn a lot of information in a short period of time become masters at note-taking.

One group of people that deals with immense course load is medical students. Medical students have one of the hardest paths to obtaining their graduate degree. The work-load is never ending, and student stress levels are always rising. There is always more work to be done, and it feels as if you are drowning in textbooks. According to a study by the National Center for Biotechnology Information (NCBI), medical school is so difficult that out of the 13 countries they studied, suicide idealization varied from about 1.8% to 53.6%. The difficulty of medical school inspired me to pose the question: What writing techniques are effective or ineffective when taking notes, specifically for medical student coursework? Note-taking is known to be effective for learning material quickly and retaining that information (Thorley 660). Medical students have a lot of material to learn and retain. The need for medical students to know how to approach their note-taking is pivotal to their success as students and future physicians.

REVIEW OF LITERATURE

Researchers have that analyzed handwritten notes versus digital notes, the effects of note-taking on memory, note-taking's effects on recall versus recognition, various forms of note-taking, and how medical students take notes. The overall themes of the research answers two questions: "How does one take notes?" and "Why should one take notes?" For example, Awole Seid and Hafte Teklay address competence among third-year nursing students about note-taking (1). This research explores e how adept nursing students are at taking notes and why their level of

maturity varies. Craig Thorley's research also attempts to determine the effects of note-taking on the memories of jurors and whether note-taking improves or impairs their memory (Thorley 655). Despite this research, many aspects of note-taking have not yet been explored thoroughly. There is little research about medical students and t which specific techniquesthey should use and why these techniques are effective. My research will answer these questions and indicate commonalities between effective and ineffective note-taking techniques. My research shows that there are general trends that will prove, regardless of who you are, the specific techniques medical students should use in most scenarios.

METHOD

When I conducted this study in a English 225 course with John Barton in Fall 2020, I was a first-year medical student in the six-year B.A./M.D. at the University of Missouri - Kansas City (UMKC) All my life I have struggled with memorizing information for school and have recently I have performed better on exams, inspiring this research. Using these techniques, I have improved my grades significantly.

To obtain accurate relevant to medical students, I conducted research using the methods of case study, ethnography, and discourse analysis. My main method was case studies of four medical students in my graduating class at the UMKC. Each of these students was chosen for their high academic performance and ability to study effectively. It is also important to note that these students were not always so successful. These students struggled at first and learned how to take notes and study effectively using them. These students explained how they changed their techniques and habits, their current writing techniques, and why they believe the techniques they use are effective. The data I collected from each of the four students is a sample of their notes that include writing techniques they find valuable and their explanation of what techniques they use in these notes. I then compare the list of techniques I compiled from these four students to the list of techniques from Tamas Makany's study "Optimising the Use of Note-Taking as an External Cognitive Aid for Increasing Learning." Makany's study has an exhaustive list of different writing techniques and sample notes included with each technique. I used their research to supplement my analysis of each of the four medical students' notes.

Another method I used is discourse analysis of three sources. The first source I will analyze is a video on how to take notes effectively by Tara Allen, an anatomy professor in the UMKC medical program. Allen helps students learn how to study quickly and efficiently

My second discourse analysis will address "Note Taking and Learning: A Summary of Research" by Francoise Boch, and Annie Piolat. The authors make discuss principal functions of note-taking, main notetaking strategies, different factors that affect learning with note-taking, and learning to take notes (Piolat and Bloch 101).

My last discourse analysis will be of "Optimising the Use of Note-Taking as an External Cognitive Aid for Increasing Learning" by Makany. As stated before, I will analyze the extensive list of techniques they present and then compare this with what I have found from my student case studies, my professor Allen, and the study by Bloch and Piolat.

Field notes are an important research method. I planned to take field notes on students who were not performing average or above average. The goal is to be able to understand what techniques these students are using and why they chose to use these techniques. The next step is to try and use the previous four forms of research to analyze why their chosen technique is ineffective. The data I plan on collecting from this form of research is a list of ineffective techniques, why the techniques are ineffective, and the commonalities between these poor writing techniques.

Lastly, I surveyed my medical school class about their note-taking techniques, effectiveness, and commonalities between effective or ineffective techniques. I asked four questions with free response answer formats: 1) What are the most effective note-taking techniques you use? 2) Why do you believe each technique you chose is effective? The next two questions are the same except they say "ineffective" instead of "effective."

Case Study 1

For all my case studies, I asked participants which techniques they use and don't use. The first student used summarizing, paraphrasing, and brain dumping, or writing everything you know about one concept or topic on a blank sheet of paper. All these techniques are efficient and quick to use, which scholars contend is important. Makany observes: "Piolat et al. (2005) argued that the most fundamental reason behind the development of differ-

ent note-taking styles and techniques is severe time pressure" (Makany et al. 2). It is vital that a medical student's note-taking techniques can be repeated multiple times in a short period of time. Summarizing and paraphrasing are good techniques because they require the student to take sizeable quantities of information and put them in their own words. Brain dumping is effective because of it quickly indicates what you have not memorized.

Below are two examples of notes from Case Study #1. Figure 1 shows an example of how this student uses brain dumping to memorize certain structures in the respiratory system. This student said they like brain dumping because of how easy it is to complete and because it forces you to paraphrase texts. Figure 2 shows an example of the student paraphrasing what the professor said during the lecture. This student took definitions written on slides and simplified them to so they can understand and memorize the information quicker. The student said paraphrasing forces you to make sure you truly understand what is being taught. They are using writing as a learning tool to comprehend what is being said, which Makany et al. say is important (2).

Figure 1. (left). Case study 1: Brain dumping.

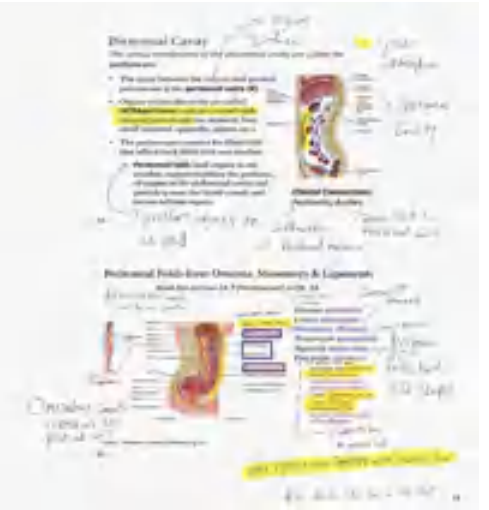

Figure 2. Case study 1: Paraphrasing and summarizing.

Case Study 2

This student said they consistently use brain dumping and drawing up the main concepts of lectures, chapters, or units. The student relied on memory to identify key idea from the unit. Figure 3 shows an example of this student employing this technique. The student also stated they used this concept summarizing technique most frequently because of its ability to ensure they are forgetting to study everything that is important for the exam. The student said there is so much information being taught, that it is easy to forget what should be learned. Summarizing the main concepts is a technique that coincides with Joseph Boyle's ideas, in "Note-Taking and Secondary Students with Learning Disabilities: Challenges and Solutions." Boyle states that professors should use a guided approach to ensure the student is making connections with all the key points from the lecture (97). Boyle maintains this technique will increase comprehension of the lecture and the amount of notes taken by students (97).

Figure 3. Case study 2: concept summarization.

Case Study 3

This student found redrawing notes without reference to the notes was extremely helpful and is known as brain-dumping visual imagery. This version of the brain dumping technique requires the student to draw images and can be useful for medical students who have to memorize the parts of the human body. The commonality I found among the three students is that each technique is requiring the student to think or recall without looking at the source. These techniques replicate quizzing, thus emulating the exams.

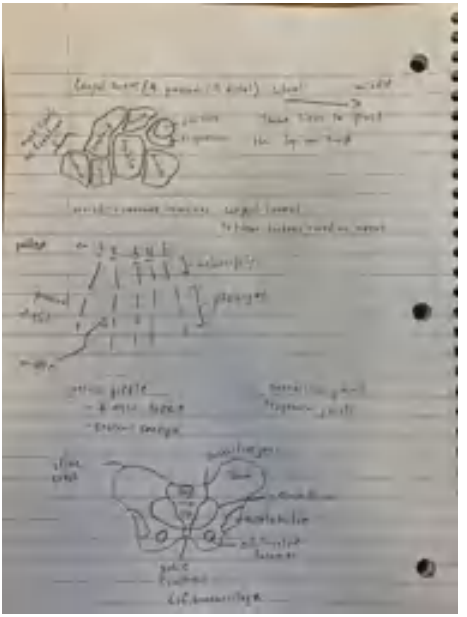

Figure 4. Case study 3: A variation of brain dumping incorporating imagery.

Case Study 4

The student had very similar responses to case study. This student primarily uses brain dumping with marking the important concepts during the lecture. After brain dumping, the student rereads sections of notes, paraphrases them, and then continues to brain dump until they feel they have fully grasped the concept. The student thinks the paraphrasing technique is effective because of how it constantly asks the student questions and does not allow the student to simply reread notes without actively learning or memorizing. This action is a big distinction among students. Some students actively study while others passively read their notes over and over. Students need to write answers on paper, quiz themselves, and paraphrase to engage with the subject.

Figure 6. Case study 4: Brain dumping technique.

DISCOURSE ANALYSIS OF ALLEN'S NOTE-TAKING VIDEO

Allen begins her video by stressing the importance of both the process and the product of taking notes, or how to take notes and what the notes should look like. She stresses that although the product is important, the process also defines a student's success in school. Then Allen talks about the inadequacies among note takers. She says the most common mistakes are "incomplete notes, missing important details, lacking examples, and inaccurate details." She then talks about a key detail: no matter how you take notes, you must be actively engaged in the note-taking process. This process means the medical student must not just copy the slide but attempt to paraphrase, summarize,

or actively listen in order to best grasp the material being taught.

One of the note-taking formats Allen suggests is Cornell notes, a system of subdividing into two sides. The left side has questions about the lecture material and the right side answers those questions. By asking questions, the student forces themselves to actively participate with the material. Furthermore, by writing the questions, a student should better remember the key concepts of the lecture and test themselves as they review.

Allen then describes techniques she finds effective when studying or taking notes: brain dumping, paraphrasing, Venn diagrams, and summarizing. Allen's advice reflects what students in my case studies do.

DISCOURSE ANALYSIS OF "NOTE TAKING AND LEARNING: A SUMMARY OF RESEARCH"

"The average writing speed of a student is around 0.3 to 0.4 words/second, whereas a lecturer speaks at a rate of around 2 to 3 words/second (Boch and Piolat 102)." This is especially true for medical students. As a medical student, you must be able to comprehend large amounts of information and take the most minimalistic notes possible. What techniques can a medical student use to do this? Bloch and Piolat recommend summarizing, abbreviating, or truncating (102). Truncating is taking large amounts of information and reducing it to its simplest form to have less material to study. It can be helpful to think of truncating as simplifying. Truncating material also serves as a form of active learning as the notes are being taken. Since the medical student is actively figuring out ways to simplify the content, they are may better understand the material as they truncate it. The hardest part is knowing what information is important to focus on. Knowing what information is relevant or irrelevant can help focus note-taking and save time. Some ways to know that the lecturer is delivering important information is if they write additional notes on the board or slides, slow their delivery, or stress certain parts of the notes, basic definitions, catch phrases, and highlighted material (Bloch and Piolat 103). In order to be able to catch these cues, medical students need to refrain from copying everything the professor says. Doing so may inhibit their ability to recognize when the lecturer stresses key parts of the material or highlights certain terms.

DISCOURSE ANALYSIS OF "OPTIMISING THE USE OF NOTE-TAKING AS AN EXTERNAL COGNITIVE AID FOR INCREASING LEARNING"

This research study primarily focuses on nonlinear note-taking techniques and their effectiveness in knowledge retention and performance for students. Nonlinear notes are more free-flowing and not as structured as conventional notes. These notes are organized but not written in the paragraph format most students use. An example of a nonlinear technique would be brain dumping and concept maps. According to the results of the research, nonlinear note-taking techniques are re more effective than the linear note-taking techniques in comprehension, accuracy, complexity, and metacognition (Makany et al. 11). Nonlinear notes force students to comprehend what they are taking notes on. With linear notes, a student can simply copy what is being said or what is on the screen. The importance of comprehending and being actively involved is proven again.

Observations/Field Notes

The most common techniques these students used for notes were rewriting their notes and rereading their notes. I then asked how they rewrote notes. These students said that they had the completed notes on one side and a blank sheet of paper on another. They then began summarizing notes as they read through the completed notes. This technique may by ineffective technique because there is no active recall. These students are not quizzing themselves while learning but instead are just rewriting notes which requires no comprehension of the material. This was the main factor I found in note-taking among students who didn't perform at the level they desired. In order for these medical students to become more successful, they should incorporate techniques involving active recall and comprehension of the information.

SURVEY

My last research method was to a survey of my medical class. Although only 28 students out of 100 responded, this survey gave me a more information. The first question I asked was, "What are the note-taking techniques you use when studying or taking notes?" The most common answers were summarizing, brain dumping, annotating minimally, and writing directly

on the lecture slides using a digital tablet. The second question I asked was, "Why do you choose to use the techniques listed above?" The most common answers for these were the fact that it actively engages the learner so that memorization becomes enhanced. The third question I asked was, "What are ineffective note-taking techniques you have used in the past?" The most common responses here were copying what the professor says, writing everything down, and copying slides. These responses correlate with my findings since none of these are a form of active learning that engages the learner. The last question I asked was, "Why did you find these techniques to be ineffective?" The most common answer to this question was that these students focused too much on writing everything down rather than listening for key information the lecturer points out. Since not every detail is tested, it is important to know key concepts that are high yield on the exam. It is important to note that most students in my class are and have been academically successful and that is why the most common answers match up with the previous research I have conducted.

Among students in my class, there are still forms of note-taking techniques that I found to be poor or misused. There were many responses that stated an effective technique they used was rewriting notes, reading the textbook, and rewriting lecture slides. There were also many answers to my second question that couldn't identify that a technique was effective due to active learning. Many people said repetition, familiarization, or even "to see what you know or don't know. These are factors that aid in memory; however, the primary reason to use a writing technique is to engaging in active learning.

CONCLUSION

Through my research, I have come to multiple conclusions about how medical students can improve their note-taking abilities and possibly to achieve higher academic success. The most important conclusion is that no matter what form of notes a medical student chooses to take, they must be actively learning through their note-taking technique or study technique. This is a requirement for any effective writing technique. It is especially important for a medical student to engage in their learning process this way because of the amount of memorization that is required. If a medical student loses focus, they will fail to learn many key details. This is why all four of

my case study medical students perform well. They have mastered the art of taking the notes while keeping themselves actively engaged with the content.

Next, it is important to know what notes should be taken or focused on. The lecturer is delivering important information if they write additional notes on the board or slides, slow their delivery, stress certain parts of the notes, basic definitions or catch phrases, and highlight material (Bloch and Piolat 103). This is a commonality of all four of my case study medical students in that they have very minimalistic notes. They do not repeat something or underline material that is unnecessary. Their ability to distinguish what material is important and should be emphasized in their notes is what separates them from the average medical student.

The next conclusion is that certain techniques are more effective ways of active learning. For example, using a summarizing technique forces the mind to actively engage in the material being taught which increases memory (Bonner and William 2). The best techniques that I have determined from my study are brain dumping, summarizing, paraphrasing, or any form of nonlinear notes.

Nonlinear note-taking techniques are more effective than the linear note-taking techniques in comprehension, accuracy, complexity, and metacognition (Makany et al. 11). The least effective techniques a student can use are rewriting notes, copying slides, copying everything the professor talks about in lecture, and just reading the notes.

Medical students also can experiment with other note-taking techniques, such as using Venn diagrams, a two-circle flowchart used to show similarities and differences between two topics, to compare ideas. Venn diagrams encourage active recall by quizzing the mind and exposing lapses in memory My study suggests medical students should use note-taking techniques, preferably nonlinear, such as brain dumping, summarizing, and paraphrasing that encourage active recall.

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USING MOOD JOURNALS TO COMBAT MENTAL ILLNESS

Nitin Nadella

Two years after the COVID-19 pandemic began, the World Health Organization (WHO) reported an approximate 27.6% increase in major depressive disorders as well as a 25.6% increase in anxiety disorders (W H O, 2022). The WHO report notes the pandemic disrupted key mental health services and school mental health programs and alcohol prevention and management programs. The resulting shift towards online mediums of mental care favored those who were younger and financially comfortable, pushing certain socioeconomic groups away from proper care (Ojha, 2020). With over 792 million people fighting mental health disorders around the world, the need to provide help has never been greater (Dattani, 2021). Thus, in an environment where mental health needs are still failing to garner support and recognition, it is crucial that individuals are empowered to address their own mental health concerns. It must also be noted that mental healthcare has many associated barriers of entry. For one-third of the world's population, there is a lack of adequate access because their countries "allocate less than 1% of their health budget to mental health" (Unite for Sight, n.d.). Moreover, a social stigma exists, influencing people at risk for mental health conditions to avoid seeking essential healthcare.

The American Psychiatric Association classifies depression as a common and serious medical illness that negatively affects how you feel, think, and act. Specific symptoms of depression include feeling sad, loss of interest in activities previously enjoyed, and feelings of worthlessness (Parekh, 2017). Considering the prevalence of depression, it essential that we address it. I propose journaling as an alternative to clinical, or traditional, forms of treatment. Moreover, people suffering from depression may allow researchers to analyze the positive impact literacy has on individuals in environments that have historically failed to recognize mental health needs.

Psychiatrists contend self-expression is one of the best ways to treat depression and similar mental disorders, a practice seen within psychother-

apy (American Psychiatric Association, 2017, Ranna Parekh). Journaling practices may help people deal with their mental health needs, but which specific journaling practices are most effective? How does journaling help individuals express themselves in ways that they have previously unable to and how does that positively impact their mental health? Research about journaling's effects on people with mental health disorders has been conducted, but certain inconsistencies must be addressed. A study by the Oncology Nursing Forum found that expressive writing was "a useful mechanism to deal with breast cancer and had an effect on physical functioning, depression, and anxiety" (Craft, 2007, p. 507). Although this study highlights the positive impact of journaling for people struggling with mental illness, it is important to acknowledge opposing perspectives. For example, S. Stosny states journaling can encourage an individual to live too much in their own head (Stosny, 2013). Journaling-induced narcissism is a concept that will be analyzed in the literacy narratives later in this article. My analysis will focus on determining if there are signs of narcissism in the authors' narratives as well as highlight certain techniques. My goal is to fill a gap in scholarship about journaling as a treatment for mental health problems.

My research regarding the role journaling plays in mental health will use literacy narratives from the Digital Archive of Literacy Narratives as primary sources. These narratives provide the experiences of individuals using journaling to overcome past trauma and take control of their present and future. My analysis indicates mood journaling and certain techniques have a positive effect on those suffering from mental illness in environments that have historically failed to address mental health.

A BRIEF REVIEW OF THE HISTORY OF MENTAL HEALTH

In ancient Egypt, Greece, and Rome, mental illness was often seen as a sign of weakness and mental health was regarded a private concern. During the Middle Ages, when the Catholic Church dominated peoples' lives in Europe, the mentally ill were associated with people who were not religious and therefore in need of salvation (PBS Online, 2022). During the 1840's in the US, negative associations with mental illness spread as the mentally ill were often inhumanely confined within developing prison systems (Unite for Sight, n.d.). Asy-

lums were infamous for their disregard for these individuals who were treated more like inmates rather than patients (Laurence, 2013).

However, during the nineteenth century in the US, activists such as Dorothea Dix helped revolutionize conditions for the mentally ill by pushing the government to fund the construction of over 30 psychiatric hospitals (Knapp, 2011). Because many hospitals were underfunded and understaffed, numerous human rights violations were discovered, leading to a push for deinstitutionalization. Deinstitutionalization efforts focused on using community-oriented care to help psychiatric patients and improve their quality of life rather than keeping them in isolated mental hospitals (Novella, 2011). Deinstitutionalization continues today, and its merits and downfalls continue to create debate among medical professionals about the solution for psychiatric patients. Opponents of deinstitutionalization argue this practice, primarily involving underfunded, community-based solutions, has worsened prison-like conditions for the psychiatric patient population (Novella, 2010).

In the 20th century, Mental Health America (MHA) was formed and continues to act as a major lobbyist working to help improve the lives of the mentally ill in America. Furthermore, laws passed such as the National Mental Health Act and the Mental Retardation Facilities and Community Health Centers Construction Act have helped create organizations such as the National Institute of Mental Health and National Alliance for the Mentally Ill that continue to create social welfare programs and help increase awareness for mental health across the country and world (NIH, 2021).

SCHOLARSHIP ON JOURNALING

Scholarship about journaling continues to explore its benefits and negative effects. The Oncology Nursing Forum (ONF) is an organization that aims to present oncology nursing research and evidence to improve cancer care, technology, education, and leadership. The ONF addresses the role journaling or expressive writing, plays in dealing with cognitive and affective distress. At the Breast Imaging of Oklahoma Hospital, the ONF conducted an experiment to determine the impact of expressive writing in newly diagnosed breast cancer patients. This s study aimed to assess whether expressive writing aided the psychological well-being of recently diagnosed breast cancer patients. Using three writing groups

made up of 120 participants, researchers found writing about breast cancer had a statistically significant increase in quality of life, as calculated via the FACT-B (an exam that measured the five main domains of health-care-related quality of life) (Craft, 2007, p. 507). Moreover, writing about exercise, diet, or sleep was found to be beneficial although not to the same extent as writing about the diagnosis. To better address the anxiety and the negative psychological repercussions that come with the diagnosis of breast cancer, expressive writing was found to be a useful tool.

Another study confirmed these findings. The National Library of Medicine and researchers at Pennsylvania State University helped establish a link between Positive Affect Journaling (PAJ) and anxiety symptoms. Using a total sample size of 70 individuals with elevated anxiety symptoms, the researchers assigned the intervention group to 15 minutes PAJ sessions to explore the link between anxiety and PAJ. Researchers found people in the intervention group (those who experienced PAJ) displayed decreased mental distress and fewer depressive symptoms (JIMR Mental Health, 2018). Ultimately, this study demonstrated that PAJ can improve various factors that are associated with psychological well-being, such as mild anxiety as well as other long-term health outcomes. Additionally, this research shows PAJ to better integrate individuals within popular culture and society as it has positive impacts on the perception of one's social environment. The idea of social reintegration is extremely helpful to individuals with mental health problems as they try to return to environments where mental health is as a taboo subject.

On the other hand, the negatives of journaling in addressing mental health must also be considered. According to Stosny, keeping a journal of one's thoughts, feelings, and experiences can have negative impacts on one's ability to reintegrate themselves in society. Stosny's research indicates that journaling can encourage individuals to focus too much on their thoughts, making them passive observers of life who wallowing in negative things (Stosny, 2013). This notion of wallowing is further supported in a study conducted by Sbarra, who found that expressive writing could further worsen psychological distress in people who are natural brooders, when looking at divorced couples (Matthews, 2017). Overall, these negatives can contribute to a worsened mental state. While the majority of researchers support journaling, researchers who question its impact suggest further study is needed.

METHOD AND METHODOLOGY

To research the effect of journaling for people with mental health problems in environments that fail to recognize their needs I conducted a case study of literacy narratives from the Digital Archive of Literacy Narratives. Literacy narratives provide a unique perspective for understanding the impact of journaling has on mental health. Focusing on the internal emotions of the narrators, these literacy narratives demonstrate the private domain of an individual, allowing us to better analyze the impact journaling has on an individual's mental health. The participants are individuals who have submitted their work to the Digital Archive of Literacy Narratives and have included their experience when it comes to journaling and its impact on their mental health. In order to maintain the anonymity of the writers, I used pseudonyms.

To frame my analysis, I define mood journaling as tracking one's emotions and feelings through different methods over a set time frame and then noticing patterns to identify ways to improve one's mental health. Some of the methods include journaling when one feels low or happy, as well as habit tracking throughout the day.

I conducted a thematic analysis of these literacy narratives to delineate a cause-and-effect relationship between journaling and its ability to aid with the private side of mental health. The case study research was limited to approximately nine literacy narratives. The literacy narratives can be split into three groups. The narratives can be grouped by 1) the link between journaling and its ability to address mental illness, 2) specific journaling techniques and their ability to address anxiety and depression, and 3) how journaling can help people in environments overcome the historical lack of concern about mental health. Additionally, as mentioned previously, an analysis of any signs of an internal focus will also be conducted to better address Stosny's research.

FINDINGS

To structure my analysis of the literacy narratives, I will first introduce the literacy narratives, their pseudonyms, and a brief introduction so it is easier to keep track of these narratives:

- Literacy Narrative 1: Emma— Narrative about how the author used journaling from her psychology class to help combat her anxiety and mental illness from her diabetes diagnosis
- Literacy Narrative 2: Liam— Narrative about how the author's negative emotions associated with his sports injury and skin condition diagnosis were addressed by his journaling
- Literacy Narrative 3: Ava— Narrative about how her negative experience with a relationship and being sexually assaulted were addressed by mood journaling
- Literacy Narrative 4: William— Narrative about how his journaling helped him overcome the difficulties of childhood
- Literacy Narrative 5: Sophia— Narrative about how the author was able to use a journal to overcome relationship trauma from her high school boyfriend
- Literacy Narrative 6: Robert— Narrative about how the author used a journal to help him process his father's death
- Literacy Narrative 7: Jessica— Narrative about how she used journaling to help address her anxiety when it came to her athletic abilities and social situations
- Literacy Narrative 8: Bob— Narrative about how the author used a journal to help overcome the COVID-19 pandemic
- Literacy Narrative 9: Bill—- Narrative about how a recent graduate used a journal to help overcome the mental hurdle of student debt

THEME 1: TACKLING NEGATIVITY

The first aspect of mood journaling and mental health to be analyzed is its ability to decrease symptoms of anxiety and depression, leading to better overall mental health. Literacy narratives one, two, and three draw a connection between journaling and mental health. In literacy narrative one, Emma, after being diagnosed with diabetes is said to have "skipped most classes, isolated myself in my room every day, and lost interest in everything" (Anonymous, 2019). However, after journaling, Emma was able to "evaluate everything [she] was feeling and thinking" resulting in her ability to "grow and learn from [her]

mistakes" (Anonymous, 2019). This narrative explained how journaling allowed her to be more in control of her own emotions by empowering her to let go of past obsessions and focus more on the positives in life.

Similarly in literacy narrative two, Liam demonstrated how journaling helped him overcome his negative emotions. Prior to journaling and after undergoing a sports injury and diagnosis of a skin condition, Liam described himself as being "pessimistic, hopeless, worthless, apathetic, nothing" (Anonymous, 2020). However, after beginning his journaling practice, Liam was able to put his bad days into context and give himself a "sense of relief because some days were fine while others were terrible but the fine moments gave me a reason to keep on going" (Anonymous, 2020). By comparing Liam's mentality before and after journaling, one can see the beneficial impact it can have. Journaling enabled Liam to see beyond the negatives in his life, overcoming innate human fixation on negativity, a phenomenon called "negativity bias" (Hara Estroff Marano, 2003). By encouraging Liam to look back on his positive days, journaling enabled him to free himself from his own negativity bias and achieve a happier outlook.

Likewise, in literacy narrative three, Ava, after a rough childhood and a few unhealthy relationships, struggled with the idea that she "didn't trust anyone enough to tell them [her] darkest thoughts, to try and explain how [she] was feeling" (Anonymous, 2019). Ava's post- journaling revelations showed one of the highest levels of self-awareness I found in my analysis. After Ava began journaling, she wrote "I was my own teacher, my own student. I am my own counselor, my own patient" (Anonymous, 2019). Starting from a mentality that emphasized hopelessness and mistrust in others, Ava used her journal to begin the process of self-recovery. Her post-journaling description shows signs of self-trust and may indicate journaling empowered her to distance herself from the negativity of the world. However, it must be noted that journaling has only started her journey to trusting others. Her journaling led her to believe in herself, but ultimately, she must reach out to others in order to re-integrate herself in society. Analyzing these three literacy narratives, a common theme can be seen: empowerment. Comparing the situations of the three narrators before and after journaling suggests journaling enabled them to believe in themselves more and encouraged them to retake control over their emotions.

From these literacy narratives, we can also see how these individuals

tackled their negative life experiences by addressing them via journaling. All three of the narrators directly referenced their bad times in their writing, instead of avoiding them. By directly tackling their traumas and insecurities, journaling may empower them to tackle future issues. In previous sections of this paper, I referenced Stosny who claimed journaling had negative effects, such as a developed narcissism. After analyzing the literacy narratives, I have found the opposite. Nearly all of the authors attribute their success to journaling and not to spontaneous self-growth, as a narcissistic individual may claim. For example, some of the narrators acknowledge the fact that their healing will be long-term, requiring their commitment, I found that Stosny's arguments are not supported by these literacy narratives. All of the authors seem to have improved lucidity after journaling which enables them to be more self-aware of their situation. Instead of claiming their own might or strength, journaling left them grateful for their personal growth and eager to continue learning and experiencing what journaling could teach them in terms of conquering their own mental illness.

THEME 2: EMPOWERMENT

Moving forward, looking at the specific techniques employed in the author's journaling practices can reveal much. In literacy narrative four, William is described as using journaling as a manner in which he would look "at his problems from a third-person view" (Anonymous, 2019). By distancing himself from the events of his life, William reports he is able to "see where he did wrong and take that as a lesson" (Anonymous 2019). By taking himself out of the situation, William can look at his past without personal bias or letting his emotions control his judgment. By using journaling to achieve a more lucid understanding of his experiences, William is able to be more objective in his understanding of the world around him.

Furthermore, in literacy narrative five, Sophia describes her journaling technique as writing about all "the anger and sadness that was built up inside of [her]" (Anonymous, 2020). Although a rudimentary technique of journaling, simple self-expression should not be overlooked, considering its efficiency. Instead of suppressing her emotions, she used journaling to purge negative thoughts and free her mind's obsession with her past. Sophia utilizes another popular form of journaling. Instead of writing and then never reviewing her entries, she revisits

her happy memories on her sad days to "relive the feeling that she felt at that exact moment" (Anonymous 2020). By looking back on her nostalgia-provoking memories, she looks forward with more optimism.

In literacy narrative six, Robert uses a journal to comprehend the years of his father's sickness and death. The specific technique Robert used in his journaling was destroying his journal entries after he wrote them (Anonymous Robert, 2009). Working in a similar manner to Rage Rooms, a safe and controlled environment that allows clients to release tension via the destruction of objects, this technique of journaling empowers the writer. Destroying the journal entries symbolizes the author eradicating their negative emotions, not letting them consume their everyday thoughts. Robert reported that the process of destroying his journal entries was liberating and gave him confidence that he would be able to control his emotions. During such a low point in his life, this technique gave him power at a time where Robert felt that he had lost all control over his life, leaving him more confident in his own abilities to continue living despite his father's passing.

Through analysis of these literacy narratives, I see the theme of overcoming sadness. By either physically or mentally placing an individual above their emotions, journaling aims to help individuals be more objective in their decision-making so that their emotions do not control them.

THEME 3: COPING STRATEGIES

My final finding is how journaling can help people who lack mental health support or collective acknowledgement of mental health problems. In literacy narrative seven, Jessica is an athlete who struggles with an anxiety disorder. Her parents are described as being confused as to how she "could be so excited about committing to something, but then fail to satisfy my commitment at the last minute" (Anonymous, 2020). Jessica's journaling practice enabled her to "deal with her emotions when she does get anxious" (Anonymous, 2020). Mental health among athletes may be overlooked because they are constantly expected to keep performing. Jessica seems to suffer from performance anxiety; however, journaling enabled her to handle her anxiety in an environment where she is expected to do well. Jessica's journaling allows her to voice her insecurities privately because in the realm of sports, such insecurities would be seen as a weakness or inability to compete. Therefore, when her options were

limited, journaling helped her combat her anxiety by herself so that her athletic career wouldn't be sacrificed as a result of her anxiety disorder.

More recently, the COVID-19 pandemic has left everyone worried about their physical well-being. In literacy narrative eight, Bob addresses the mental aspect of experiencing a pandemic and more specifically, quarantine. Bob uses his journal to help him comprehend unexpected responsibilities, such as increased care for his child and mother. After a long day of taking care of them, he would dive into his journal where he would be able to "hide away and express himself" (Anonymous, 2020). Bob's literacy narrative demonstrates mental health may have been overlooked during the pandemic and some people used journaling to express themselves and adapt to major life changes.

The last literacy narrative, number nine, to be analyzed in this paper by a recent college graduate, Bill, who used journaling to handle his student loan financial debt. Bill's journaling was centered around his finances; however, he also kept a daily and monthly tracker of his emotions to see if there was a connection between his mood and his expenses (Anonymous, 2020). Ultimately, the knowledge of how his mood impacted his spending practices enabled him to better manage the stress associated with being in debt. Society assumes most new graduates able to keep their stress managed, but that may not be true, given their sudden increase in responsibilities and independence. In Bill's case, journaling helped him comprehend and conquer his stress regarding his financial situation.

A thematic analysis of these three literacy narratives explores how journaling directly addresses mental health problems and illness. In environments where mental health has not historically been valued, journaling helps people consider their mental health. Moreover, because journaling may serve as the only opportunity to address mental health, narratives may reflect drastic change in the narrator's outlook towards life.

CONCLUSION

With over 18% of adults experiencing a mental health illness in America, the days of keeping mental health under wraps has long passed. The need for addressing mental health problems and stigma must be addressed. For far too long individuals with mental health issues have been seen to have personal problems, whereas the true

problem lies in a lack of structure and support in the community.

While the connection between journaling and decreasing depression symptoms has been noted, further study of specific journaling techniques is needed. Journaling provides a different form of expression than conversation. Looking forward, journaling may have impact on the medical/healthcare industry. Up to this point, mental health has remained a taboo subject for many people who are part of societies that view mental illness as a sign of weakness. With this paper, I hope that medical professionals will work with writing studies researchers to integrate journaling in mental health treatment plans.

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GRAPPLING WITH RELIGION AND CULTURE IN THE WESTERN WORLD: MUSLIM WOMEN WRITERS

Ariej Rafiq

With Islam commonly preconceived as a religion that subjugates and demeans women, an essential component of the debate regarding this issue is the voices of Muslim women themselves. Seeking their perspectives on Muslim women's rights, along with how they apply their religious beliefs in the contexts of cultural pluralism and assimilation into western culture, can significantly assist in dispelling common misconceptions and prejudices. Muslim women writers, coming from a long-standing tradition, can be found across a diverse array of cultures, age groups, time periods, and writing platforms, reflecting different purposes and paths towards self-actualization across themes of religion and gender. As Muslim women reflect, through writing, on the components of their lives that best shape their identities and perceived roles in society, they can shed light on the strengths and weaknesses within the western world of accepting and accommodating those of diverse backgrounds. This paper will explore the context methods to study autobiographies, social media content, letters, and intellectual discussions written by Muslim women writers and analyze these works. Because Muslim women must navigate a cultural rift between Islamic beliefs and customs and those of the western world, they may experience greater difficulty than other writers in expressing their identities. However, when they overcome these barriers, Muslim women writers learn to effectively strike a balance between their native cultures and assimilation into western society in the interests of advocacy, self-discovery, interpreting Islamic doctrine, and dispelling misconceptions.

In beginning this discussion, it is useful to consider the history of Muslim women's attempts to ponder their interactions with the West and their own cultures, along with their attempts to vocalize their perspectives. Sharif Gemie's book *Women's Writing and Muslim Societies: The Search for Dialogue, 1920–Present* (2012) explains the background of Muslim women writers from approximately the eighteenth century to the present. Gemie observes that the nature of the dialogue between the East and West is inegalitarian and

inherently condescending to cultures in the Eastern world. Throughout the book, Gemie analyzes the "errors" within writing and communication between Muslim cultures and the western world. Two examples include a fixation on political turmoil within the Islamic world and the denial that globalization has created multifaceted identities across many cultures. Both shortcomings, according to Gemie, hinder productive reflections on personal identity, development, and cross-cultural connections. This finding provides context into the evolution of literature written by Muslim women and how it can combat this inequality across intercultural discourse.

Tansin Benn, in *Muslim Women in the United Kingdom and Beyond* (2003), discusses the process of assimilation for Muslim women in the West. Although Benn presents no writing component, her book is a critical source for understanding the complexities, dynamics of identity, and discrimination Muslim women face. In doing so, Benn gives deeper insight into the contexts within which Muslim women understand their identities and roles and then write about them. Especially useful is her investigation of texts written by non-Muslim writers that perpetuate negative stereotypes of Muslim women as "subservient, oppressed, exotic, victimized" (Benn 15). Combined with its discussion of Muslim women's efforts to refute these stereotypes, *Muslim Women in the United Kingdom and Beyond* encourages readers to reconsider our beliefs about and actions toward Muslim women.

Pondering technical aspects of categorizing autobiographies is also informative. In her journal article "Life/History/Archive: Identifying Autobiographical Writing by Muslim Women in South Asia," Siobhan Lambert-Hurley's objective of "defining the genre" of autobiographical writing provides a useful method of analysis that can clarify the focus of autobiographies by Muslim women. Lambert-Hurley's work demonstrates that the Muslim women's writing tradition is incredibly diverse, not always in alignment with Euro-American definitions of a conventional "autobiography." This amorphous classification of Muslim women's writing thus lends itself to unique, varied, and rich interpretations that may not always be present in more traditionally defined autobiographies. In addition, her article "raises questions about the nature of archives and the distinctiveness of women's writing as these relate to nomenclature, structure, chronology, language, voice, and regional specificity" (Lambert-Hurley 61). Thus, this discussion applies to the archival research presented later

in this paper. For now, Lambert-Hurley's work is best applied to Amrah Abdul Majid's book *The Practice of Faith and Personal Growth in Three Novels by Muslim Women Writers in the Western Diaspora* (2017), which tells the stories of three women and their journeys of self-actualization through implementing rituals of their Islamic faith. Abdul Majid presents these women's stories to argue that they do not consider their wearing of hijab a hindrance but rather a path to further develop their identities. She indicates that Muslim women experience great difficulty in expressing their identities due to the discrimination they face in western societies, identity conflicts, and the impact on sexual morality. However, as they continue their journeys of self-improvement that they believe Islam and its rituals provide, they overcome these struggles (Abdul Majid). The autobiography as a medium to illustrate this growth has significant implications both in defining an autobiography and determining its purposes, which will be explored through the following works written by Muslim women themselves.

One way these works can be categorized is by the author's age, which is why a young Muslim demographic can offer fascinating stories about growing up in a western culture that deems Islam controversial. In their book *Growing Up Muslim: Muslim College Students in America Tell Their Life Stories* (2014), Andrew Garrod and Robert Kilkenny share fourteen essays by Muslim college students that wrestle with religion, race, ethnicity, prejudice, and nationality. One student, Zahra Ahmed, recalls her experience moving far from home and living at a predominantly privileged and white university. In her essay, she realizes that this experience has strengthened her understanding of being an African American female Muslim and that her faith has been instrumental to her identity in navigating the western world (Garrod and Kilkenny 15). Another student, Sara L., narrates her Islamic journey and her ultimate decision to wear a headscarf in the context of both her Afghan background and her life in the United States. Reflecting on her journey, she discovers that the decision to wear the hijab was both a "personal and beautiful" type of "outward change that drew… [her] inward" with the desire to "be better than… [she] was" (Garrod and Kilkenny 173, 174). Both narratives provide the voices of young individuals from diverse cultural backgrounds, highlighting the struggles they faced while trying to balance Islamic tradition with assimilation into the western world. In this sense, the writing process reflects both the difficulties and the

strong messages of these women and how it has the potential to transcribe these journeys to make an indelible impact on both writer and audience.

Another notable memoir is Shelina Zahra Janmohamed's *Love in a Headscarf* (2009). Claire Chambers addresses Janmohamed's memoir in her journal article "Countering the 'Oppressed, Kidnapped Genre of Muslim Life Writing: Yasmin Hai's *The Making of Mr. Hai's Daughter* and Shelina Zahra Janmohamed's *Love in a Headscarf*." Juxtaposing the memoirs of two British authors from Muslim backgrounds, Chambers states that both memoirs reflect that their respective authors were raised in secure environments, a sharp contrast to the "misery memoirs" of other Muslim women that contribute to stereotypes of repression. Yet, she also asserts that Hai's and Janmohamed's memoirs differ fundamentally in their messages. Whereas Hai associates Islam primarily with her culture and family but maintains a relatively secular outlook, Janmohamed prioritizes religion above culture—she argues that culture can either beautify the human experience or occlude Islamic teachings and philosophy (Chambers 2). Understanding both perspectives can provide useful insight into the authors' respective upbringings, which contributed to differences in their attitudes towards Islam, along with the voices they use to share those viewpoints with their audience. As for the writings mentioned previously and the ones to come, using a feminist lens to read these works closely and thoughtfully can enrich a nuanced understanding of Muslim women writers' perspectives on religion, culture, assimilation, and advocacy.

In fact, voice is not limited to self-advocacy alone; it can extend to speaking on behalf of many Muslim women. In *Redefining #YourAverageMuslim Woman: Muslim Female Digital Activism on Social Media*, Inaash Islam describes influencer Dina Tokio. Tokio, a Muslim hijabi who wears a headscarf and uses social media to dispel the myth of the oppressed Muslim woman, produced a documentary in collaboration with YouTube titled *#YourAverageMuslim*. Additionally, she created a four-part series for YouTube's "Creators for Change" initiative to "'celebrate Muslim women who have shunned cultural stereotypes in hopes of inspiring young girls'" (Inaash 221). Because Tokio wrote a description for each episode, her series provides visually persuasive content and empowerment through written word. Her use of social media as a delivery forum also creates a more relaxed and casual tone, which assists in making her content both engaging and accessible to

a large number of media consumers. For instance, she starts her description with an informal "Hi guys" and admits that she is "pretty tired of constantly being praised for 'breaking the stereotype'" simply because she is a successful Muslim woman (Inaash 221). However, she continues that "This should be the NORM!" and implores her followers to share their own narratives on social media (Inaash 221). Although Tokio's relaxed tone contrasts with the more formal and academic tones of the college essays examined by Garrod and Kilkenny, her writing on social media is no less useful in understanding the expression and advocacy of Muslim women.

Continuing this focus on advocacy, archival research can present fascinating views of the writing and community involvement of Muslim women. One example is President of the League of Muslim Women Carolyn Saahir's 1997 letter. Introducing this service institution as a "unique non-profit organization" that has conducted work ranging from opening a food pantry to giving donations, she addresses Muslim women within her community and urges them to join her chapter (C. Saahir). Saahir writes in an open, straightforward, and amicable tone that easily allows her to communicate with female Muslim audiences. However, because it is relatively short, her letter functions less as an exhibit of voice and best as the premise for introducing a powerful document from the League of Muslim Women titled "A Woman's Worth" (M. Saahir). One could argue that Saahir's 1997 letter is primarily technical and service-oriented, whereas "A Woman's Worth" empowers Muslim women to recognize the value inherent within their identities confidently. The League of Muslim Women presents the voice of a self-assured woman speaking to a man about marriage, who asserts that she is "in a position to ask a man what he can do for [her] that [she] can't do for [herself]" in open defiance of stereotypical subservience (M. Saahir). She firmly elaborates on her desire for "a man who is striving for perfection in every aspect of his life" (M. Saahir). For instance, mental perfection in a man would fulfill her desire for "conversation and mental stimulation" that she would not find in "a simple-minded man" (M. Saahir). What makes Saahir's work remarkable is the fact that it reflects a Muslim woman's use of the written word and her leadership within an organization for Muslim American women as well. As exemplified by her position, she has been able to preserve her values as a Muslim woman while living within American society, and she uses this balance to help other Muslim women

within her community. Specifically, Saahir's 1997 letter and "A Woman's Worth" illustrate that the League of Muslim Women's contributions come from both community service and rebuttals of demeaning stereotypes surrounding Muslim women. The value of archival research in unearthing local, service-oriented communities and the vital role Muslim women play in cultivating them through leadership and writing thus stands strong.

Transitioning to a work that combines the personal and intellectual, Mona Siddiqui's *My Way: A Muslim Woman's Journey* (2014) provides a distinct vantage point to discuss Islam and its pertinence to one's history. Siddiqui states that she writes "from within the Islamic faith but not on behalf of other Muslims," but she also emphasizes that her book is not an autobiography. Rather, she considers her Muslim background and various stages of her life to "explore those personal, social and theological issues which shaped the way [she] grew up and which continue to challenge [her] thinking today" (Siddiqui). Siddiqui explores issues such as multiculturalism and the relationship between Islam and the modern world, which could enhance awareness of the debates surrounding the consolidation of the two. By including both Western influences that have impacted her perspective and her experiences with Islam as it pertains to academia, she finds a middle ground between the two that she applies to her own life. Thus, Siddiqui's work serves as an example of a writing journey centering less on advocacy and more on the interpretation of Islam itself, including how the process of discovering those answers relates to her.

Despite the presence of these empowering works of female Muslim literature in modern society, the western world often fails to recognize that such works have persisted for centuries. Lambert-Hurley, in her book *Elusive Lives: Gender, Autobiography, and the Self in Muslim South Asia* (2018), challenges the commonly propagated view of the Muslim woman as being part of "a culture that idealizes female anonymity" in which "women's bodies are veiled, and their voices silenced" (Lambert-Hurley). She instead highlights the examples of various women from the subcontinent who detailed their life stories, presenting rich narratives of vocal women from the sixteenth century to the present. Her book offers a framework for understanding gender, personal narrative, and self-determination through a non-Eurocentric lens and in the contexts of "imperialism, reformism, nationalism and feminism" (Lambert-Hurley). This framework demonstrates that the narratives of Muslim

women of the modern era draw their roots from a long-standing history of Muslim women writers, contrary to misconceptions that Muslim women have historically remained silent on gender, religion, and identity issues.

The culmination of these discoveries conveys that Muslim women writers experience significant struggles in finding and writing about their identities, arguably to a greater extent than writers of other backgrounds due to the widespread prevalence of preconceived notions surrounding them. Nevertheless, they represent an increasingly influential body of individuals, highlighting the necessity of understanding diverse intersections between religion, race, gender, class, ethnicity, and other factors in the western world. This paper builds on comparisons other researchers have made between works; however, this paper also takes these considerations into a broader scale in order to answer questions regarding purpose in the works of Muslim women, the intersections they have with background and identity, and the contributions they make to a more informed, accepting national and global community. One consideration for future research may be to find content from various genres, ethnicities, and even experiences Muslim women obtain from fields of study outside of theology. Such information can also be analyzed in view of the objectives these writers aspire to achieve through their work, perhaps advocacy or reflection as examples. This research, in turn, can facilitate representing the diversity that exists within the female Muslim community itself.

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"IT NEVER WILL THUMP AGAIN": DOMESTIC HORROR IN "THE DAUGHTERS OF THE LATE COLONEL"

Lauren Textor

Katherine Mansfield's short story "The Daughters of the Late Colonel" is unapologetic domestic horror. While not as jumpy or flashy as modern horror classics like *The Shining*, Mansfield (1888—1923) brings a disquieting sense that something is not right to her readers that is all the more frightening for its subtlety. She realizes better than most that horror is in the details. *The Longman Anthology of British Literature* notes: "Mansfield turned the short story away from contrived plot conventions, and toward the illumination of small events as they reveal the fabric of a life, making of short fiction an almost dramatic form" (2478). In "The Daughters of the Late Colonel," Mansfield wields themes of belonging, relationships, and time, producing an unnerving piece of literature about two sisters navigating their father's death. Although she spends time describing the grueling illness and the breakdown of the fragile human body–common tropes of horror–she especially emphasizes clothing, meals, condolences, and sorting through inherited objects. This is a unique approach taken by 18th- and 19th-century female writers of the domestic horror subgenre to illustrate the importance of family and household dynamics on psychological well-being. "The Daughters of the Late Colonel" was published in 1921, before Shirley Jackson's better-known "The Lottery" came out in 1948. Today, Mansfield remains less popular than Jackson and Charlotte Perkins Gilman, author of the classic short story, "The Yellow Wallpaper," but Mansfield is similarly skilled in portraying the anxiety typical of this genre. Mansfield's often-overlooked story is key to understanding the historically\ alarming powerlessness of women in their own homes. Domestic horror demonstrates that the traditionally feminine fears associated with the home are no less valid or horrifying than those of the outside world. Throughout "The Daughters of the Late Colonel," Mansfield suggests that our own daily rituals and the possibility of a monotonous and meaningless life are more frightening than death.

A HOUSE IS NOT A HOME

Mansfield struggled to define home for herself, which is perhaps why her characters have such a difficult time finding it for themselves. Born Kathleen Mansfield Beauchamp in Wellington, New Zealand in 1888, her comfortable childhood became a tumultuous life of failed marriages, bitter rivalries, and scandalous affairs. However, her numerous misadventures made her a more compelling, imaginative writer.

In "The Daughters of the Late Colonel," two sisters struggle to find stability and meaning after the death of their authoritarian father. In his absence, they are unsure what to do with themselves, as they have spent their entire lives following his strict rules. Mansfield's personal life was also characterized by uncertainty and self-doubt.

In "Finding a Foreign Home in Katherine Mansfield's 'The Daughters of the Late Colonel,'" Sam Jacob describes letters from Mansfield that display a longing for domesticity and comfort. The essay describes how "The Daughters of the Late Colonel" reflects Mansfield's struggle between having a family life and an intellectual literary life (Jacob 9). Jacob opens with an excerpt from one of Mansfield's letters to her husband: "Why haven't I got a real 'home', a real life––Why haven't I got a Chinese nurse with green trousers and two babies who rush at me and clasp my knees . . . Shall I ever have them?" (1). Mansfield was adventurous and direct in pursuing the life she thought she wanted, but she also stopped to wonder if she had made the wrong decision in leaving New Zealand. The subgenre of domestic horror often builds upon a concept of home as a liminal space by creating anxiety that one is simply passing through somewhere that is meant to be a permanent fixture in their life. Mansfield is able to capture this in her writing perhaps because of her own feelings of impermanence and apprehension surrounding her legacy.

Although the sisters in the short story do not have Mansfield's determined nature as their dreams of a new life dissipate at the end of the story, they share her sense of displacement. Mansfield's familiarity with this feeling contributes to the eerie aspect it lends to the story. The sisters are strangers in their own home. After their father's death, Constantia and Josephine are terrified to go through his things. The sisters have lived in this house for their whole lives, but they hardly recognize their father's room when they enter it because everything inside is covered (Mansfield

2483). The lack of belonging that the sisters feel in their own house and the sense that things are not as they appear is present on every page. The idea that the sisters are disturbing the motions of their own household is powerful. They tremble at the thought of opening their father's drawers or the wardrobe, certain that his ghost will punish them for such monumental transgressions. The displacement that they experience makes the story uncomfortable to read. The sisters dutifully took care of their father up until the very end, but they have no idea what to do with themselves after his death. Because the dead father described in such concrete and forceful terms, it is almost as though he is still living while his daughters haunt the house by aimlessly drifting through their own lives.

HOUSEHOLD RELATIONSHIPS IN CONFLICT

Relationships are at the heart of this story. In particular, the relationships between Josephine, Constantia, the maid, Kate, and the dead father are of note. Memory haunts the sisters rather than a physical manifestation of a ghost, making them irritable and on edge. They are each other's only allies, but there is still visible tension between them due to their precarious living situation. The stress of existing in a house alongside its psychological phantoms causes them to lash out at each other, as they cannot express their frustrations to Kate or their father. Josephine snaps at her sister and is reactionary when Constantia asks questions about handling the household arrangements. Mansfield writes: "Have you got enough stamps?' came from Constantia. 'Oh, how can I tell?' said Josephine crossly. 'What's the good of asking me that now?' 'I was just wondering,' said Constantia mildly" (2479). The sisters get along with each other better than anyone else we see in the story, but they also feed off each other in both passivity and passive-aggressiveness. They are indirect when upset, as seen in their interactions with their maid, Kate.

While the sisters would traditionally hold more power over Kate as her employers, they are instead frightened of her. When their father dies, Kate steps into his role as the alpha of the household. Her aggressive nature enables her to bully them into submission with few words. Benefitting from the figurative ghost of the sisters' trauma, Kate flips the typical power dynamics and creates psychological suspense with her silent temper. When the sisters are having dinner with Nurse Andrews,

their father's former caretaker, they ring for Kate to bring more butter at the nurse's request. Mansfield writes, "And proud young Kate, the enchanted princess, came in to see what the old tabbies wanted now. She snatched away their plates of mock something or other and slapped down a white, terrified blancmange" (2480). Kate performs her duties in a whirlwind without speaking, but it never occurs to the sisters to reprimand her. Instead, they live in fear of her interruptions and judgment. They bestow an almost supernatural knowingness on her, much as they did with their father. As a result, she has the run of the household.

The power dynamics between Kate and her employers are flipped. Later, Josephine and Constantia are bickering about who should enter their father's room first when Kate appears in the kitchen doorway like an apparition. To explain her hesitation at the room's entrance, Josephine attempts to make an excuse about the door handle's stiffness. She thinks, "As if anything ever deceived Kate!" (Mansfield 2483). In "'That Moment of Suspension': Class and Belonging in Katherine Mansfield's Short Stories, 'The Daughters of the Late Colonel' and 'The Doll's House,'" writer Saskia McCracken focuses on the role of class in Mansfield's stories. McCracken's analysis recognizes how Kate transcends the typical boundaries between employer and servant by interrupting private conversations and entering rooms unannounced. McCracken writes:

> The drawing room, where the sisters "always [...] retired when they wanted to talk over Kate,", is cast as the only space where Kate will not interrupt her employers. It is notable that "Josephine closed the door [to the drawing room] meaningly," because this signifies an attempt to re-establish the boundaries between domestic servants and domestic employers. (5)

Kate is disruptive and rude, showing she holds the power in this dynamic despite her lower economic position. She embodies the silent and ever-present anger of the father. She appears where she does not belong, bursting into rooms as if they are her own. The sisters can never be sure that she isn't listening or that they are truly alone. This lack of safety and belonging in one's own home is an early example of a theme that distinguishes domestic horror as a subgenre.

Similarly, the father is omnipresent, even in death. Mansfield writes, "...neither of them [the sisters] could possibly believe that father was never coming back. Josephine had had a moment of absolute terror at the cemetery, while the coffin was being lowered, to think that she and Constantia had done this thing without asking his permission" (2482).

As terrifying as their father was in life, he is perhaps made even more terrible by death. Josephine and Constantia are unable to confront their grief and their tentative relief, so they obsessively manage the household. Legally, the house now belongs to the sisters, but their anxiety keeps them from leaving and from feeling at ease in their own home. They are just as terrified of the familiar as they are of the unknown. This depiction of home as simultaneously safe and unsafe is another early example of the subgenre's themes.

THE FLEETING NATURE OF TIME

The concept of time, particularly the idea that there is not enough of it, characterizes this story. It's about death but also about how the sisters choose to spend their own finite time on earth. In "'The Daughters of the Late Colonel': Feminine Temporality in Katherine Mansfield's Short Fiction," Gerardo Rodriguez-Salas delves into Mansfield's depictions of feminine and masculine time. Feminine time is described as cyclical and internal, while masculine time is linear and moves with the wider world (Rodriguez-Salas 6). Rodriguez-Salas writes, "Both she [Constantia] and Josephine live in their own world, characterized by repetitive routine, so that they are unable to break with it; thus, time goes by almost imperceptibly to the extent that they see themselves aged and single, but more immature than ever" (9).

Externally, the sisters are dealing with arrangements for their father's belongings, the animosity of their maid, and the overstepping of their father's nurse. However, their central conflicts are internal: they are essentially cut off from the rest of the world, aside from occasional visits from outsiders like their nephew Cyril. This isolation is partially self-imposed, as the sisters are no longer constrained by their father, though they remain infantilized by his memory. This seclusion further debilitates their social and functional skills over time until they have increased difficulty making even small and seemingly inconsequential decisions. They also become less able to vocalize their emotions, even to each other.

Section XII of the story describes Josephine and Constantia's difficulty in conceptualizing their father's death. The sisters leap to their feet to stop the organ-grinder on the street outside from playing his tune, as their father used to be irritated by the noise. Josephine orders her sister to run and get the money to quiet the musician so that their father's stick doesn't thump angrily—but she then grasps that this is no longer necessary. The passage reads:

> It never will thump again,
> It never will thump again,
> played the barrel organ (Mansfield 2489).

The colonel's death is linked to the external world, but this does not stop his echo from haunting his daughters, which demonstrates that the physical death of an authoritarian does not necessarily equate to sudden freedom or safety. His importance to the world is diminished, except to his daughters, who remain immobilized. All they can do is continue to live compact lives within a house that can never be home. The sisters know that their father will never harass them over the organ-grinder's music again, but they are unable to break away from the conditioning they have received since childhood.

As Josephine and Constantia cannot bring themselves to leave the house, they must keep occupied in other ways. The sisters spend their time maximizing the importance of small tasks and decisions so that they do not have to consider all that they are missing out on. Near the end of the story, Constantia meditates on their life before their father's death. Mansfield writes:

> There had been this other life, running out, bringing things home in bags, getting things on approval, discussing them with Jug [Josephine], and taking them back to get more things on approval, and arranging father's trays and trying not to annoy father. But it all seemed to have happened in a kind of tunnel. It wasn't real. It was only when she came out of the tunnel into the moonlight or by the sea or into a thunderstorm that she really felt herself. What did it mean? What was it she was always wanting? (2490)

Here, the sisters briefly confront their lives have passed them by, but then they forget their desire for more. Their domestic life, which dominates their days, feels unreal to Constantia. She gets short glimpses of a brighter world of color and nature, but she can't identify why it moves her. Because she is unable to determine what she wants, she lets it slip between her fingers. Therefore, both sisters are resigned to spending the rest of their lives feeling hollow and trapped in a nightmare realm of endless monotony.

CONCLUSION

Mansfield's "The Daughters of the Late Colonel" is an absorbing and sometimes uncomfortable rendition of domestic horror. Although Mansfield often is overlooked in general and within the context of the literary movement of domestic horror, she was a key contributor to the subgenre and managed to shape its emerging tradition. Whether they know it or not, contemporary writers and filmmakers benefit immeasurably from this inheritance. Books or films such as *The Babadook, Hereditary*, and *Gerald's Game* all center on family and loss. The cornerstones of the horror genre go beyond jump scares and gore—horror is about giving the audience someone to root for and something to lose. It's about consequences, whether they're deserved or not. The consequences of Josephine and Constantia's inaction echo on every page. Themes of belonging, relationships, and time tie in with an overarching idea of death as potentially impermanent. Mansfield uses small household events to build a narrative of missed opportunity and loneliness. The two sisters at the center of the story have a chance to start over once their father dies, but they are unable to do so because they are held captive by his memory. Mansfield uses this short story to validate and dismiss household responsibilities simultaneously, in keeping with her own internal conflict between a life of adventure and familial comfort. Neither the characters in this story nor Mansfield herself are able to successfully balance both of these desires, so they continue seeking an alternative that doesn't exist.

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Kyle Broley (he/him) is a recent graduate of UMKC and a first-year Master of Science in Geology student at Kansas State University. He wrote "Xenolith Structures in Welded Basalt Agglutinate Associated with Dotsero Crater, Colorado" for his Senior Honors Thesis with the aid of his thesis advisor, Dr. Alison Graettinger. He would like to thank the SUROP and SEARCH grant programs, whose funding allowed for the completion of fieldwork and necessary laboratory analysis and the Earth and Environmental Sciences department. He would like to thank Dr. Graettinger, without whom this project would not be possible and Dr. Jim Murowchick, whose expertise in the field of minerology informed the laboratory analysis of the samples in the study. When he finishes his master's degree, Kyle hopes to continue his education and research in volcanology and igneous petrology in a PhD program.

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Lauren Melton (she/her) graduated cum laude from UMKC in May 2022 with a degree in Biology. She also has a minor study in Psychology and Chemistry and an emphasis in Biomedical Sciences. Lauren is a pre-med student in a gap year, gaining experience at the PICU at Children's Mercy. She wrote "The Walking Ecosystem: How Gut Psychobiotics Bifidobacteria and Lactobacilli Alleviate Symptomatology of Depression and Anxiety" for an independent study biology class where she worked closely alongside Dr. Margaret Kincaid. She thanks Dr. Kincaid and Dr. Tara Allen for being such wonderful and inspiring educators (and for never giving up on her!) They fostered her love for microbiology and physiology, which this essay encompasses. Lauren plans are to gain experience at her current job and prepare to go back to school next fall.

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Madison Pope (she/her) is a May 2022 graduate of UMKC who received her bachelor's degree in biology with a minor in chemistry. "Strange Mating Behaviors and Maximizing Reproductive Success" was her term paper for Biology 498WI, a writing intensive course for science majors. Dr. Jess Magana, Madison's professor for this course, kindly suggested Madison submit it for publication in *Lucerna*. Madison is grateful for Dr. Magana's encouragement, the feedback of classmates who peer-reviewed her essay, and Kimla Virden's editing recommendations. After working at the Stowers Institute for Medical Research for a year, Madison is searching for new opportunities to combine her passions for science, education, and working toward health equity.

Ariej Rafiq (she/her) is a second-year medical student in the six-year medical program at UMKC. She wrote the essay "Grappling Religion and Culture in the Western World: Muslim Women Writers" for her English 225 class, instructed by Cody Shrum. She thanks Mr. Shrum and her classmates for their feedback and support in writing this paper. Upon completing her medical education, Ariej is passionate about pursuing ophthalmology along with conducting research in the field, particularly in retinal or neuro-ophthalmic conditions and treatments.

Lauren Textor (she/her) is pursuing a bachelor's degree in English with a minor in sociology. She wrote "'It Never Will Thump Again': Domestic Horror in 'The Daughters of the Late Colonel'" for Professor Emeritus James McKusick's 18th- Century Studies class. After graduating in the spring, she will continue to write in an academic and journalistic capacity. She thanks Professor McKusick for his support and her mother, Christine Textor, for listening to her read aloud each draft as she finished it.

Jessica Wise (she/her) is a senior Psychology major with a Business Administration minor. She wrote "Co-sleeping vs. Cry-it-Out Sleep Training Methods in Conjunction with Attachment Style and Emotional Regulation" in her Sociology 306 class with Dr. Jeff Bennett. She thanks Dr. Bennett for his inspiration and support in writing this essay. Jessica plans to be a project manager in her career and, eventually, she wants to be a mother, which piqued her interest in this topic.

2023 - 2024 SUBMISSION GUIDELINES

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We accept submissions from currently enrolled UMKC undergraduates. Your submission must have been completed during your undergraduate career at UMKC. You may submit one essay per year. Previously published or simultaneously submitted work will not be considered for publication in *Lucerna*. For more information, contact Editor-in-Chief Lauren Ferguson at umkcLucerna@umkc.edu.

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Articles should be between 2,000-6,000 words, MLA or APA style, 12-point font, double-spaced, and include a works cited or reference page. Include cover page with your name and phone number, as well as your instructor/PI/faculty mentor's name and email address. Submissions should be sent as Word documents to umkcLucerna@umkc.edu. PDFs are acceptable if needed to maintain text formatting.

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