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Evaluating the Self-Reference Effect as an Encoding Strategy for Individuals Displaying Autistic Traits: An Eye Tracking Study

ABSTRACT

Autism Spectrum Disorder (ASD) is characterized by difficulties in communication, social, and behavior skills. Recent research shows that memory differs between autistic individuals and neurotypical (NT) individuals. Tracking eye movements investigates memory mechanisms by evaluating brain activity. The self-reference effect (SRE) is a strategy used in NT adults to improve the intake of new information. Research on SRE and ASD shows conflicting results of whether SRE is helpful for autistic individuals. This project uses the Autism-Spectrum Quotient (AQ) to measure the degree to which adults exhibit autistic traits. Eye tracking and SRE encoding strategies determine if hippocampal function varies between those with a higher AQ score and those with a lower AQ score. This research contributes to the growing knowledge of differences in memory mechanisms, which is essential to combat the historically monolithic approach to human cognition research that is not applicable to all people.

PERSONAL STATEMENT

I have always found myself in an environment with people who differ from me. Over time, these experiences have manifested into two key ideas that I keep in mind: (1) everyone learns differently and (2) inclusion exceeds a mindset and can help everyone reach their full potential.

One notable experience that cultivated these ideas was my time as a gymnastics coach for Special Olympians at Chattooga Gymnastics, a center for developmentally disabled athletes. It is a vibrant community that I was honored to take part in, but my role as a coach had a rocky start. Although I was a gymnast before coaching, my previous experiences of learning and teaching skills were not transferable to many of the Chattooga gymnasts. Eve (name changed due to the privacy of the gymnast), an autistic gymnast, had an exceptional floor exercise routine but struggled to memorize the floor pattern. During competitions, gymnasts are scored on the execution of skills and their ability to follow a pre-choreographed routine. Eve strived to improve and I was determined to help her reach her potential. This required many individual lessons walking through the routine together and coming up with new strategies to help her memorize the specific directions on the floor she needed to tumble towards. After working together, I learned that Eve benefitted from looking at the floor routine pattern written on paper. In my twelve years of learning gymnastics routines, I had never thought to take this approach, but was ecstatic that a strategy resonated with Eve's learning. Eve dominated the season's remaining competitions; she was proud of herself and we continued to practice with visual aids. Our practices evoked an ardent question: why was my strategy for learning new routines so different from Eve's?

With the support of Chattooga Gymnastics, I secured a shadowing experience at the Marcus Autism Center where I encountered eye tracking technology to study autism. The ongoing project tracked the eye movements of infants to establish a pattern that could be used for the early detection of autism. The infants in the study were too young to receive an autism spectrum disorder diagnosis, but the longitudinal study design helped researchers establish when atypical eye movements that are usually found in autistic individuals appeared. I was fascinated by the researchers' ability to predict a neurodevelopmental disorder through the eyes and knew a career in making discoveries like these would be in my future.

Despite the captivating technology used at the Marcus Autism Center, I still had questions about my experiences with Eve. My interest and continued connection with Eve inspired me to take this passion for neuroscience research into my college degree. At Elon, I found the Cognitive Neuroscience of Memory and Aging (CNMA) Lab where Dr. Overman and her students study memory differences of various populations via eye tracking; it felt like a better match did not exist! An opportunity in a human cognition lab, along with the Lumen Prize will supply me with the tools to investigate my passion and develop my growth as a neuroscientist. The Lumen Prize will allow me to explore my interests through state-of-the-art equipment, professional conferences, and access to a vastly understudied population. The experience I would gain from this research will give me a better understanding of the neurodivergent community and allow me to produce a meaningful project.

PROJECT DESCRIPTION

Focus:

This project will use identity-first language to describe the autistic community. Sources indicate that the preferred phrasing depends on the individual and the scholarly literature varies between identity-first and person-first language. My writing follows the guidance of autistic researchers researching autism [1].

Autism Spectrum Disorder and the Connection to Memory:

Autism Spectrum Disorder (ASD) is a developmental disorder that affects over five million adults in the United States and is characterized by difficulties in communication, social interactions, and other behaviors [2,3]. Recent research suggests that there are memory differences between ASD individuals compared to neurotypical (NT) individuals, primarily in the encoding of information [4]. Encoding is the first step of the memory process–the input stage. This allows the brain to store, and later retrieve, information. Elaborative encoding strategies refer to methods that enhance the learning of new information by relating it to prior knowledge. As a result, information learned using these techniques becomes easier to store and retrieve in the future [5]. However, prior memory studies show the opposite effect of elaborative encoding for autistic people. In the Gaigg et al. study, ASD participants showed a reduced recall of semantically-related words compared to unrelated words [6]. This finding was supported by functional magnetic resonance imaging (fMRI) data that showed atypical function during encoding in the inferior frontal gyrus, which is a brain region associated with semantic (meaning-related) and elaborative encoding [6]. Although elaborative encoding strategies are a helpful learning tool for some populations, it is hypothesized that alternative techniques would be more effective for autistic people.

Eye Tracking as a Measurement of Brain Function:

The hippocampus is a brain structure critical for declarative memory and its function can be measured by eye movement patterns [7]. Declarative memory involves the conscious effort to take in new material (encoding), and the hippocampus supports this process, as well as supporting the transfer of declarative information to the other brain areas for long-term storage (consolidation) and the retrieval of information from long-term storage. Eye movements extract information from the environment, allowing individuals to compare these stimuli to prior experiences they retrieve from memory, and act accordingly (e.g. decision making about whether they've encountered something before). Eye tracking data is supported by fMRI data that demonstrates the role of brain structures in memory processes [7, 8, 9]. Eye tracking technology is a useful methodological approach because it assesses memory without having to entirely rely on the participant's memory decisions [7].

Typical Eye Movement Patterns for ASD:

Atypical patterns of repetitive behavior are common among autistic people and demonstrated in eye movement studies. For example, a study that investigated the perception of images revealed that autistic participants' eyes spent less time examining the core features (eyes, mouth, and nose) of faces in photographs compared to the NT group [10]. Other studies used eye tracking to determine if encoding-related eye movements could predict memory and explored the differences in eye movement between the ASD and NT groups [4]. A significant finding was that the number of encoding fixations of the eyes predicted false alarms (incorrect responses) during the trials for the NT group but not the ASD group [4]. Furthermore, an increase in encoding fixations in the ASD group led to better recall, a finding that contradicts prior studies implying that encoding in ASD individuals varies from NT memory function [4].

The Self-Reference Effect and Memory:

The self-reference effect (SRE) is an under-researched encoding strategy that suggests encoding is enhanced by relating information to oneself [11]. One study found that information presented as self-descriptive adjectives yielded better recollection. A few studies have explored the connection between SRE and ASD. Grisdale et al. showed SRE through a card-sorting task in which self-owned cards were better recalled than other-owned cards in the NT group [11]. For the ASD group, self-owned items did not provide an advantage in the recall portion of the experiment [11]. Another study examined the SRE with autistic individuals concerning perceptual processing [12]. NT and ASD groups were tasked with remembering a shape with a word that could be encoded using SRE. Results indicated no significant difference between the groups, suggesting that autistic traits do not affect the extent to which self-reference influences perception [12]. The conflicting outcomes in Grisdale et al. and Williams et al. highlight an unanswered question in the field of memory and autism research about the role of self-reference in memory [11,12]. Tracking eye movement behaviors would provide greater insight into the effects of the SRE as an encoding strategy for the ASD population. Currently, no literature investigates the relationship between SRE and eye movements, let alone how autistic traits may influence the use of self-referential strategies.

Measuring Autistic Traits:

It is important to note that the above information discusses research on clinical diagnoses of ASD. Even without a clinical diagnosis, individuals can still display autistic traits (AT). People who express AT represent a neurodiverse, but still understudied group. The Autism-Spectrum Quotient (AQ) is a 50-

question survey to measure the degree to which adults exhibit AT by assigning a score from 0 to 50. A high score on the AQ correlates to a clinical diagnosis of ASD [13,14]. However, the AQ is not a diagnostic tool and cannot be used to classify participants as autistic because many factors must be evaluated to determine a clinical diagnosis. For this reason, and the fact that NT individuals can be prescribed AT with this test, it has been deemed a controversial tool in the ASD community. Nonetheless, the AQ has been replicated in various studies and shown as a valid tool for research [15].

With the Lumen Prize, I will explore whether SRE is associated with AQ scores and examine eye movement patterns via eye tracking because eye movements have shown to be a direct indicator of hippocampal activity [7]. Beyond the scope of my Honors scholarship, the Lumen Prize will afford me the opportunity to access a neurodiverse and understudied population outside of the Elon Psychology Participant Pool. My research will contribute to the growing knowledge of memory differences amongst people with varying degrees of AT. The goals of my study are:

(1) gain a greater understanding of the underlying mechanisms of memory involved in elaborative encoding strategies

(2) determine the effectiveness of SRE as an encoding strategy for individuals displaying autistic traits via eye tracking

(3) increase my knowledge about the brain and relevant technology to prepare me for a career in neuroscience.

Scholarly Process:

Participants:

This study analyzes the encoding and retrieval differences in an adult sample as a function of the AQ score. Sixty participants between the ages of 18 and 25 will be recruited from the Elon/Burlington communities via flyers, mailings, and direct outreach of local autism community centers (e.g. The Arc of Alamance County Autism Now Center).

Materials:

The survey portion of this experiment will include administering the AQ to categorize participants into high-trait and low-trait (HT/LT) groups based on a threshold score of 26, based on prior research findings. The Gazepoint GP3 eye tracker will be used to track the participants' eye movements in response to the memory tasks presented on a computer monitor situated above the eye tracking device and presented using E-Prime stimulus presentation software.

Procedure:

Design aspects of this project synthesize elements from the experiments of Leshikar et al. and Cooper et al. [4,16]. Similar to the Leshikar et al. design, my project will examine SRE by having participants encode and later recall a list of adjectives. During the study phase, participants will be asked whether the adjective was self-descriptive. In the test phase, participants will be asked if they remember, know, or think the adjective presented to them is new [4]. In alignment with Cooper et al., I will incorporate eye tracking into the study design [4]. In the encoding phase of my experiment, I will record participants' eye movement behavior as they learn the adjectives presented on the screen. During the retrieval trials, I will also record eye movement to determine if eye fixation times match the encoding fixation times because that relationship has been predictive of recollection success and has been shown to differ between ASD and

NT groups. Fixation times and eye movement revisits to certain words will provide valuable insight into the work of the hippocampus.

Proposed Products:
(1) Written paper submitted for publication to the Journal of Cognitive Neuroscience or the Journal of Autism and Developmental Disorders
(2) Presentation at research conferences such as SURF, the Cognitive Neuroscience Society, and the Annual Neuroscience Conference sponsored by the Autism Tree Project.
(3) Scientific journal for my semester-long reflections to illustrate my growth and development as a scientist.

FEASIBILITY

Although this is a multifaceted project, my growing knowledge of neuroscience, personal experiences working with autistic people, respect for the autistic community, and Dr. Overman's expertise in memory, brain function, and experimental design make this a feasible project. Dr. Overman's decades of experience working with human participants and obtaining Institutional Review Board (IRB) approval will aid in the Elon IRB approval process.

Furthermore, Dr. Overman has extensive experience utilizing eye tracking technology (e.g. [17,18]) and her primary research focuses on differences in hippocampal function and memory representations between older and younger adults. She also has 20+ years of experience recruiting participants from the community to participate in her research studies. Her skills working with neurodiverse individuals who are older adults will translate to the HT group in my research.

To increase the feasibility of my project, I will immerse myself in many experiences to broaden my knowledge. This summer, I will work in the Cognitive Neuroscience and Aging (CNMA) Lab at Elon to assist other researchers on their projects with younger/older adults from Elon and the surrounding community. This will provide me with the necessary interpersonal data analysis skills I can translate to my research. Coursework from my biology major and neuroscience minor will supply my foundational knowledge and my previous honors seminars will be useful throughout the research process. Attending professional conferences and workshops will establish my professionalism in the neuroscience field.

The Lumen Prize will grant me access to a neurodiverse, racially, ethnically, and socioeconomically-diverse individuals, rather than drawing primarily from the Elon community as I would need to do with only Honors funding. I strive to create a high-quality project that is generalizable beyond the types of participants traditionally studied in human cognition research (white, high-socioeconomic status, neurotypical) [19].

Additionally, there are barriers associated with autism research that may carry over to my project. ASD research can be perceived as a method of finding a cure. The neurodiversity movement conveys that autism is an inseparable aspect of identity, not a deficit that needs a cure [20]. I am not aiming to identify deficits in the memory of individuals with autistic traits; my work highlights variations in SRE encoding strategies between HT and LT groups. To ensure my sensitivity to the autistic community, I will inform myself on the neurodiversity movement through scholarly literature and consult members of the autism community throughout various stages of my project. I will accomplish this by compiling feedback from participants and their family members after the pilot study and consulting the works of researchers with ASD who study ASD [21].

Lastly, my desire to learn about the brain and the autistic community fuels my passion to commit the necessary time for a project of this caliber. I am beyond excited for an opportunity to contribute to neuroscience and develop my skills as a scientist while working with a community for which I care deeply.

BUDGET

Although the Honors Scholarship provides a research stipend, the costs of this project will exceed the $1,000 Honors budget. To complete a project of this magnitude, I need additional financial support.

Equipment and Scholarly Readings – $1,500

- Gazepoint GP3 eye tracker, 60 Hz system (hardware only) – $845
- The Reason I Jump: The Inner Voice of a Thirteen-Year-Old Boy with Autism [22] – $16.20
- Connecting With the Autism Spectrum: How to Talk, How to Listen, and Why You
- Shouldn't Call it High-Functioning [23] – $9.99
- Neuroscience of Autism Spectrum Disorders [24] – $112.46
- Remembering: An Activity of Mind and Brain [25] – $45.00
- Cognitive Neuroscience of Memory [26] – $48.44
- Memory Makes the Brain [27] – $78.00
- Other equipment and scholarly readings – $345.35

Participant Recruitment and Compensation – $3,265

- Printing and mailing costs, sending out on letterhead w/2- page insert ($1.55/letter packet x 1200 people) – $1,860
- Business reply envelopes, return rate of 5% (60 people x $1.75) – $105
- Flyers – $100
- Participant compensation (60 people x $20 gift card) – $1,200

Conferences – $6,500

*Travel costs based on current rates of travel through from conference websites.

- Cognitive Neuroscience Society annual meeting 2024 (East Coast) – $1,575
  - Flight – $250
  - Hotel ($270/night for 4 nights) – $1,080
  - Registration – $245
- Society for Neuroscience annual meeting 2023 (West Coast) – $1,625

- Flight – $300
- Hotel ($270/night for 4 nights) – $1,080
- Registration Fee – $245
- Annual Neuroscience Conference - Autism Tree Project – $1,500
  - Flight – $250
  - Hotel ($270/night for 4 nights) – $1,080
  - Registration Fee – $170
- Additional conference fees and associated costs – $1,800

Professional Development – $4,000
- Cognitive Neuroscience Society Membership – $100
- GRE Test Prep and Study Guides – $70
- Graduate school interview travel costs – $1,000
- Eye tracking workshop – $1,000
- Additional items relating to professional development – $1,830

TOTAL: $15,265

Tuition and Course-Related Supplies – $4,735

PROPOSED EXPERIENCES and PRODUCTS

	Experiences	Products
Summer 2022	- Work in the CNMA Lab at Elon - Continue reading relevant literature to - Increase my knowledge of the field and hone my project ideas - Enroll in R coding class	- Expansion of knowledge of topic - Learn the necessary research skills and analysis techniques for my project - Experimental design/procedure completed
Fall 2022	- Submit Honors thesis Proposal - Conduct 2 semester hours of 4998 Research - Apply for IRB approval - Continue reading relevant literature - Semester-long reflection of growth as a researcher and project progress	- Approved Honors Thesis Proposal - Literature review of relevant sources - IRB Approval - Increased knowledge of research style and growth as a scholar - Reflective journal of research progress
Winter 2023	- Participate in health-related study abroad course	- Gain knowledge in the application of ASD research - Strengthen collaboration skills with other scientists
Spring 2023	- Conduct 2 semester hours of 4998 research	- Data from pilot study - Updated literature review with current

	- Continue reading relevant literature - Run a pilot study - Consult community members about the pilot study and incorporate feedback into the experiment design - Semester-long reflection of grow	research - Reflective journal of research progress - List of potential graduate school programs - Reflective journal of research progress
Summer 2023	- Participate in science and health/technology internship in Tel Aviv, Israel - Study and take the GRE - Finalize list of potential graduate school programs - Continue reading relevant literature and staying up to date on novel findings	- Strengthen collaboration skills with other scientists - Graduate school preparation - Updated literature review
Fall 2023	- Conduct 2 semester hours of 4998 research - Data collection - Apply to graduate schools - Finished abstract to submit to conferences - Semester-long reflection of growth as a researcher and project progress	- Graduate school applications - Completed introduction and methods sections for Honors Thesis - Completed abstract for conferences - Reflective journal of research progress - Submitted applications for conferences
Winter 2024	- Begin poster for Cognitive Neuroscience Society - Finish data collection	- Completed poster for conferences - Completed results section for Honors Thesis
Spring 2024	- Conduct 2 semester hours of 4998 research - Begin preparation for SURF presentation - Iterative revisions to full Honors manuscript draft throughout February/March - Semester-long reflection on growth as a researcher and project p	- SURF presentation - Completed Honors Thesis - Paper submitted for publication in relevant journals - Reflective journal of research progress

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