Sex-related differences in resolving proactive interference during associative memory tasks

A Thesis
Presented to
The Academic Faculty

by

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In Partial Fulfillment
Of the Requirements for the Degree
B.S. Neuroscience with the Research Option in the
School of Biological Sciences

Georgia Institute of Technology

May 2021

Sex-related differences in resolving proactive interference during associative memory tasks

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Acknowledgements

      I would like to thank my research mentor, Kyoungeun Lee, as well as my advisor and principal investigator, Audrey Duarte, for their help and guidance. I would also like to thank my communications professor, Amanda Madden, for her continuous support and encouragement.

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Abstract

Prior studies have shown that males and females perform differently on a variety of memory tasks. It is suggested that certain biological factors can lead to sex-related differences in cognitive decline, memory, and learning. The present study explores this further by examining the performance of males and females on associative memory tasks when exposed to proactive interference (PI). The findings of this study may aid in understanding the underlying mechanisms involved in overcoming interference and improving memory. This study utilized 49 individuals (*F = 26, M = 23)* between the ages of 18 and 77. The participants were asked to complete associative memory tasks while exposed to varying levels of interference (high interference, low interference, or no interference). During the encoding portion of the memory task, participants were asked to determine the ease in which two images presented together could be imagined. During the retrieval portion of the memory task, participants were asked to recall which associate category (face or scene) the presented object was most recently paired with in the encoding phase. Electroencephalography (EEG) data was also collected while the participants completed the memory tasks, but due to time-constraints and limitations introduced by the COVID-19 pandemic, this data was not analyzed. A 3x2 repeated measures ANOVA conducted found a significant main effect of interference on memory accuracy, but no significant difference in the effects of interference on the memory accuracy of both sexes. Additionally, no interaction between interference conditions and sex was found. However, a paired samples t-test found significant differences in memory accuracy between the three interference conditions used in this study. Given this, future studies may modify components of this study to observe sex-related differences, such as changes to the associative memory task or an increase in the sample size. In the future, the potential analysis of EEG data may shed light onto differences in neural activity between the two sexes when exposed to PI.

Introduction

The mechanism of proactive interference (PI) in memory has been studied frequently in cognitive neuroscience. PI is a common occurrence in which information previously learned will interfere with the ability to retrieve new information (Luenendonk, 2019). Currently, there are not many studies that examine the effect of PI on the performance of individuals during associative memory tasks. Associative memory is the ability to learn by utilizing the relationship between seemingly unrelated items that one is presented with (Suzuki, 2005). For example, one might associate the smell of a bakery with a person they once met there, causing them to remember that individual each time they enter the bakery (Suzuki, 2005; Luenendonk, 2019). While existing studies have examined the influence of age and other factors in proactive interference (Emery et al., 2009; Nee et al., 2007), studies have not explored potential sex-related differences in resolving proactive interference in associative memory.

Because proactive interference in memory is commonly experienced by individuals, it is important to study the different factors that may influence its impact on memory, and more specifically, associative memory (Luenendonk, 2019). Prior research focused on the role of aging in resolving proactive interference has suggested potential sex-related differences due to differing performances between males and females in verbal episodic memory assessments (Emery et al., 2009; Graves et al., 2017). Emerging research studying the effect of biological factors in learning, memory, cognitive decline suggests that the neurobiology of the different sexes could impact performance on memory tasks (Beydoun et al, 2012; Andreano & Cahill et al., 2009; Choleris et al., 2018). Although sex-related differences in resolving proactive interference have not been studied, previous research, like the aforementioned, give reason to believe that these differences may exist. Furthermore, because there is evidence for the claim that males and females utilize different brain regions during certain memory tasks, it is possible that the mental strategies used to perform the tasks may vary across both sexes, resulting in differences in performance (Bass et al., 2014; Butler et al., 2006).

In the present study, the neural activity of both male and female participants was recorded using electroencephalography (EEG) as they performed a series of associative memory tasks on a computer. During the associative memory tasks, participants were exposed to varying levels of interference. The purpose was to determine whether a significant difference existed in the

performance of males and females on the associative memory tasks due to differences in the ability to resolve, or overcome, the PI. In order to determine whether biological sex plays a role in the ability to resolve proactive interference, it is important to examine neural correlates alongside the behavioral data. The EEG data collected during the associative memory tasks will be processed through time-frequency analyses in order to closely examine alpha oscillations of participants. Previous studies have suggested that alpha oscillations are involved in coordinating top-down control processes and inhibitory mechanisms that manage access to task-relevant information (Wolff et al., 2017; Klimesch, 2012). These mechanisms are important in associative memory tasks, like the one used in this study, in order to inhibit interferences from previous tasks (Klimesch et al., 2007). The time frequency analyses of these alpha oscillations will shed light onto neural activity correlated with overcoming the proactive interference during associative memory tasks. Because proactive interference is a common occurrence that individuals experience in a variety of domains, understanding the factors that may affect its severity is important. Sex-related differences in resolving PI during associative memory tasks, if found, could provide more detail about the underlying mechanisms involved in interference in memory and how it may be overcome.

Literature Review

Many studies have supported the idea that an individual's ability to store and retrieve information is influenced by the brain activity that occurs as a result of proactive interference (Bowles & Salthouse, 2003; Emery et al., 2009). Less commonly studied is the effect of PI on the performance of individuals during associative memory tasks. While research regarding brain regions involved in PI and the effect of age-related differences on PI have been conducted (Emery et al., 2009; Nee et al., 2007), studies have not explored potential sex-related differences in the reduction of proactive interference in associative memory.

Results of studies that are examining the role of aging in memory often shed light on potential correlations between sex and memory. More specifically, it has been found that age plays a role in recall and recognition abilities and that biological sex is a factor as well. A study that used the California Verbal Learning Test to measure recall and recognition discriminability shows that scores on this assessment decreased with age (Graves et al., 2017). Additionally, results showed that females generally performed better than males in the verbal episodic memory assessment (Graves et al., 2017). While the present study does not utilize verbal episodic memory tests, the evidence that females outperform males in the episodic memory tasks suggests that similar differences may exist in associative memory tasks. This is because associative memory is the memory that creates the connections which in turn form episodic memory (Sompolinsky & White, 2005).

To expand on the sex-related differences in resolving PI during associative memory tasks, it is imperative to study the biological factors related to cognitive impairment and the neurobiology of memory. For example, one allele in particular, the Apolipoprotein E epsilon 4 allele (ApoE-ε4), could potentially be related to the sex differences in the context of dementia, cognitive impairment, and onset of cognitive decline (Beydoun et al., 2012). The presence of E epsilon 4 predicted cognitive abilities - females had stronger associations between presence of the allele and greater impairment of verbal memory in old age. Furthermore, researchers argue that both males and females excel at different memory and learning tasks due to their biological sex. For example, males are shown to perform better than females when asked to complete spatial tasks, while females perform better than males when asked to complete verbal tasks (Andreano & Cahill, 2009). These differences could arise from the variations in grey matter in

the brain across sexes as well as the hormonal differences which could potentially influence neural circuits involved in memory (Choleris et al., 2018). Because there is numerous evidence that biological factors may influence the memory of males and females differently, there is reason to believe that PI will affect the performance of both sexes to a different extent during associative memory tasks. In the present study, this would appear as high PI resulting in worsening of associative memory performance during memory tasks. This entails the memory for image pairings, including face and scene identification.

Previous research has shown that males and females utilize different brain regions during a variety of memory or mental tasks. This suggests that in order to perform certain mental processes, both sexes are employing different strategies that affect their performance. For example, a proactive strategy was found to exist which may reduce the effect of PI in a list recall activity including similar words (Bass et al., 2014). Although the same strategies were not completely consistent across groups, younger adults reported using the method of loci strategy in order to reduce the effects of PI on their task performance. The method of loci strategy utilizes top-down processing which may be used to resolve the effects of PI. With this method, participants enhance their memory by visualizing spatial environments to place information and thus improve their ability to recall (Bass et al., 2014). During a mental rotation task in a different study, females had greater activity in the dorsal medial prefrontal cortex when compared to males, which suggests that females perform mental processes in a more top-down fashion. In contrast, males tended to have greater activation in the primary sensory cortices and basal ganglia, which is highly suggestive of bottom-up processing (Butler et al., 2006). While these differences allow males to perform better in visuospatial tasks, the evidence that females are more likely to use top-down processing is suggestive of the fact that females may be better able to resolve the effects of PI during associative memory tasks.

In conclusion, the present study is important for expanding upon current neuroscientific research regarding sex-related differences with respect to cognition, memory, and learning. If it is found that one sex is better able to reduce the effects of PI on performance during associative memory tasks, further research can be conducted to understand the neural mechanisms responsible for this change. Additionally, more evidence of sex-related differences in memory tasks under the influence of PI could shed light onto performances in other situations in which overcoming interference would be beneficial. Furthermore, while there are hypotheses to explain

the known differences between males and females in memory tasks such as visuospatial memory or verbal recall, this study could help garner more information related to how these differences may manifest when under the influence of proactive interference.

Methods

<u>Participants</u>

In the present study, the sample of participants included twenty-six females and twenty-three males between the ages of 18 and 77. Each of the participants in the sample were right-handed and had normal or corrected vision. Additionally, prior to participating in the study, each participant was screened for health conditions that would exclude them from participating. More specifically, the participants who answered yes to neurological or psychological conditions were excluded. Based on these exclusionary criteria, no participants were excluded. Furthermore, if the participants scored lower than 23 out of 30 on the Montreal Cognitive Assessment (MoCA), their data was excluded in the analysis (Carson et al., 2018). Four females and one male were excluded based on this criteria. The demographics of the included participants is shown in Table 1.

Each participant was compensated for participation in the experiment. Participants were either paid $15 per hour that they spent in the study or awarded with institutional credits if eligible. The experiment lasted an average of 4 hours. Before beginning the experiment, all participants were asked to sign consent forms approved by the Georgia Institute of Technology Institutional Review Board.

Measure	Female (n = 26)	Male (n = 23)
Age	35.6 (20.90)	45.9 (23.93)
Education	16.9 (2.88)	16.7 (2.16)
MoCA	27.7 (1.86)	27.2 (2.42)
Race/Ethnicity	8 NHW, 6 NHA, 8 BL/AA, 4 UNK	12 NHW, 3 NHA, 6 BL/AA, 2 UNK

Table 1. Group demographic information of included participants. Standard deviations in parentheses. BL/AA = Black/African American, NHA = Not Hispanic Asian, NHW = Not Hispanic White, UNK = Unknown.

<u>Materials</u>

The associative memory task consisted of two-hundred and sixteen pictures of objects, eight pictures of faces and eight pictures of scenes. The pictures of faces consisted of four female and four male images and the scenes consisted of four indoor and four outdoor images. Hemera Technologies Photo-Objects DVDs and Creative Commons were used to obtain the pictures of objects. The pictures of faces were obtained from Max Planck Institute's FACES database (Ebner et al., 2010) and the pictures of scenes were taken from the SUN database (Xiao et al., 2010). During the associative memory task, each object was paired with either a face or a scene. Each pair of images was presented against a grey background on the computer screen with a fixation cross presented before each pair.
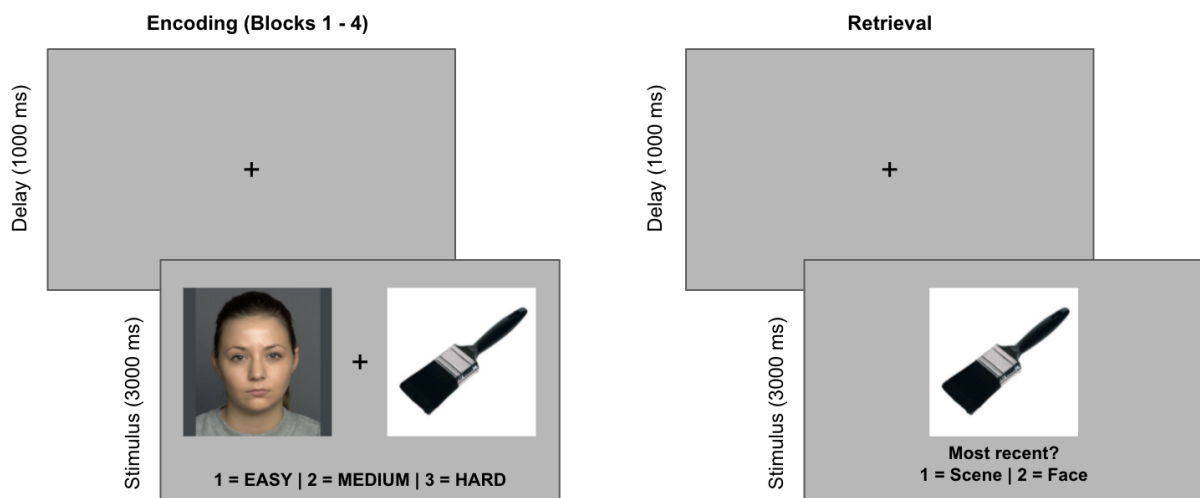
<u>Associative Memory Tasks</u>

Figure 1. Associative memory task that begins with encoding phase (4 blocks) and ends with the retrieval phase. Stimulus presentation in both phases is preceded by a delay period of 1000 ms.
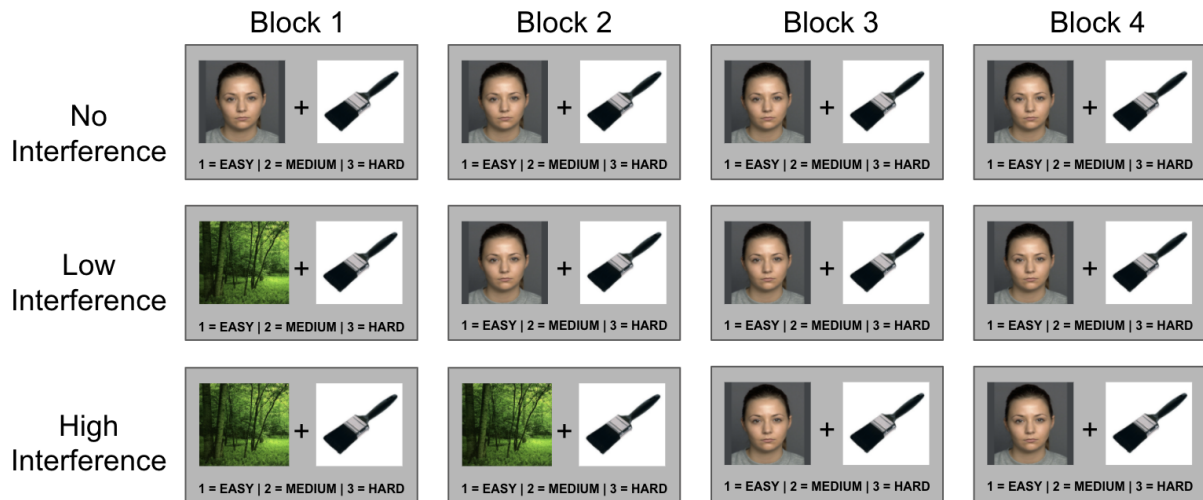
| | Block 1 | Block 2 | Block 3 | Block 4 |

Figure 2. Example of three interference conditions during four blocks of encoding phase of associative memory task.

The associative memory task was divided into two parts. Part one was encoding and part two was retrieval. During encoding, different objects were paired with either faces or scenes while being exposed to varying levels of interference. During retrieval, participants were asked to recall the picture that each object was most recently paired with (Figure 1). EEG was recorded during both encoding and retrieval, but the data was not analyzed due to time constraints and other limitations.

Encoding

The encoding phase was divided into four blocks. Each block had a duration of 15 minutes. In each block, participants examined 216 objects paired with either a face or a scene under varying levels of proactive interference (Figure 1). The positions of the objects and faces/scenes (associates) were balanced across participants. All of the object images were evenly divided into the following three proactive interference conditions: high interference, low interference, and no interference. Each of the three interference conditions was assigned 72

object images. For the high interference conditions, the object was paired with an associate from one category (e.g. specific face) for the first two blocks and paired with a second associate from the other category (e.g. specific scene) for the remaining two blocks. For the low interference conditions, the object was paired with an associate from one category (eg. specific face) for one of the first three blocks and then with a second associate from the other category (e.g. specific scene) for the three remaining blocks. For the no interference conditions, the object was paired with only one associate from a single category for all four blocks, with no other associate introduced (Figure 2). In the fourth block, the object was consistently paired with the associate the participant would be asked to recall later. Each image pair was preceded by a delay with a fixation cross displayed in the center, lasting 1000 ms. The stimulus was presented for 3000 ms (Figure 1). For each pair presented in the encoding phase, the participants were asked to indicate, with a keypad, how difficult it was for them to imagine the object and associate together. A three-point scale was used in which 1 corresponded with easy, 2 with medium, and 3 with hard.

Retrieval

The retrieval phase was initiated after the completion of the fourth encoding block. In this phase, participants' memory for the 216 associations studied in the encoding phase was tested. For each trial, an object was presented in the center of the screen and the participants were asked to select the associate category (face or scene) the object was most recently paired with in the fourth encoding block (Figure 1). Half of the participants were instructed to respond by pressing "1" if the object was most recently paired with a scene and "2" if the object was most recently paired with a face. The other half of the participants were instructed to respond with "1" if the object was most recently paired with a face and "2" if the object was most recently paired with a scene. The entire retrieval phase lasted 15 minutes, with each object displayed on the screen for 3000 ms. Before each object was presented, there was a 1000 ms delay in which a fixation cross was displayed in the center of the screen (Figure 1).

Statistical Analyses

In order to examine the effects of interference and sex on the memory accuracy of the object and face/scene pairings, the behavioral data collected from the associative memory tasks was utilized. To determine the memory accuracy, the percentage of correct memory responses during the retrieval phase was calculated for each interference condition. In this case, correct memory responses consisted of those in which the participant was able to correctly select the associate category (face vs. scene) that the object was paired with in the fourth encoding block. For both sexes, memory accuracy for the associate was calculated on average across all interference conditions as well as independently for each of the three conditions. Memory accuracy was calculated to represent the ability to resolve PI during the associative memory tasks.

An independent sample t-test was conducted in order to examine sex-related differences in memory accuracy during the retrieval block across all interference conditions. To examine interaction effects between interference levels and sex on associative memory accuracy, a 3 (interference levels) x 2 (sex) repeated-measures ANOVA was conducted. This test accounted for the three independent variables, which were the no interference, low interference, and high interference conditions. A paired samples t-test was also done to study differences in memory accuracy between high interference and low interference conditions, high interference and low interference conditions, and low interference and no interference conditions. To ensure that the participant age was not a confounding factor in the results, a 3 (interference levels) x 2 (sex) x 2 (age) ANOVA was conducted. The data collected from all participants was categorized into two groups, younger adults (18-35 years) and older adults (61-77 years), and the memory accuracy of males and females in both groups, under all three interference conditions, was analyzed. Lastly, to study any potential effects of visual stimulus category (face or scene) on the memory accuracy of males and females during the associative memory tasks, a 2 (stimulus category) x 2 (sex) repeated measures ANOVA was conducted. For this 2x2 ANOVA, the memory accuracy of males and females during the no interference conditions was utilized to eliminate interference from the other image category. All statistical tests were conducted in IBM SPSS Statistics.

Results

Sex & Memory Accuracy

An independent sample t-test was used in order to determine the effects of sex on the memory accuracy of participants across all interference conditions. A p-value of 0.05 was used. There was no significant difference in the average memory accuracy of males and females across all interference conditions (t(1,47)= 0.251, p = 0.803) (Figure 3).

Interaction Effects Between Interference and Sex on Memory Accuracy

A 3x2 repeated-measures ANOVA was conducted for the three different interference conditions (no interference, low interference, and high interference) and the two different sexes being studied. An alpha-value of 0.05 was used. The main effects of interference on memory accuracy were significant (F(2,94) = 91.929, p < 0.001). The main effects of interference on the memory accuracy of the different sexes, however, were insignificant (F(1,47) = 0.074, p = 0.803) and no interaction was found between interference and sex (F(2,94) = 0.109, p = 0.853). An estimated marginal means was conducted in order to obtain the mean memory accuracy of males and females across the different interference conditions as well as their standard deviations (Figure 4).

As a post-hoc analysis, a paired samples t-test was done to examine differences in memory accuracy between high interference and low interference conditions, high interference and low interference conditions, and low interference and no interference conditions. A multiple comparison correction to the alpha-value was made and an alpha-value of 0.016 was used. It was found that there were significant differences between the memory accuracy of participants when exposed to high v. low (t(48) = -6.762, p < 0.001), high v. no (t(48) = -13.915, p < 0.001), and low v. no interference conditions (t(48) = -7.213, p < 0.001).

Interaction Effects Between Interference, Sex, and Age on Memory Accuracy

A 3x2x2 repeated measures ANOVA was conducted in order to evaluate any confounding effects of age on the performance of males and females on the associative memory tasks under

the three interference conditions. An alpha-value of 0.05 was used. The main effects of interference on the memory performance of the two age groups, younger and older adults, were significant ($F(1,45) = 4.397$, $p = 0.042$). However, the main effects of interference on the memory accuracy of the two sexes were again insignificant when younger and older adults were analyzed separately ($F(1,45) = 0.478$, $p = 0.493$). Lastly, no interaction was found between interference, sex, and age for both younger adults or older adults ($F(1,45) = 0$, $p = 0.989$) (Figure 5).

Effects of image category on memory accuracy of both sexes

A 2x2 repeated measures ANOVA was conducted to explore any potential effects of image category (face or scene) on the memory accuracy of males and females. The memory accuracy for faces was significantly higher than the memory accuracy for scenes for both males and females ($F(1,47) = 14.33$, $p < 0.001$). However, there were no significant differences between males and females in the memory for faces or the memory for scenes ($F(1,47) = 0.033$, $p = 0.857$).
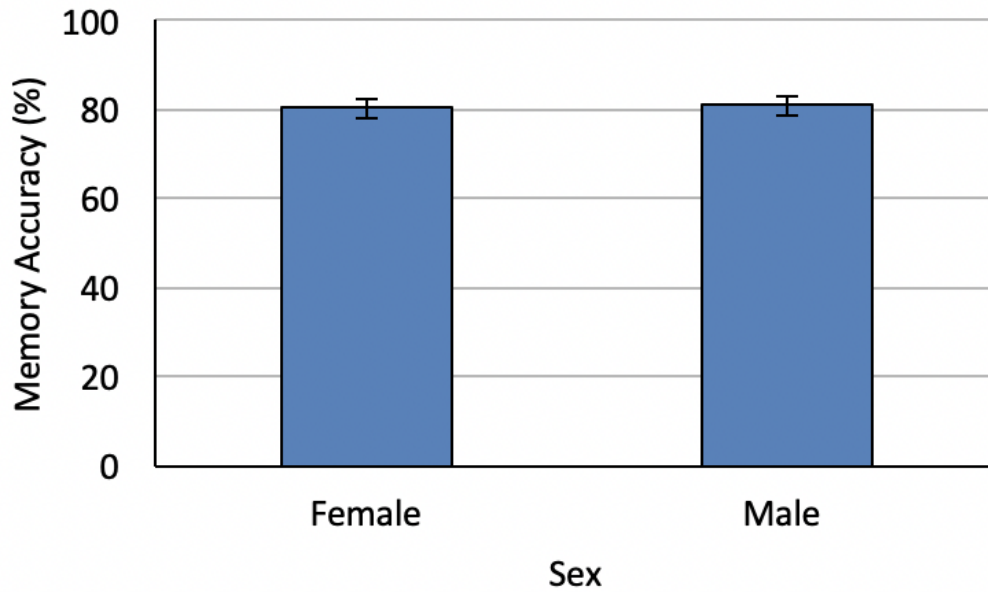
Figure 3. The average memory accuracy for males and females in the retrieval phase of the associative memory task. Memory accuracy was calculated as the percent of correct responses during retrieval, following encoding, across all interference conditions. Males had an average memory accuracy of 80.9% (SD = 9.72) and females had 80.3% (SD = 8.82) memory accuracy. These results were insignificant (t(1,47)= 0.251, p = 0.803). Error bars represent SEM.
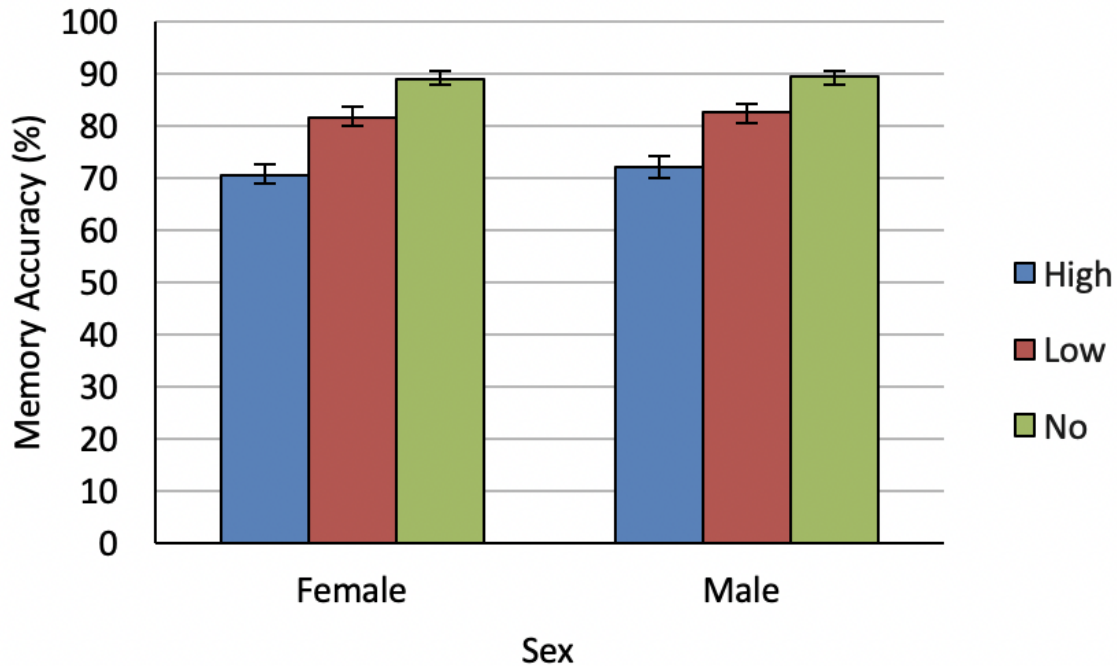
Figure 4. The average memory accuracy of both sexes during the retrieval phase of the associative memory task under varying levels of interference. The percent memory accuracy of both sexes increased as the level of interference decreased. In the high interference conditions, females had a percent average memory accuracy of 70.6% (SD =12.7) while males had 71.9% (SD = 12.8) accuracy. For the low interference conditions, females had an average memory accuracy of 81.5% (SD = 10.5) while males had 82.2% (SD = 7.75) accuracy. Lastly, for the no interference conditions, females had 88.9% (SD = 7.94) memory accuracy while males had 89.1% (SD = 11.0) accuracy. The average memory accuracy of males and females under each of the interference conditions was not significantly different (F(2,94) = 0.109, p = 0.853). Error bars represent SEM.
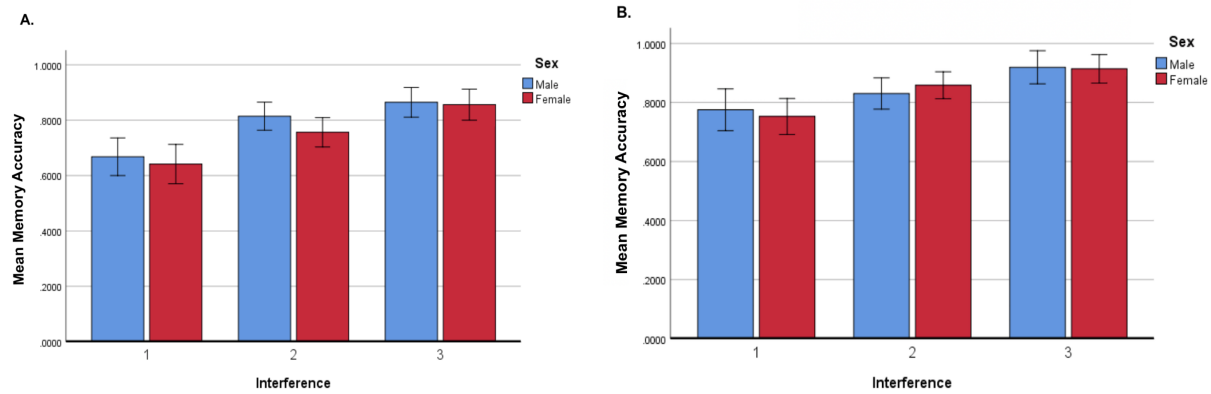
Figure 5. A. Mean memory accuracy of older adult males and females during the retrieval phase of the associative memory tasks under varying levels of interference. B. Mean memory accuracy of younger adult males and females during the retrieval phase of the associative memory tasks under varying levels of interference. 1 corresponds to high interference conditions, 2 corresponds to low interference conditions, and 3 corresponds to no interference conditions. Overall, no significant difference in mean memory accuracy was observed between younger adult males and females or older adult males and females ($F(1,45) = 0$, $p = 0.989$). Error bars represent 95% confidence interval.

Discussion

The present study investigated potential sex-related differences in resolving proactive interference (PI) during associative memory tasks. In order to do this, behavioral data was collected while the participants completed the retrieval phase of the associative memory tasks. EEG data was also collected during both the encoding and retrieval phases, but due to time-constraints the time frequency analysis was not completed.

It was hypothesized that as the level of proactive interference increases, the memory accuracy of both sexes would decrease, but both sexes would have different abilities in resolving PI, as measured by memory accuracy during the retrieval phase of the memory tasks. This is because there is evidence that females tend to use top-down processing, which has been associated with mental strategies such as the method of loci, which can reduce the effects of proactive interference (Bass et al., 2014; Butler et al., 2006). Furthermore, previous studies have

shown females outperforming males in episodic memory tasks, and episodic memory is created from the connections formed through associative memory (Graves et al., 2017; Sompolinsky & White, 2005). Alternatively, because evidence shows that females have a biological predisposition to experience stronger cognitive impairments, it was hypothesized that there would be differences in abilities of males and females in resolving PI during associative memory tasks (Choleris et al., 2018; Baydoun et al., 2012)

The results of the present study showed that there were significant effects of PI on both sexes, with both sexes demonstrating decreasing memory accuracy as the interference levels increased. This is consistent with existing literature which discusses the negative effects of proactive interference on associative memory (Jacoby et al., 2001; Nee et al., 2007; Corbett & Duarte, 2020). However, there were no significant differences in the memory accuracy of both sexes during the retrieval phase of the associative memory task.

Because the males and females participating in the present study were not all of the same age, there was a possibility that age was a confounding variable. Previous literature has shown that associative memory declines with age due to the decreasing volume of the anterior hippocampus, but the exact point in which this decline begins to occur is still unknown (Nordin et al., 2017). To explore this further, statistical analyses were conducted that examined the memory accuracy of both younger and older adult males and females. Overall, it was found that there was no significant difference in memory accuracy of the two sexes in either age groups.

Furthermore, it was possible that the visual stimuli used in this associative memory task influenced the performance of both sexes in different ways. Particularly, the present study utilized images of faces and scenes as the associates, and faces have proven to be remembered better by females (Rehnman & Herlitz, 2007). After conducting statistical tests to explore this possibility in the present study, it was found that both sexes had a higher memory accuracy for faces. However, there was no significant difference in the memory accuracy of males and females for either faces or scenes. This suggests that the visual stimuli were not influencing memory accuracy of either sex differently during the associative memory tasks.

In regards to the general difficulty of the associative memory task utilized in the present study, it is possible that the task was too easy and therefore causing difficulties in detecting any differences in memory accuracy across males and females when exposed to PI. More

specifically, the memory task utilized in this study asked the participants to choose between two choices, face or scene, when identifying what the object presented was most recently paired with. This question provided a 50% chance of answering the question right, meaning that even if the participant was unsure, they could guess one of the two choices. The likelihood of guessing leading to the false impressions of memory accuracy is highly likely and can be diminished in future studies by increasing the number of categories of associates to choose from. For example, instead of choosing only between a face and scene, the participant will have to decide between a third category, such as animal.

Additionally, while previous studies have shown evidence of sex-related differences in verbal fluency, perceptual speed, spatial memory, and working memory, there has not been strong evidence to suggest differences in associative memory (Upadhayay & Guragain, 2014; Graves et al., 2017; Andreano & Cahill, 2009). While hippocampal volume can predict differences in associative memory in older women, similar correlations have not been seen in older men (Zheng et al., 2017). The results of the present study support these findings, as no significant differences were found in the associative memory accuracy of males and females when exposed to varying levels of PI. Furthermore, when the memory accuracy of the two sexes was examined in both age groups, no significant differences were found. However, due to the small sample size of the present study (*M=23, F=26)*, the results may not be representative of the general population and thus cannot be generalized.

Because the sample size of the present study was a potential limiting factor, a power analysis was conducted in order to determine the sample size needed to detect any sex differences. According to similar previous studies which found significant sex differences in episodic memory (Herlitz et al., 1999; Lewin et al., 2001), the sample size required to detect sex-related differences in the present study was found to be approximately 200-206 participants total. This estimated sample size includes about 100-103 males and females each, compared to the present study which utilized 23 males and 26 females. Future studies may expand the sample size accordingly in order to detect potential sex-related differences.

The present study found no significant differences between associative memory accuracy of both sexes while under the influence of PI. This may have been a result of potential confounding variables, as mentioned above, as well as the small sample size used. Furthermore,

while EEG data was collected during both the encoding and retrieval phases of the associative memory task, the time frequency analyses were unable to be completed due to time constraints. Additionally, due to the COVID-19 pandemic it was deemed unethical to collect more data and recruit more participants.

Conclusion

In conclusion, the hypothesis that there would be a difference in the associative memory accuracy of males and females while under the influence of proactive interference was not supported. While the effects of PI on memory accuracy across both sexes were significant, the interaction between sex and interference was not significant, suggesting that there are no sex-related differences in resolving PI during associative memory tasks. The present study was severely limited by time constraints and limitations on procedures that needed to be conducted in the lab due to the COVID-19 pandemic. As such, the behavioral data collected was utilized in order to examine any potential differences in resolving proactive interference and a number of statistical tests were done to determine significance. Because there were no significant differences in memory accuracy evident in the behavioral data, it is unlikely that such differences would be evident in the EEG data. This study is significant because proactive interference commonly occurs on a day-to-day basis, and understanding the potential factors, like sex, that may influence its effects on memory is important. While the present study found no significant effects of sex on the ability to resolve PI and improve memory accuracy, future studies can expand on this research to understand the underlying mechanisms involved in PI and how it may be overcome.

Future Directions

Because the EEG data collected in the present study was not analyzed, future studies may focus on studying the brain activity while both sexes are completing the retrieval task. More specifically, the EEG data may be used to conduct time-frequency analyses in order to examine alpha-oscillations while the participants are completing the retrieval task. This is because existing literature suggests that alpha oscillations are involved in top-down control mental

processes and inhibitory mechanisms which are important in associative memory tasks to resolve interferences from previous memories (Wolff et al., 2017; Klimesch, 2012; Klimesch et al., 2007). If significant differences are found between males and females, the neural activity correlated with resolving PI may be understood.

Additionally, future studies may account for the lifestyle differences across the male and female participants. It has been found that exercise differentially affects memory task performance in males and females, with females showing better recognition memory compared to males following exercise (Coleman et al., 2018). Given these findings, future research may account for the amount of physical exercise each participant partakes in weekly, and then study memory accuracy during associative memory tasks. Because females have been shown to have improved recognition memory following exercise, it is possible that similar effects may be seen during associative memory tasks in the present study, which involve recognition of the most recent pairing. Any differences, if found, may be related to interactions between exercise and sex hormones that may impact memory, which will be interesting to examine further in future studies.

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