Running Head: STRESS, GENDER, AND MEMORY

Gender Difference in Human Memory Under Stress

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Abstract

Past research has demonstrated that endogenous stress hormones such as epinephrine and corticosterone can enhance human memory consolidation for emotionally arousing material. This study investigated the effect of stress on memory and further examined any gender difference in memory. Participants viewed a set of images that varied in emotional arousal. Immediately after, the experimental group immersed their arm in ice cold water, known as cold pressor stress (CPS). A control group immersed their arm in warm water. The results showed no significant difference in the number of slides or details recalled overall (warm vs. cold water). The gender analysis revealed no significant differences between males and females in recall between arousal or the CPS and warm water groups. No interactions were found between gender and temperature. While the study was unable to find any significant results, a floor effect, inability to test cortisol levels and determine increased stress levels, and opposing studies that argue stress hormones can actually impair memory may help explain this outcome.

Gender Differences in Human Memory Under Stress

If one has an experience and then undergoes stress, how well will they remember that specific experience? What factors play into what they will remember about that experience? Why are stressful experiences remembered more clearly than events that are less arousing? Much research has been done to investigate certain aspects of memory and the factors that influence it. Among the research on memory, topics have included gender, stress, arousal, emotion, sociocultural, and neural aspects. Past research provided evidence that the degree of arousal experienced at encoding of visual stimuli can affect human memory. Researchers Cahill, Gorski, and Le (2003) have shown that human memory consolidation can be enhanced through the interaction of post-learning stress and the degree of arousal at encoding. They demonstrated that the stress hormone epinephrine interacts with degree of arousal at encoding of material to enhance human memory for emotionally arousing sides.

Participants viewed different images that varied in content from neutral, pleasant, to unpleasant. Cold pressor stress (CPS) was administered to experimental participants immediately following the images to increase stress. A free recall memory test given one week later showed that those who were given CPS were able to recall significantly more of the emotionally arousing images than those in a warm water control group. The groups did not differ in the number of neutral slides remembered. The study suggested that CPS activated a stress hormone that when interacting with arousal was able enhance long term memory consolidation.

In the same study, little was able to be evaluated regarding gender because of sample numbers. Women in the CPS group remembered more of the emotionally

arousing slides than participants in the control group, but did not differ in the number of neutral slides remembered. There were not enough male subjects in this study to make the same conclusions.

A follow up study by Andreano and Cahill (2006) looked at the effect of CPS on memory in men and women. Participants immersed their arm in ice water (CPS) or warm water immediately after reading a relatively neutral story and were tested for retention one week later. As in the previous research, they found that CPS activated stress hormones in both men and women. However, this study showed that memory of the story was only enhanced in male subjects who were administered CPS. There was no difference in recall between genders for the control condition. This study suggested a gender related difference in the effects of stress on memory consolidation. The results also demonstrated the first inverted-U relationship between stress hormone activation and human memory. This implies that midrange cortisol levels can enhance memory while low or high levels do not affect or impair memory of such material. Current research is working to explain the differences between the genders and cortisol levels in response to stress.

Akirav, Kozenicky, Tal, Sandi, Venero, and Richter-Levin (2004) conducted a similar study involving the activation of hormonal systems and the acquisition and retention of a spatial learning task in rats. Their previous research concluded that rats trained in cold water performed better at the spatial learning task compared to those trained in warm water. Those in cold water also had higher levels of the stress hormone corticosterone. Their research demonstrated that rats who previously performed well on the spatial task in cold water showed deterioration with the suppression of corticosterone

levels. Those rats that previously did not perform as well in warm water showed improvement when corticosterone levels were increased. Their results suggest that corticosterone levels play a significant role in the animal's ability to learn and retain spatial learning tasks.

Southwick, Davis, Horner, Cahill, Morgan, Gold, Bremner, and Charney (2002) also suggested that post-learning adrenergic modulation has a significant effect on human memory enhancement for emotionally arousing events. After participants viewed a series of slides, they either received an intravenous infusion of yohimbine to stimulate norepinephrine during consolidation of memory or an intravenous placebo. Overall, the participants (placebo and experimental) showed enhanced memory for a series of slides when norepinephrine levels were at a peak, supporting the idea that noradrenergic activity during memory consolidation is associated with long-term memory in humans.

Zorawski, Cook, Kuhn, and LaBar (2005) investigated the relationship between gender, stress hormones, and the acquisition and retention of conditioning to fear relevant stimuli in humans. All participants underwent differential delay conditioning, using fear-relevant conditioned stimuli and a shock unconditioned stimulus. Salivary cortisol levels were taken at baseline and after acquisition training and a 24 hour delayed retention test. A significant relationship was found between postacquisition cortisol levels and conditioned fear acquisition in males, but not in females. No relationship was found between postacquisition cortisol levels and retention of conditioned fear. The results of this study suggest there are individual differences in fear acquisition that need further research to better understand the complex relationship between gender, stress, and fear.

The previously discussed studies consistently suggest that an increase in hormonal activation after a task has the ability to affect retention.

As Cahill suggested, the degree of arousal is also a significant factor in memory. Bradley, Greewald, Petry, and Lang (1992) provide consistent evidence for better long term picture memory in humans as affected by the degree of arousal. A year after images were shown to participants, those rated as highly arousing were remembered significantly better than those with low arousal. The effect was validated in a speeded recognition test, where the highly arousing images seen a year earlier produced faster reaction times than the low arousal stimuli, regardless of their pleasantness.

In this same study, Bradley et. al. were able to evaluate the differences in memory between genders. Men recalled more images containing weapons, mutilated bodies, and attractive women. Women recalled more household objects, food items, and attractive men. Those categories such as sports, nature scenes, and males/females showed no difference in recall or arousal rating between men and women. It appears that some of the categories recalled were related to the subject's gender rather than the arousal level alone. While both pleasantness and arousal are found to be processed at initial encoding, this study suggests that long term memory performance is mainly affected by arousal.

Another study by Bradley, Codispoti, Sabatinelli, and Lang (2001) suggested a difference in picture processing between males and females. As expected, both men and women produced the largest affective reactions to the highly arousing images in their study including threat, mutilation, and erotica. Women responded with greater defense reactivity (more intense displeasure, greater facial EMG activity, and greater cardiac deceleration) to adverse pictures regardless of content where men showed increased

appetitive activation (greater sympathetic arousal as measured by palmer conductance and reports of more intense pleasure and arousal) for erotic images. Women rated the most unpleasant images as more arousing than men and indicated a stronger coupling between unpleasantness and arousal. Men found the most pleasant pictures more arousing than women did and presented a stronger coupling between pleasure and arousal.

Bradley et. al. were able to suggest both biological and sociocultural factors as reasons for differences in men and women's affective perception of the images. Social and clinical research also supports the findings that women are more reactive to aversive stimulation as women consistently report fear and anxiety disorders more often than men. Hormonal balance, physical size, and strength are all intrinsic factors that are suggested as potential explanations for gender differences in the reactions. An explanation for men suggests that emotional expression in the context of sexual stimuli is accepted and reinforced for men, but not women, especially in Western culture. As research continues, clearer explanations for gender differences will appear.

Research has also demonstrated that emotional effects can play a role in a human's ability to retain certain type of images. Gard and Kring (2007) provided research that showed a complex gender difference in emotion. The researchers measured reported emotional experience and startle response magnitude (EMG activity), both during the presentation and after the onset of emotional stimuli that engage these motivational systems. They wanted to see if men and women differ in their patterns of immediate response to emotional stimuli and in their patterns of recovery from these responses. Women showed greater potentiation to negative (mutilations and threatening animals and humans), but not positive (action/adventure scenes and other sex-erotica), emotional

pictures compared to men during the presentation of images. Women also showed a continued potentiation of the startle response after the presentation of negative pictures compared to neutral (household objects) ones. This suggests that women were continuing to engage in the aversive motivational system after the onset of negative emotional pictures when men were not. The study implies that further research must be done to extend a better understanding of the gender differences in emotional responding.

An interesting study by Minnema and Knowlton (2008) suggested that directed forgetting relies on cognitive control processes (ability to inhibit certain cues) that may be disrupted by negative emotion. The emotional content of words can influence the degree to which participants can be directed to forget them. In their first experiment, negative valence words were recalled better when participants were told to forget them than when they were told to remember them. The recall of a negative list of words with a "forget" cue increased, but only when they were followed by another list of negative words. This suggests that negative emotion can attenuate directed forgetting cue and that arousal may be particularly detrimental when negative words are used.

Research by Maheu, Joober, Beaulieu, and Lupien (2004) suggested that the interactions between adrenal hormonal systems affect emotionally arousing declarative memory in humans. Beta blockers work by blocking the effects of the hormone epinephrine. They cause the heart to beat more slowly and with less force, which reduces blood pressure. The researchers found that when administered, the beta blocker Propranolol impaired short and long term declarative memory for emotionally arousing material. However, corticosteroid synthesis inhibitor, Metyrapone, when administered, did not impair short term declarative memory, but did impair long-term declarative

memory for both emotionally arousing and neutral material. The results demonstrate a somewhat differential effect of both types of adrenal hormones on short and long term declarative memory for emotionally arousing information.

Research continues to investigate gender involving different memory tasks. Colley, Ball, Kirby, Harvey, and Vingelen (2002) investigated gender-related motivational effects in an everyday task. They discussed several findings from previous research indicating that women were better at remembering names, shopping lists, and childhood events as well as placing familiar names while men appeared to perform better at remembering directions. Colley et. al. provided two explanations for such results. One explanation suggests that men and women perform better on certain memory tasks by increasing effort on memory tasks specific to their own gender-type. The other suggests that a gender cue may invoke stored knowledge that varies according to different gender-related experiences of men and women.

Colley et. al. applied a gender cue in the label of the information provided and manipulated information ("women better" vs "men better") provided about men's and women's performance. Women performed significantly better than men on a recall test for a "grocery" list. They also recalled a similar number of items as men on the "hardware" list, making them recall more items overall. Colley et. al believe that the "hardware" label was gender-neutral and not specific to the male or female gender role where the better recall for the "grocery" label indicated an association of shopping for domestic items with the female gender role. Motivation also played a role as men recalled more items in a "women better" condition where women performed better in a "men better" condition suggesting that men and women try harder if the task favors the other

gender. The results suggest that the differences in gender appear to be some combination of the explanations provided by Colley et. al.

More research is looking into the specifics of neural differences between men and women's memory abilities. Bradley, Sabatinelli, Lang, Fitzsimmons, King, and Desai (2003) found data that confirmed extensive visual cortex activity for participants viewing emotional verses neutral pictures. The three picture contents that prompted most extensive cortical activation were those containing erotica, mutilation, and threat. Canli, Desmond, Zhao, and Gabrieli (2002) demonstrated the differences in gender of the neural networks that are used during emotional experiences and memory encoding. All emotionally arousing pictures were remembered better, but women remembered more than men. Men showed more activation in the neural circuit involving the right amygdala where women showed greater activation in a circuit surrounding the left amygdala. Similarly, Cahill, Haier, White, Fallon, Kilpatrick, Lawrence, Potkin, and Alkire (2000) found a clear gender related lateralization of the amygdala. Supporting past research, men showed activation of the right amygdala and women showed activation of the left when viewing a series of emotionally provocative films. This research continues to suggest that theories of neurobiological basis of emotionally influenced memory can account for some influence in gender.

Much of the research presented has discussed the memory enhancing abilities of hormonal activation. However, there is some research that has contradicted these findings. Shors (1998) specifically discusses the observation that exposure to a stressful experience enhances classical conditioning in male rats and impairs conditioning in female rats. The study suggests differences in neuronal and hormonal mechanisms

between males and females animals that respond to similar emotional events. Differences in the amygdala, hippocampus, estrogen levels, and NMDA glutamate receptors are all discussed as potential areas of influence.

Strange, Hurleman, and Dolan (2003) showed that memory of emotional words can be enhanced, but is coupled with decrements in memory for items preceding the emotional stimulus. The B-adrenergic antagonist can reverse the enhancements and decrements and those effects can be abolished by bilateral amygdala damage. These results show that memory is enhanced if adrenergic activation occurs at the time of encoding, but is impaired if activation occurs 3-6 seconds after initial encoding. The data suggest that emotion evoked B-androgenic activity disrupts the encoding of items preceding an emotional event.

Another study by Cahill (2003) noted that emotional arousal can have both memory-enhancing and memory-impairing effects. In one study, subjects recalled more emotionally arousing words than they did neutral, but were found to remember significantly less of the words presented immediately before the emotional word than other neutral words. In a follow up study, a B-adrenergic blockade was administered to an experimental group. Additionally, a patient with bilateral amygdala damage was given the same test. Participants with the B-adrenergic blockade and the amygdala damage showed the same results of enhanced memory for emotional words and impaired memory for words presented immediately before the emotional word. A similar study found that emotion-induced decrement was twice as large in woman than men and the difference between the memory enhancing and impairing effects of the emotional words was also

greater in woman than men. This provides evidence that gender affects neural mechanisms of emotionally influenced memory.

Donders and Woodward (2003) investigated gender differences in memory after traumatic brain injury (TBI) in children. They found that boys with TBI performed worse on the Wide Range Assessment of Memory and Learning and the Wechsler Intelligence Scale for Children than girls with TBI and healthy control children. Gender appears to be an influential variable on TBI memory outcomes for children, but a recent study of gender difference in outcome after TBI in adults suggested that women actually tended to do slightly worse than men. Longitudinal studies are suggested to asses the possibility of developmental change in differences between gender and memory performances after TBI. Similar to the studies regarding neural differences and amygdala lateralization, the current research intends to investigate gender difference in memory, which could later help explain such TBI differences.

Finally, there is a portion of research that suggests that increased stress hormone levels have the opposite effect of enhancing memory. Wolf, Schommer, Hellhammer, McEwen, and Kirschbaum (2001) showed the first evidence for human gender differences in the association between stress induced cortisol elevations and memory performance after termination of the stressor. A negative association between the cortisol increase and memory was observed as those with large cortisol levels recalled less words than those with a small cortisol increase. Men with a strong stress induced cortisol increase showed reduced memory performance after stress, while no such associations were found in women.

Researchers Kirschbaum, Wolf, May, Wippich, and Hellhammer (1996) investigated the relationship between cortisol levels and memory in adults and found that subjects with high cortisol response to a stressor showed poorer declarative memory performance. It was also found that cortisol administered without a psychological stress impaired performance in declarative memory and spatial thinking tasks, but not in a procedural memory. Their results suggest that elevated free cortisol levels in healthy humans are associated with impaired memory function.

These final studies are also opposed to much of the research suggesting the enhancing memory abilities by increased arousal and stress hormone activation. Some studies suggested decrement in memory of images or words with increased stress hormone levels, the administration of Beta-blockers, or the placement of the emotionally arousing stimuli. The intent of the present study was to replicate the findings of Cahill et. al. (2003). While research has also begun to investigate the differences in gender, the research by Cahill and colleagues in his initial study were unable to find any differences between gender in the memory tests. This study also aimed to explore memory differences between male and female participants in the same study conducted by Cahill. The current study predicts that participants in the cold water will remember more images than those in warm water overall when tested one week later in a surprise memory test. When comparing the arousing versus neutral slides, participants in the cold water condition are expected to remember more of the emotional arousing images. The cold water should increase stress hormones and interact with arousal to help consolidate long term memory for the arousing material. As much research has provided, women tend to rate unpleasant images more arousing than men. Since arousal and post-learning stress

has had an enhancing effect in the past, it is hypothesized that females in the experimental CPS condition will remember more of the emotionally arousing images than men in the same condition. No difference should be found between genders in the neutral images.

Method

Participants

Forty-four undergraduate students from Gustavus Adolphus College participated in this research experiment between the months of November 2008 through January 2009. Students received class credit or extra credit, depending on the course they were taking. This study was approved by the International Review Board at Gustavus, and all students signed a written consent form before testing began.

Materials

The same 21 slides used in the study by Cahill et. al. were used in this research for replication purposes. All slides viewed came from the International Picture System (IAPS), a collection of over 900 standardized images with normative ratings of arousal and valence. The neutral images in the Cahill study were selected because of their low to moderate arousal quality, which was determined by the independent IAPS ratings (Lang et al. 1999). The testing was performed in two small labs. All slides were viewed using a Microsoft PowerPoint presentation. Participants view each of the slides for 15 seconds beginning with one of three neutral slides (fork, cow, light bulb). The slides proceeded automatically with no blank slide between each image. Three different presentations were used to avoid any order effects.

Procedure

The testing for all participants was conducted between the hours of 3:30 and 9:00 pm. While Cortisol levels were not being tested in this study, the idea was to stay consistent with the Cahill study. Following the student's arrival and consent for part one of the study, they were told that the study intended to see if there was a difference between cold or warm water on emotional reactions to visual stimuli. The cover story was used to avoid knowledge of a memory study. They were then informed that they would view 21 different images that would be neutral, pleasant, or unpleasant. They were also aware that they would be immersing their arm in either cold or warm water, but that they would not know which temperature they received until after they viewed the images. They were reminded of their right to withdraw from the study at any time, but none of the participants did.

The study began and five seconds after viewing each image, participants were prompted to identify the picture with a short word or phrase, such as "truck" or "flower." The responses were recorded by a researcher on paper. Immediately following the presentation, participants immersed their left forearm in either ice cold or warm water. Warm water temperatures were between 37-40 degrees Celsius and cold water temperatures ranged from 0-3 degrees Celsius, both assessed with a digital thermometer. Those participants in the cold water condition were asked to leave their arm in the water as long as they could, but to remove it if the feeling became uncomfortable or painful and that the maximum time allowed was three minutes. Warm water participants were asked to remove there arm at one, two, or three minutes randomly. Following the arm immersion, all participants rested for three minutes with their arm under a dry blanket.

Finally, participants were asked to think about the most intense physical pain they had ever experienced and rate it on a zero to ten scale with zero being "no pain or discomfort," five being "medium pain or discomfort," and ten being "worst pain or discomfort imaginable." On the same scale, they were asked to rate the peak pain or discomfort they experienced with their arm in the water. Participants were asked to keep the process confidential and reminded to return one week later for part two of the study.

Memory Testing

Students arrived six to seven days from their initial participation. Before the study continued, everyone was asked to tell the researcher what they thought the study was about when they arrived that day. If no definite connection was made between the water and memory of the images, their data was used. Only one female participant's data was removed due to an answer that indicated she knew what the research was truly looking at. The process began by giving each participant a sheet of paper with 21 blank lines. They were asked to recall as many images as they could remember, in no particular order, from the slides they saw a week prior. When they felt they were finished, they were then asked to recall as many details as they could about each slide. There was no time limit given for either task. For the final part of the study, participants view the same slideshow seen a week earlier. They were asked to rate how arousing they found each slide on a scale of one to nine with one as "calming/relaxing," five as "neutral," and nine as "exciting/agitating." After they completed this, all participants were debriefed as to the true nature of the research. Again, they were asked to keep the process confidential until the study was completed by all participants.

Results

Out of the forty-three participants, only one set of data was excluded due to the participant's indication that they were aware of the actual intent of the study. As a result there were 21 (12 female, 9 male) participants in the CPS condition and 21 (11 female, 10 male) participants in the warm water control condition.

Recall of All Slides

There was no significant difference in the number of slides recalled between the CPS and warm water control condition, regardless of slide arousal. An independent sample T-test was used with the level of alpha set at .05. Out of 21 slides, those in the CPS condition recalled a mean of 2.7 slides. Those in the warm water control condition recalled a mean of 2.8 slides ($t[40] = .27$, $p = .79$). There was also no difference between the two groups in the amount of details remembered about the slides. Both the CPS and warm water participants remembered a mean of 5.0 details total ($t[40] = .05$, $p = .96$).

Recall of Arousing Versus Neutral Slides

There was no significant difference in the number of slides recalled when comparing the slides rated by participants as arousing versus the neutral slides. For the arousing slides, those in the CPS condition recalled 48% of the slides labeled as arousing overall whereas those in the warm water condition recalled 44% of the arousing slides ($t[40] = .55$, $p = .59$). For the neutral slides, those in the CPS condition remembered 25% of the neutral slides whereas those in the warm water condition remembered 27% of the neutral slides ($t[40] = .50$, $p = .52$). See Figure 1.

There was also no difference in the number of details remembered between the slides and their arousal. For the arousing slides, CPS participants recalled 5.4 details and

warm water participants remembered 4.8; (t[40] = .55, p= .59). For the neutral slides, those in the CPS condition recalled 6.2 details and those in the control condition remembered 5.8; (t[40] = .30, p = .77). See Figure 2.

Gender Recall

The current research intended to identify any gender differences; however none were identified. For the arousing slides, women in the CPS remembered 52% of the slides where men remembered 42% (t[19] = .93 p = .36). In the warm condition, females were able to identify 45% of the arousing slides, where males remembered 42% (t[19] = .25, p = .81). For the neutral slides, female participants in the CPS group remembered 27% of the slides where males remembered 23% (t[19] = .75, p = .47). Females in the control group were able to recall 28% of the neutral slides where male remembered 24% (t[18] = .92, p = .37) of the slides.

No significant difference was found in the numbers of details recalled between the slides. For the arousing slides, females in the CPS group were able to remember 6.3 details and men remembered 4.1 details (t[19] = 1.39, p = .18). Females in the warm water condition recalled 4.9 details from arousing slides whereas males remembered 4.7 (t[19] = .16, p = .88). For the neutral slides, females in the CPS condition remembered 6.4 details where males were able to recall 6.0 details (t[19] = .19, p = .85). Females in the control condition remembered 4.3 details from neutral slides where males remembered 5.8 details (t[19] = 1.18, p = .25). See Table 1.

Interactions

To look for interactions between gender and temperature, a 2(gender) x 2(temperature) between subjects ANOVA was used to analyze results. There was no main effect for gender or temperature with the neutral slides. Females remembered 28%

and males remembered 24%; $F(1,38) = 1.56$, $p = .22$. Participants remembered 27% of the slides in the warm water and 25% of the slides in cold water $F(1,38) = .30$, $p = .59$. There was no interaction between gender and temperature $F(1,38) = .007$, $p = .94$. For the arousing slides, there was no main effect for gender or temperature. Females remembered 48% and males remembered 43% $F(1,38) = .74$, $p = .40$. Participants remembered 44% of the slides in the warm water and 48% of the slides in cold water $F(1,38) = .20$, $p = .65$. No interaction was found between gender and temperature $F(1,38) = .28$, $p = 60$. Regarding the number of details recalled, there was no main effect for gender or temperature with the neutral slides. Females remembered 6.1 details and males remembered 5.8; $F(1,38) = .04$, $p = .84$. In the warm water 5.8 details were recalled and 6.2 were recalled in cold water; $F(1, 38) = .07$, $p = .79$. There was no interaction between gender and temperature $F(1,38) = .00$, $p = .95$. For the arousing slides, there was no main effect for gender or temperature. Females remembered 5.6 details and males remembered 4.4; $F(1,38) = 1.37$, $p = .25$. The number of details recalled in warm water was 4.8 and 5.3 in the cold water $F(1, 38) = .16$, $p = .69$. There was no interaction found between gender and temperature $F(1,38) = .94$, $p = .34$. See Table 2.

Pain Rating

Participants were asked to rate their most painful experience ever on a scale of zero to ten, with ten being the most pain imaginable. They were also asked to rate the peak amount of pain experienced while their arm was immersed in the water, on the same scale. Those in the warm water rated their peak pain as .4 while those who immersed their arm in the cold water rated the experience as 4.4, a significant difference, $t[40] = 9.2$, $p = .00$. However, there was no correlation between how long their arm was kept in

the water (three minutes maximum) and the pain rating; r = .93, p = .20. Of the cold water participants, 52% kept their arm immersed for the full three minutes.

Discussion

This study intended to investigate the effect of post-learning stress and arousal during encoding of stimuli on long-term human memory. Overall, there was no significant difference in the number of slides or details recalled between the CPS and warm water conditions. Recall between the arousing and neutral slides also showed no significant difference in either the CPS or warm water conditions. The number of details recalled between the arousing and neutral slides when comparing CPS to warm water was not significant. When investigating gender, there was no significant difference in the number of slides or details recalled between the CPS and warm water condition. The data was also analyzed to identify any interactions between gender and water temperature, but there were no main effects or interactions found. The one significant finding in the study was found in the peak pain rating during the arm immersion. Of the CPS participants, 52% kept their arm in the water for the maximum three minutes. On a scale of zero to ten, they rated the peak pain as 4.4 while warm water participants rated the experience as .4. However, there was no correlation between the time participants left their arm in water (three minutes maximum) and the pain ratings.

The current study intended to replicate the findings of Cahill et. al. (2003). In his initial study, Cahill and colleagues found significant differences in the number of arousing slides recalled with participants in the CPS condition compared to those in the warm water condition. However, they were unable to find any correlations between

gender and memory. This study intended to further explore memory differences between male and female participants in the same study conducted by Cahill.

A reliable test should yield about the same results as it did previously, if using the same participants, variable levels, procedures, etc. The current research used participants of the same age group from a different college. The procedure used to replicate in this study remained as consistent as possible. The major difference with this study was the inability to perform the cortisol level testing. Cahill was able to test salivary cortisol levels immediately before the slide viewing began (baseline) and ten minutes after their arm removal from the water. The pain ratings (4.4 on scale of 0-10) provided by the participants in this study showed that the cold water condition was somewhat painful. However, there was no way of verifying the possible elevated stress levels without cortisol levels. It is possible that while the participants said the cold water experience felt painful, it may not have increased their stress hormone levels. While participants rated the cold water as significantly more painful than those in the warm water, it may not have been enough to induce stress to raise cortisol levels. This is what the cortisol levels could have been able to tell us. Additionally, a large number of participants (52%) were able to leave their arm in the water for the maximum time allotted. Allowing participants to leave their arm in the water as long as possible, without a time limit, may have provided increased opportunity for stress and cortisol levels to increase as participants may have felt pressure to leave their arm in the water. However, that may pose a problem as leaving the arm in the CPS water for an extended period may eventually have adverse effects on the skin.

The dependant variable in this study was the number of slides and details recalled, which were supposed to depend on the difference in water temperature. The cold water was intended to induce stress on the participant. According the Cahill, the cold water participants should have remembered more of the emotionally arousing images. From his study and others, research has suggested that the increase of endogenous stress hormones, such as epinephrine and corticosterone, can increase human memory consolidation. The CPS condition was used to act as a stressor to activate such stress hormones. Additionally, the post-learning stress interacts with arousal at initial encoding to enhance long-term human memory. However, this research found no significant differences in the number of slides or details recalled between the experimental CPS condition and the warm water control condition.

A null result is an experimental outcome in which the dependent variable was not influenced by the independent variable. The null results of this study may have been caused by a scale-attenuation effect. Specifically, a floor effect makes it difficult to interpret results when performance on the dependent variable (number of slides recalled) are nearly lacking altogether. Out of 21 slides, those in the cold water condition only remembered an average of 2.7 slides, and those whose arm was in warm water remembered 2.8. In the Cahill et. al. study, those in the CPS condition remembered a mean of 9.2 where those in the warm water remembered 7.9. The numbers from that study are not closely related to the slides recalled in the current research. A floor effect may help explain the reason no significant results were found. Because so few slides were remembered overall, the numbers were too low to see a difference between conditions. Even though participants in this study were not supposed to know they were

receiving a memory test, floor effects are sometimes caused by a task being too difficult. It is possible in further experiments to make the memory task easier by reducing the number of slides shown and presenting the material more slowly. This might allow for better encoding of the images.

There were also no differences in gender and the amount of slides and details remembered. Because the floor effect made it difficult to analyze results overall, the likeliness of finding a difference in gender was also unlikely. Past research has suggested that women tend to rate unpleasant images more arousing the men. In the past, arousal and post-learning stress has had an enhancing effect on memory. This study hypothesized that females in the experimental CPS condition would remember more of the emotionally arousing images than men in the same condition. No difference between the number of slides remembered overall and between genders were suspected with the neutral images. The hypothesis was correct in suggesting no differences overall for the neutral slides, regardless of water temperature condition.

While much research has suggested the increased memory effects from stress hormone activation, researchers Kirschbaum, Wolf, May, Wippich, and Hellhammer (1996) found research that concluded elevated free cortisol levels are associated with *impaired* memory function. They investigated the relationship between cortisol levels and memory in adults. In their first study, participants were exposed to the Trier Social Stress Test which included a public speaking task and mental arithmetic task, both five minutes in length, and in front of an audience. Ten minutes following their stress exposure, participants were asked to learn a list of 24 nouns. After it was learned, they were given a five minute distraction task, and then asked to recall all words from the list that began

with the letter “Mo” (10 total) from the learned list. The study found a significant negative relationship between stress-induced cortisol levels and performance on the memory task. In their second study, it was found that cortisol administered without a psychological stress impaired performance in declarative memory and spatial thinking tasks, but not in a procedural memory. Declarative memory was assessed with a cued recall test and two mental rotation tasks while procedural memory was tested with a wordstem priming task.

This research is noteworthy in helping explain the results of the current research. Kirschbaum et. al. found acute elevations of cortisol levels can impair memory performance in humans. He also determined that the effect of impaired memory function from increased cortisol levels appeared to be specific for declarative memory functions. The slide recall test in the present study was a declarative memory test. While there was no way of proving elevated cortisol levels from the CPS task, if cortisol levels did in fact increase, this research supports the impaired memory function found in the current study. Even if the CPS task was not highly stressful, low cortisol levels have also either had no enhancing or impaired effects on memory. The midrange doses have often been the most successful in increasing memory.

Other research also suggests increased stress hormone levels have the opposite effect of enhancing memory. Wolf, Schommer, Hellhammer, McEwen, and Kirschbaum (2001) provided evidence for human gender differences in the association between stress induced cortisol elevations and memory performance after termination of the stressor. Similar to the previous study, participants were exposed to the Trier Social Stress Test. They were then asked to learn a list of 25 words and given a 25 second distraction task.

Immediately after the distraction task, participants were given a free recall test of the word list previously presented. Subjects exposed to the stressor did not show impaired memory performance when compared to the control group. However, the cortisol increase in response to the stressor was negatively correlated with the memory performance within the stressed group. Subjects showing a larger cortisol response recalled fewer words than subjects showing only a small increase in cortisol. Men with a strong stress-induced cortisol increase showed reduced memory performance after stress, while no such associations were found in women.

This study is also important in helping explain the results found in the current research. Their study provides some of the first evidence for human gender differences in the association between stress-induced cortisol elevations and memory performance after a stressor. Men in this study with a strong stress-induced cortisol increase showed reduced memory performance after stress while women showed no such association. While it cannot necessarily help explain the female impairment, this study does support the reduced slide recall for males in the current study. In the current study, while it was not significant, women tended to recall slightly more slides and details than men overall. Clearly, additional research is needed to evaluate differences between stress and gender.

It is evident that much research has suggested enhanced human memory for arousing images with post-learning stress. However, these studies and the current research suggest otherwise. The lack of cortisol tests in this study are unable to confirm or disconfirm the possible elevated stress levels. While the CPS condition was rated as painful, there is uncertainty as to the stress it actually caused the participants, which is unknown without cortisol tests. The floor effect cause by the low number of slides

recalled overall also made it hard to find any significant results throughout the study. While much research appears to support the enhanced memory with the CPS test, other suggests further research is necessary to conclude how effective stressful stimulus is in increasing memory for any material.

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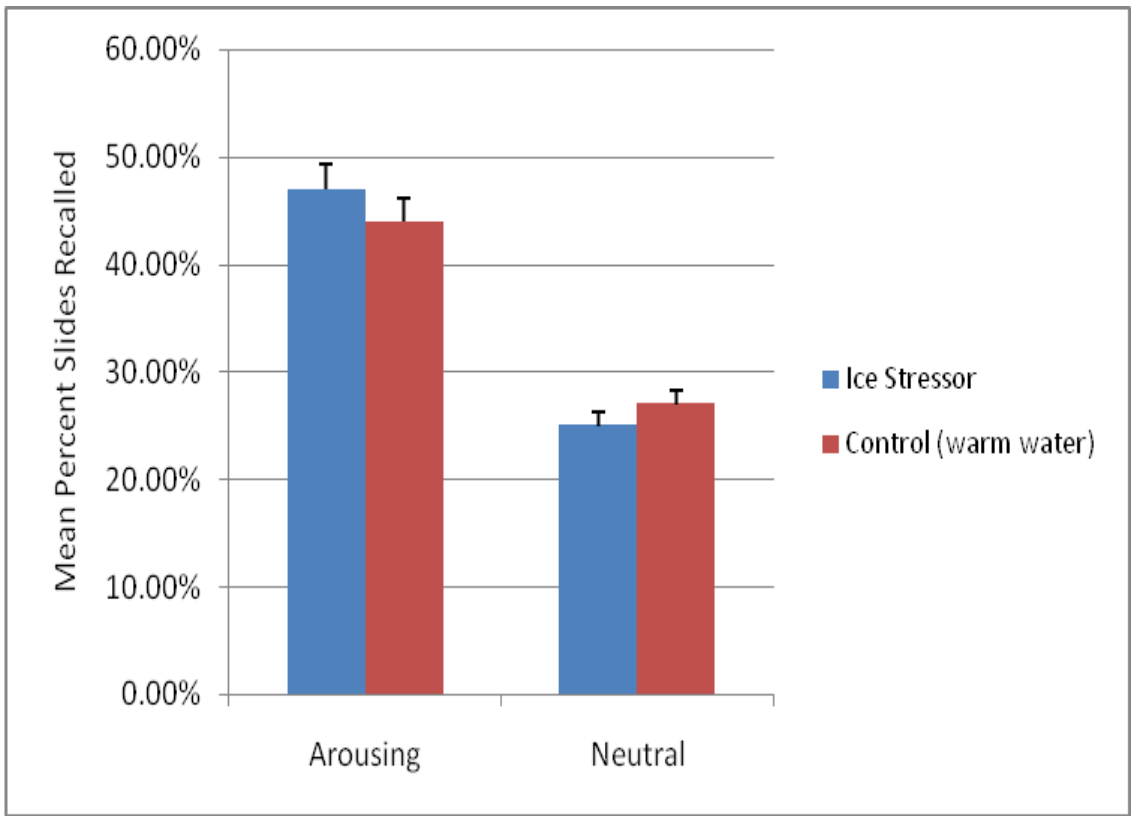
60.00%
50.00%
40.00%
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20.00%
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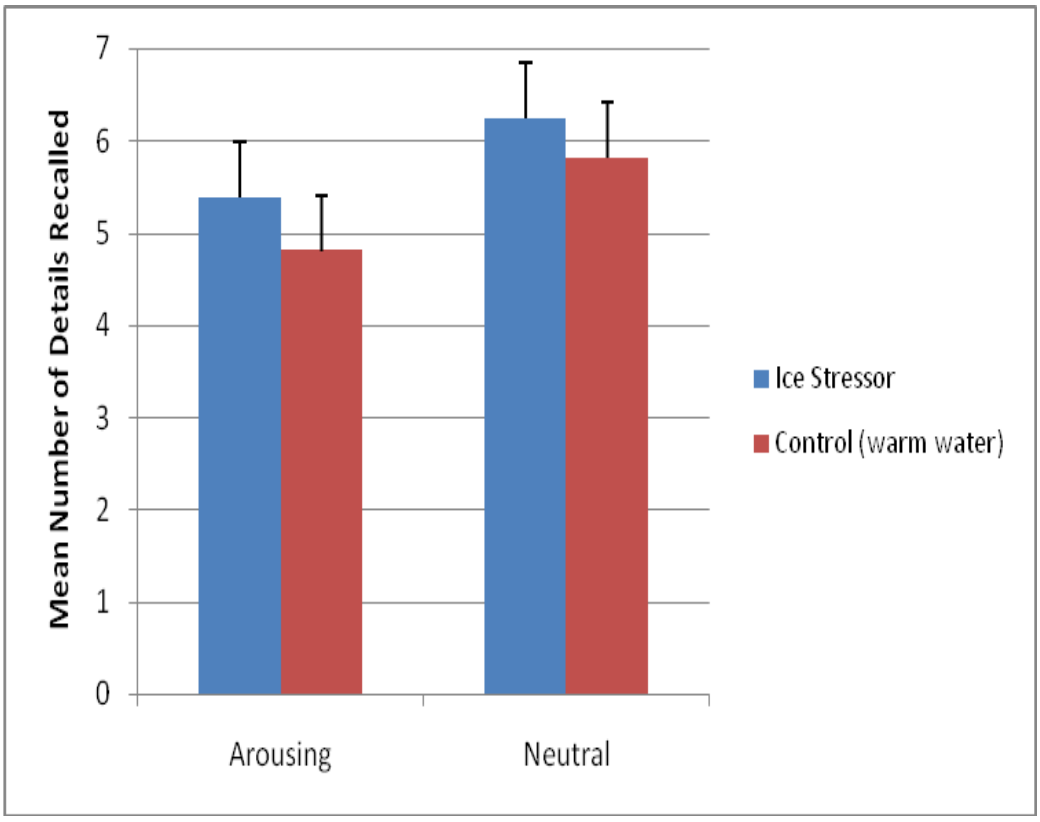
Mean Percent Slides Recalled
Arousing
Neutral
Ice Stressor
Control (warm water)

Christine Grotjohn
Figure 1


Mean Number of Details Recalled
7
6
5
4
3
2
1
0
Arousing
Neutral
Ice Stressor
Control (warm water)

Christine Grotjohn
Figure 2

Table 1. Gender recall of slides and details by the CPS and control groups.

Condition	N	Means	SD	t	p
Percent Arousing Cold	F= 12 M= 9	F= 52% M= 42%	F= .23 M= .23	.93	.36
Percent arousing warm	F= 11 M= 10	F= 45% M= 43%	F= .19 M= .23	.25	.81
Percent neutral cold	F= 12 M= 9	F= 27% M= 23%	F= .11 M= .12	.75	.47
Percent neutral warm	F= 10 M= 10	F= 28% M= 24%	F= .10 M= .09	.92	.37
Details arousing cold	F= 12 M= 9	F= 6.3 M= 4.1	F= 4.33 M= 2.37	1.39	.18
Details Arousing warm	F= 11 M= 10	F= 4.9 M= 4.7	F= 3.53 M= 2.36	.16	.88
Details Neutral cold	F= 12 M= 9	F= 6.4 M= 6.0	F= 5.66 M= 4.12	.19	.85
Details neutral warm	F= 11 M= 10	F= 4.3 M= 5.8	F= 2.73 M= 3.19	1.18	.25

Christine Grotjohn
Table 1

Table 2. Main effect and interactions between gender and temperature from both the CPS and control groups.

Condition	N	Temperature	Gender	F	p
Percent recalled neutral slides	F= 23 M= 19	W= 27% C= 25%	F= 28% M= 24%	F temp= .30 F gender= 1.56 Temp*gender= .007	.59 .22 .94
Number details neutral slides	F=23 M= 10	W= 5.8 C= 6.2	F= 6.1 M= 5.8	F temp= .07 F gender= .04 Temp*gender= .00	.79 .84 .95
Percent recalled arousing slides	F= 23 M= 19	W= 44% C= 48%	F= 48% M= 43%	F temp= .20 F gender= .74 Temp*gender= .28	.65 .40 .60
Number details arousing slides	F= 23 M= 19	W= 4.8 C= 5.3	F= 5.6 M= 4.4	F temp= .16 F gender= 1.37 Temp*gender= .94	.69 .25 .34

Christine Grotjohn
Table 2

Figure 1 Average percent recall of slides defined as arousing and neutral by the CPS and control groups.

Figure 2 Average number of details recalled from both arousing and neutral slides by the CPS and control groups.