DETERMINING THE EFFECTS OF EMOTION ON PROSPECTIVE MEMORY PERFORMANCE

By

Danielle R. Gershman

Jill Talley Shelton
UC Foundation Associate Professor of Psychology
(Chair)

Ashley N. Howell
Assistant Professor of Psychology
(Committee Member)

Julie Madden
Lecturer of Psychology
(Committee Member)

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ABSTRACT

Prospective memory is the ability to remember to complete future intentions. Throughout the study of prospective memory, the use of emotional stimuli tends to lead to contradictory effects. Some studies suggest that emotional stimuli, particularly positive stimuli, lead to better prospective memory performance. However, emotional stimuli have also been associated with detrimental effects or even no effect on prospective memory. This study aimed to further investigate the potential influence of both positive and negative emotions on prospective memory. College students completed three blocks of an n-back task with positive and negative emotionally valenced images in the prospective memory blocks for the Experimental condition and neutral images in the Control condition. Results revealed that although there were no differences between positive and negative stimuli, the emotional stimuli overall decreased prospective memory performance. Examination of ongoing task data suggests that emotional images may have suppressed the spontaneous retrieval process.

DEDICATION

This thesis is dedicated to everyone who has supported me throughout this process. I appreciate you all more than I could ever describe.

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LIST OF ABBREVIATIONS

PM, prospective memory

DMPV, Dynamic Multiprocess View

RT, reaction time

ANOVA, analysis of variance

LIST OF SYMBOLS

M, mean

SD, standard deviation

F, ANOVA test statistic

p, significance value, the probability that the result is due to random chance

η_p^2, partial eta squared, a measure of effect size

CHAPTER I

INTRODUCTION

Prospective memory (PM) is the ability to remember to execute future intentions. These intentions could include anything from remembering to take medication to remembering to call a family member or friend. This ability to remember to, and in turn, complete our intentions is vital to our day-to-day lives. Given our limited ability to complete multiple tasks at once (Wood et al., 2012; Wood & Cowan, 1995), individuals must rely on their memories and external cues (e.g., to-do lists) as a means of completing tasks in a timely manner. Studying prospective memory will help to elucidate its underlying processes and the interaction between PM and other cognitive processes, such as emotion. The purpose of this study is to explore the influences of emotional information on PM performance. In doing so, this study may help in understanding how emotional context influences our ability to remember to complete tasks.

There is a wide variety of research exploring the effects of emotion on memory, with the earliest studies focusing on retrospective memory. Though much of the early research focused on "mood" as opposed to "emotion", the eventual shift from one construct to the other leads to the assumption that mood may be an aspect of emotion, and in turn, both will have similar effects on PM performance. Although sometimes used interchangeably, mood and emotion are separate constructs. Mood refers to a "feeling state", where a broad feeling or state of mind is present for a period of time (Isen et al., 1978). Emotion instead is a state of mind that uses mood as a response or motivator in the presence of situations or stimuli (Altgassen et al., 2010). The study of the influence of mood on retrospective memory has shown that an induced mood influences one's memory. A positive mood may lead to higher recall performance of positive stimuli (Isen et al., 1978). This can be explained through the encoding specificity hypothesis that was developed by Tulving and Thomson (1973), which states that mood can act as an effective retrieval cue by associating a specific cognitive element that can influence the way information is encoded and stored. This means that individuals can use the positive information to remember later because the emotional association to this information affects how it is encoded and stored in the memory system. On the other end of the emotional spectrum, researchers theorize that feelings like anxiety-related worry is a dual-task that can reduce attention and overall working memory performance (Moran, 2016). Given the effects of mood on retrospective memory, it is plausible to anticipate that emotion will similarly influence prospective memory. The typical lab-based prospective memory paradigm does, however, contain some distinct features that may elicit a different profile of the underlying processes.

Laboratory PM tasks typically require participants to work on a continuous cognitive task, or ongoing task (Kliegel & Jäger, 2006). The purpose of the ongoing task is to engage participants' attention in other activities until the opportunity arises to execute their future intention, similar to what occurs in everyday life. Examples of ongoing tasks include working memory tasks, such as the n-back, or decision-making tasks, such as a lexical decision-making task. The n-back task specifically presents a list of stimuli (e.g., letters, words, or images), and at the end of the list, participants are asked to recall whether the stimulus currently presented is the same as the stimulus presented *n* spaces back in the list. Most commonly, participants are asked about stimuli presented one, two, or three spaces back from the response slide. To measure the cognitive processes associated with PM, there are two different kinds of lab-based tasks: Time-based and event-based tasks. Time-based tasks, as the name suggests, require a specific amount of time to pass before the task can be executed. Alternatively, event-based tasks use the appearance of a specific external cue to initiate the task-execution process.

In addition to completing the ongoing task, participants are typically expected to complete the PM task that is dispersed intermittently within the ongoing task, such as making a keypress when presented with a specific stimulus during that ongoing task. In turn, the participants' attention must switch during the ongoing task to complete the PM task. One advantage of using standard cognitive measures as the ongoing task is that they allow researchers to isolate the underlying PM processes, like monitoring and spontaneous retrieval. Monitoring is a cognitively effortful process that involves holding the intention in mind while actively searching for the target cue to execute the task (Smith et al., 2007). Typically, monitoring is measured through ongoing task costs, or cognitive effort used during the ongoing task. Ongoing task costs are normally measured through reaction times (RTs). When a participant takes longer to respond to the ongoing task during a PM block, that is a sign that they are actively monitoring for the PM target, even if that target is not present during the current trial. Spontaneous retrieval, by contrast, relies on retrieval cues to bring the intention to consciousness so it can be executed, making the process less cognitively demanding (McDaniel & Einstein, 2000). Spontaneous retrieval processes are typically seen when accuracy on the ongoing task during a PM block is high, but with lower RTs, as costs are lower without active monitoring.

The design of the typical laboratory, event-based PM task was developed to isolate specific underlying cognitive processes (Einstein et al., 2005). According to the multiprocess theory, the two main processes that underlie PM retrieval are a cognitive control process referred to as strategic monitoring and a more reflexive process referred to as spontaneous retrieval

(Einstein et al., 2005; McDaniel & Einstein, 2000). However, other theories suggest that there is a single process, strategic monitoring, that supports retrieval (Smith et al., 2007). Preparatory processes like strategic monitoring involves maintaining the intention while looking at the external environment for cues that show the intention should be executed, which leads to costs in other ongoing activities (Einstein et al., 2005; Smith et al., 2007). Spontaneous retrieval, on the other hand, is argued to support the successful execution of PM intentions without incurring costs on ongoing activities (Einstein et al., 2005; Scullin et al., 2013). A recent extension of the multiprocess theory, the Dynamic Multiprocess View (DMPV), suggests that a range of bottom-up (spontaneous retrieval) and top-down (monitoring) processes interact in a dynamic fashion to support PM and contextual information, such as emotion, can modulate this interaction (Shelton et al., 2019; Shelton & Scullin, 2017). A primary goal of the present study is to investigate how an emotional context may influence the underlying processes supporting PM throughout the life of the intention.

Emotional prospective memory paradigms typically involve some sort of stimulus that is intended to be an emotional manipulation for the participants. The most common stimulus sets contain word lists, using cognitive tasks like lexical decision tasks and the ongoing task (May et al., 2012; May et al., 2015). These words are often ones that may evoke a sense of discomfort ("murderer" or "killer") (May et al., 2012; May et al., 2015), express a particular emotion ("love" or happiness", or meant to be completely neutral ("apple" or "rabbit") (Altgassen et al., 2011). However, other tasks (and the methodological focus of the current task) use images as either supplements (Kensinger & Schacter, 2006) or alternatives to word lists. In studies where the images are the stimulus of choice, the emotional aspect of these images may be represented in either the encoding phase only (Henry et al., 2015), or at both encoding and retrieval phases (Altgassen et al., 2010; May et al., 2012; May et al., 2015).

When presented, positive images activate more areas of the brain associated with executive functioning and memory than do negative images (Seo et al., 2014). Rendell et al. (2011) found that using positively valenced cues improved PM functioning. When compared to neutral stimuli, positive stimuli were found to decrease in ongoing task costs in both younger and older adults (Cona et al., 2015; May et al., 2012; May et al., 2015). The reason for this improvement is believed to be that the saliency of the cue reduces monitoring, and in turn, cognitive resources for completing the task (Altgassen et al., 2010; Cona et al., 2015; May et al., 2012). In turn, positive stimuli led to less cost and decreased the number of times they accidentally repeated a task.

Negative emotions have been shown to improve PM performance depending on the circumstance. For example, the use of negative stimuli can increase the likelihood someone will remember the visual features of an item on a list, as the negative stimuli are more salient than neutral stimuli (Kensinger et al., 2007). For tasks that have a deadline or start at a specific time (time-based tasks), those who have anxiety perform better than those without anxiety. On the other hand, for tasks that are initiated by a cue or even (event-based tasks), those who have depression perform better than those who have anxiety (Kliegel & Jäger, 2006). Depending on the circumstance, anxiety or depression can either improve or decrease PM performance (Harris, 1999; Kliegel & Jäger, 2006; Nigro & Cicogna, 1999). Those with high anxiety completing time-based PM tasks tend to have better PM performance, while those with high levels of depression tend to have better performance on event-based tasks (Kliegel & Jäger, 2006). Unlike highly anxious individuals, those with depression completing time-based tasks have worse performance, as they are unable to allocate the resources necessary to complete the task at the set time interval (Kliegel et al., 2005).

Both patterns suggest a concept known as the mood congruent effect. As a type of encoding specificity, altering one's mood into a negative mood leads to an increase in remembering negative memories or stimuli more than positive ones (Ellis & Ashbrook, 1988; Ellis & Ashbrook, 1989; Lange & Carr, 1999). According to Bower (1981), stimuli that are congruent with one's mood will be more salient than stimuli that are incongruent. A person in a depressed mood will have limited attentional resources to apply to the task at hand, so a less effortful task, like an event-based task, tied with negatively-valenced cues would allow depressed individuals to perform better on those tasks (Ellis & Ashbrook, 1988). Anxiety is also a negative mood, but unlike depressed individuals, the nature of anxiety allows for better performance on time-based tasks. The negative mental state allows for constant rehearsal of important and specific details (e.g., times for responses), so paired with mood-congruent cues, highly anxious individuals have higher performance on time-based tasks than those who have lesser anxiety (Eysenck & Calvo, 1992; Kliegel & Jäger, 2006).

Although negative stimuli have been found to improve performance in comparison to neutral stimuli, the presentation of positive stimuli is the most effective for improving performance (Hostler et al., 2018). Regardless of the emotional cue presented, whether it was positively or negatively valenced/pleasant or unpleasant, having the emotion attached to the cue removed the age deficit found in older adults and improved PM performance in both younger and older adults (Altgassen et al., 2010; May et al., 2015). However, these emotional cues could also show a reduction of PM performance at encoding in older adults (Ballhausen et al., 2015). Performance, in turn, was lower when participants were instructed to remember an emotional image for the PM task. Negatively valanced cues have also been found to be less useful for retrieving intentions in comparison to positive cues (Clark-Foos et al., 2009). PM performance has also been reduced in situations where the emotional context of the cue is incongruent with the emotional content of the cue (e.g., neutral instructions for a positive or negative cue) (Graf & Yu, 2015). Additionally, when the manipulation takes place only in the encoding phase, and not retrieval, there are no differences in the groups, regardless of valence (Henry et al., 2015). Results like these further justify that the stimuli presentation method moderates how the cues effect performance (Hostler et al., 2018).

The cues we use frequently can remind us to complete our tasks. Whether we see an advertisement for the supermarket on the way home from work or see a post-it note reminding us to do our taxes, we have visual reminders many tend to take for granted. Emotional ties to these stimuli may assist in helping individuals remember to execute their intentions; however, this relationship is unclear and marred by contradictory results (Harris, 1999; Henry et al., 2015; Hostler et al., 2018; Kliegel & Jäger, 2006). Upon examining the methodologies of past studies like Henry et al. (2015), a ceiling effect in task performance, could have led to a lack of differences observed in PM performance in the presence of emotional stimuli. Another possible reason for these past results is that Henry et al. (2015) only presented the emotional images during the encoding stages, as opposed to encoding and retrieval; in a study where images were only presented at encoding, there was a lack of differences between groups. In turn, to find differences in effects of emotional stimuli on PM performance, the emotional manipulation may have to take place during encoding and retrieval, rather than encoding alone.

Present Study

The goal of the current study is to examine the influence of positive and negative emotional contexts on PM performance. An event-based task will be the focus of this study, and more specifically, the use of these tasks in the context of using emotional stimuli to initiate the execution of the PM task. Additionally, the task used in the present study, by contrast of previous studies, will focus on the use of emotional images at encoding and retrieval. The methodology of this study is based on that of Henry et al. (2015), but instead I will have a more difficult task in comparison to previous studies (a two-back task over a one-back task). By doing so, I will be attempting to isolate the differences in PM task performance across stimulus blocks and conditions. I have three hypotheses for the current study: the first (*H1*) is that there will be an increase in PM performance when presented with emotional stimuli in comparison to neutral stimuli, the second (*H2*) is that there will be a difference in PM performance, with higher performance in the positive block compared to the negative block, and (*H3*) I hypothesize that there will be lower ongoing task costs in the emotional blocks in comparison to the neutral blocks.

CHAPTER II

METHODOLOGY

Participants and Design

A sample of 71 undergraduate participants were collected from two sources, the University of Tennessee at Chattanooga in Chattanooga, Tennessee and Stevenson University in Stevenson, Maryland. Twelve participants were cut in total from the sample (experimental *n* = 11; control *n* = 1). Eleven participants were excluded due to a failure in correctly answering the retrospective memory check question at the end of the prospective memory blocks. One participant was excluded for not following instructions. The final sample was 59 participants. Participants were predominately white (67.8%). This sample also included Black (6.8%), Hispanic (11.9%), Asian/Pacific Islander (6.8%), and mixed-race (6.8%) participants. The sample was also predominantly female (76.3%), with some male participants (20.3%). Two participants disclosed they were transgender/gender non-conforming. One participant stated they had a neurological condition (occipital neuralgia). Although 22 participants stated they were diagnosed with a mood disorder, only eight stated they were taking medications for their mood disorder.

This study used a 2 (Condition: experimental/control) x 3 (Task Block: No PM/PM block 1/PM block 2) x (Order: No PM First/No PM Last) mixed-factor design with the block as the within-participants factor and condition and order as the between-participants factors.

Materials

Demographic Questionnaire

The demographic questionnaire consisted of questions asking about age, race, major, school year, native English-speaking status, whether they had normal vision, hours of sleep per night, neurological conditions, history of mood disorders, and mood disorder medication.

Cognitive Task

The task used for this study was created using the lab.js builder (Henninger et al., 2020). A prospective memory task was created for this study, with two counterbalancing orders where the block with no PM target trials ("no-PM block") was either first or last in the trial order. The task was run using a computer and requires the use of a keyboard and mouse. The prospective memory task consists of three blocks, with 70 images per block. Each image was able to be repeated three times, for a total of 30 trials per block, or 90 total trials. These images were from the International Affective Picture System (IAPS). The IAPS were normed for an undergraduate sample, using the SAM rating system, with responses ranging from 1 (feeling unhappy) to 9 (feeling happy). Each emotional category was rated and averaged based on a sample of responses (neutral images, M = 5.14; positive images, M = 7.40; negative images, M = 2.35; overall, M = 4.86) (Lang & Bradley, 2007). In each experimental block, the images are of a corresponding emotional valence (positive, negative, and neutral), where of the two PM blocks, one block contains only positive images, while the other PM block contains only negative images, and the block containing no PM targets (the no-PM block) contains only neutral images. For the control condition, both PM blocks and the no-PM block have only neutral images. However, initial practice trials for the ongoing task contained neutral images, as well.

To control for practice effects in the ongoing task that may influence cost measures, participants were randomly assigned to either have the no-PM block first or last in the block order, with the PM blocks pseudo-randomly placed before or after the no-PM block. For the control condition, the PM trials are counterbalanced in the order of the experimental trials, with the first and second PM blocks as analogs to the positive and negative experimental blocks, respectively.

During each trial, the images are displayed in a list of six or eight images at a rate of one image per second. At the end of the trial, the participant was asked whether they saw the specific image displayed one or two positions back in the list, with the number of positions back alternating per trial. If they saw the corresponding image, participants would press the “1” key for “yes”, and if it was not that image, they would press the “2” key for “no”. Half of the trials were 1-back trials, and the other half were 2-back trials. Additionally, half of the trials had “yes” as the correct response, and half had “no” as the correct response. Ongoing task cost was measured using the average reaction time (RT) of a participant’s responses during each block of trials on non-PM target trials. Accuracy for both the PM and ongoing tasks was measured as the proportion of correct responses to the total number of possible responses.

Prospective Memory Task

During the PM trials, participants were instructed to press the spacebar key if they saw the image of a dog or baby (the categorical cues) in the list of images. Participants were informed that if they missed pressing the spacebar key initially, they were still able to hit the key when they remembered while still on that trial, but not on that image itself. Participants were also instructed to respond to the PM target, even if it was regarded a late response (e.g., two trials past the initial target viewing). Prospective memory performance was measured by the number of correct key presses by the participants per trial. Within each block, there were six PM targets for each emotional category. They were pseudo-randomly dispersed between the positive block (trials 4, 9, 13, 18, 22, 26), negative block (trials 2, 6, 14, 19, 21, 27). The control condition version of the task had the same target image order, with the PM targets in blocks containing the same trials as the experimental condition. More specifically, the control PM block that has the same PM target order as the positive block is “PM Block 1”, and the control PM block with the same PM target order as the negative block is “PM Block 2”. All trials were pseudo-random to avoid practice effects.

Verbal Fluency Task

In between receiving the instructions for the PM blocks and starting the task, the participants completed a verbal fluency task for three minutes in each block. The purpose of the task was to be a filler in between receiving the instructions for, and then starting, the PM task to ensure encoding of the instructions. This task involves having participants list as many words starting with a specific letter (“F”, “A”, or “S” for the positive/first PM block and “M”, “B”, and “L” for the negative/second PM block) for a minute per letter. However, participants were instructed to not list similar words (the same word with a different prefix or suffix), places, names, or numbers (Duchene et al., 1998).

Procedure

This study was completed entirely online. Participants were given a link to the task, which was run in their web browser of choice. Once entering the task, they completed the informed consent form. After giving informed consent, participants first completed the demographic survey. Then, they received the instructions for the ongoing tasks, and completed two practice trials. Afterwards, they were to either begin the no-PM block or the PM block of trials, depending on the version they received. If they start with the no-PM block, they completed the task as demonstrated through the initial practice before moving on to the next block. When starting the PM block, they then receive instructions on the PM task, with these instructions only appearing before each PM block. After receiving instructions, the participants completed the verbal fluency task. Once they have completed the verbal fluency task, the participants went through each block of the PM task; those in the experimental condition received the positive and negative PM blocks, and the neutral no-PM blocks, while those in the control condition received two neutral PM blocks, and a neutral no-PM block. At the end of each block, participants were asked to rate their perception of the pleasantness of the stimuli (1 = very unpleasant, 4 = neutral, 7 = very pleasant) and their perception of difficulty (1 = very difficult, 4 = neutral, 7 very easy). For the PM blocks, along with those questions, participants are also asked a retrospective memory check question about the PM targets ("In addition to the picture memory task, what are the two images you should be looking for?"). Once completed, participants were able to close the task window and exit the study (see Figure 2.1).

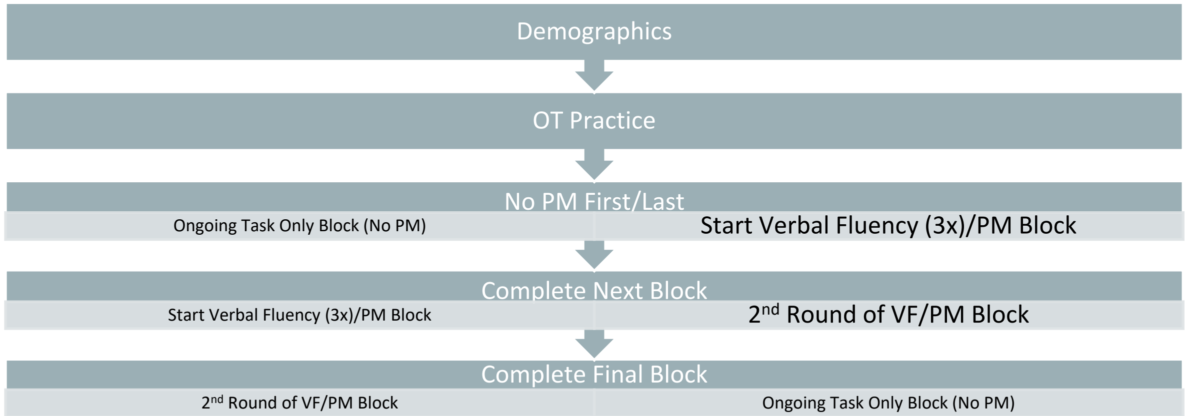


Figure 2.1

Diagram of procedure process

CHAPTER III

RESULTS

Prospective Memory Performance

PM performance was operationalized as the percentage of correct responses out of the total six targets per block and was analyzed using a 2 (Task Block: PM 1/PM 2) x 2 (Condition: experimental/control) x 2 (Block order: No PM first/No PM last) mixed-factor ANOVA. Task block was the within-participants factor and both condition and block order variables were between-participants factors. For all analyses within task block and order, those in the experimental condition received the positive and negative PM blocks, and the neutral no-PM blocks, while those in the control condition received two neutral PM blocks, and a neutral no-PM block. There were no within-participants main effects (block, $F(1,55) = .167$, $p = .69$, $\eta_p^2 = .003$) or interactions (block x condition, $F(1,55) = .04$, $p = .85$, $\eta_p^2 = .001$; block x order, $F(1,55) = .50$, $p = .48$, $\eta_p^2 = .01$), but there was a between-participants main effect of condition, $F(1,55) = 11.06$, $p = .002$, $\eta_p^2 = .17$. The lack of an interaction effect shows no difference between the positive and negative PM blocks. The control condition had higher performance on average ($M = .76$, $SE = .04$, 95% CI [.67, .84]), than the experimental condition ($M = .56$, $SE = .04$, 95% CI [.48, .65]; see Figure 3.1). There was no main effect for order, $F(1,55) = 2.13$, $p = .15$, $\eta_p^2 = .04$, or an interaction between condition and order, $F(1,55) = .05$, $p = .83$, $\eta_p^2 = .001$

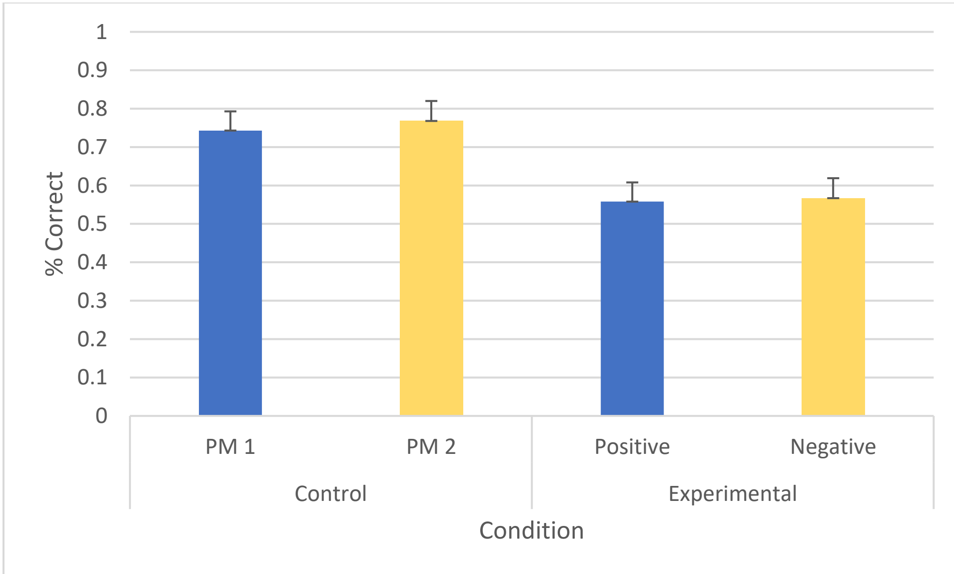


Figure 3.1

Proportion of correct responses for PM performance by condition

Ongoing Task Accuracy

Ongoing task accuracy was operationalized as the proportion of correct responses to the ongoing task, excluding PM task trials, with proportions out of 24 ongoing task trials per block for the PM trials and 30 for the no-PM block. A 3 (Task Block: No PM/PM 1, PM 2) x 2 (Condition: experimental/control) x 2 (Block order: No PM first/No PM last) repeated-measures ANOVA was used, with task block as the within-participants factor and the condition and block order as between-participants factors. There was no within-participants main effect for block, $F(2,110) = 2.32$, $p = .10$, $\eta_p^2 = .04$. However, there was an interaction of block and order, $F(2,110) = 3.21$, $p = .04$, $\eta_p^2 = .06$, with no interaction between block and condition, $F(2,110) = 1.17$, $p = .32$, $\eta_p^2 = .02$. There appears to be a practice effect, as participants were more accurate during the PM blocks when they came after the no-PM block, (PM Block 1, *M* = .93, *SE* = .03, 95% CI [.88, .98]; PM Block 2, *M* = .92, *SE* = .01, 95% CI [.89, .95], No-PM Block, *M* = .88, *SE*

= .01, 95% CI [.85, .95]; See Table 3.1). There were also no between-participants effects (condition, $F(1,55) = .01$, $p = .94$, $\eta_p^2 < .001$; order, $F(1,55) = 1.29$, $p = .26$, $\eta_p^2 = .02$; condition x order, $F(1,55) = .29$, $p = .59$, $\eta_p^2 = .01$).

Table 3.1

Ongoing task accuracy across condition and block

Order	Block	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
No PM First	PM Block 1	0.93	0.03	0.88	0.92
	PM Block 2	0.92	0.01	0.89	0.98
	No PM	0.88	0.01	0.85	0.91
No PM Last	PM Block 1	0.86	0.03	0.80	0.99
	PM Block 2	0.92	0.02	0.89	0.95
	No PM	0.89	0.01	0.86	0.93

To analyze if there were differences between the 1- and 2-back trials, a 3 (Task Block: No PM/PM 1, PM 2) 2 (Task Type: 1-back/2-back) x 2 (Condition: experimental/control) x 2 (Block order: No PM first/No PM last) mixed-factor ANOVA was used, with task block and task type as the within-participants factors and the condition and block order as between-participants factors. There was a within-participants main effect for block, $F(2,110) = 27.95$, $p < .001$, $\eta_p^2 = .34$. There was also an interaction between trial type and block order, $F(3,110) = 5.02$, $p = .03$, $\eta_p^2 = .08$, and between block and trial type, $F(2,110) = 8.84$, $p < .001$, $\eta_p^2 = .14$. PM Block 1 had the highest overall accuracy (*M* = .96, *SE* = .01, 95% CI [.94, .98]), in comparison to PM Block 2 (*M* = .86, *SE* = .01, 95% CI [.83, .88]) and the No-PM Block (*M* = .89, *SE* = .01, 95% CI [.87, .91]). Additionally, within the task type x block order interaction, accuracy was highest when the no-PM block was first (*M* = .97, *SE* = .02, 95% CI [.93, 1]). When examining the block x task type interaction, the accuracy for both 1-back and 2-back trials in PM Block 2 was the lowest (1-back, *M* = .83, *SE* = .02, 95% CI [.77, .87]; 2-back, *M* = .89, *SE* = .01, 95% CI [.87, .92]). See Tables 3.2 and 3.3. There were also no between-participants effects for condition, $F(1,55)$ = .005, p = .94, $\eta_p^2 < .001$, block order, $F(1,55) = 1.35$, $p = .25$, $\eta_p^2 = .02$, or an interaction between condition and block order, $F(1,55) = .30$, $p = .59$, $\eta_p^2 = .01$.

Table 3.2

Mean n-back task performance by block order

Order	N-back	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
No PM First	1-back	0.92	0.02	0.88	0.95
	2-back	0.91	0.01	0.88	0.93
No PM Last	1-back	0.87	0.02	0.83	0.91
	2-back	0.92	0.01	0.89	0.94

Table 3.3

Mean n-back task performance by block

Block	N-back	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
PM Block 1	1-back	0.95	0.02	0.91	0.99
	2-back	0.97	0.01	0.95	0.99
PM Block 2	1-back	0.83	0.02	0.78	0.87
	2-back	0.89	0.01	0.87	0.92
No PM Block	1-back	0.91	0.01	0.89	0.93
	2-back	0.87	0.01	0.85	0.89

Ongoing Task Cost

Ongoing task cost was operationalized as the average response time during the ongoing task for each block, in milliseconds; higher costs are reflected in a greater difference between the PM and no-PM blocks. The typical RT trimming procedure was also used, where RT data that was 2.5 standard deviations away from the mean were trimmed out. A 3 (Task Block: No PM/PM 1, PM 2) x 2 (Condition: Experimental/Control) x 2 (Block order: No PM first/No PM last) repeated-measures ANOVA was used, with task block as the within-participants factor and the condition and block order as between-participants factors. There was no within-participants main effect for block, $F(1,110) = 1.58$, $p = .21$, $\eta_p^2 = .03$, and no interaction between block and condition, $F(1,110) = .50$, $p = .61$, $\eta_p^2 = .01$. However, there was an interaction between block and order, $F(1,110) = 16.40$, $p < .001$, $\eta_p^2 = .23$. On average, the no-PM block had the slowest RTs when it was first (*M* = 1990.09, *SE* = 112.43, 95% CI [1764.78, 2215.39]) in comparison to when the block was last (*M* = 1466.08, *SE* = 122.19, 95% CI [1221.21, 1710.96]; see Table 3.4). There were also no between-participants effects for condition, $F(1,55) = .44$, $p = .51$, $\eta_p^2 = .01$, or order, $F(3,55) = .04$, $p = .83$, $\eta_p^2 = .001$. There was also no interaction between the two factors, $F(1,55) = 3.26$, $p = .08$, $\eta_p^2 = .06$.

Table 3.4

Mean reaction times by block and block order

Order	Block	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
No PM First	PM Block 1	1423.66	66.39	1290.60	1556.71
	PM Block 2	1634.36	125.33	1383.19	1885.53
	No PM	1990.09	112.43	1764.78	2215.40
No PM Last	PM Block 1	1762.59	72.16	1617.98	1907.20
	PM Block 2	1740.16	136.22	1467.18	2013.15
	No PM	1466.08	122.19	1221.21	1710.96

Based on the practice effect, simple effects tests were conducted to tease out the difference in the groups. These tests were repeated measures ANOVAs with block (No PM/PM Block 1/PM Block 2) as the within-participants factor and focused on one block order group (No PM first/No PM last) per test. The first test found a main effect for block, $F(2,62) = 9.80$, $p < .001$, $\eta_p^2 = .24$. The no-PM block RTs (*M* = 1977.21, *SE* = 136.95, 95% CI [1697.90, 2256.53]) were slower than PM Block 1 (*M* = 1421.49, *SE* = 57.77, 95% CI [1303.67, 1539.31]) and PM Block 2 (*M* = 1622.58, *SE* = 156.40, 95% CI [1303.60, 1941.56]). Pairwise comparisons were completed using a Bonferroni adjustment (see Table 3.5).

Table 3.5

Pairwise comparisons of block for order 1

(I) block	(J) block	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
PM Block 1	PM Block 2	-201.09	148.62	0.56	-577.22	175.05
	No PM	-555.72	109.26	<.001	-832.24	-279.21
PM Block 2	PM Block 1	201.09	148.62	0.56	-175.05	577.22
	No PM	-354.63	120.27	0.02	-659.02	-50.25
No PM	PM Block 1	555.72	109.26	<.001	279.21	832.24
	PM Block 2	354.63	120.27	0.02	50.25	659.02

For the second block order group, there was also a main effect of block, $F(2,52) = 9.94$, $p < .001$, $\eta_p^2 = .28$. The no-PM block, which came last for this group, was faster *M* = 1455.34, *SE* = 74.31, 95% CI [1302.58, 1608.09]) than PM Block 1 (*M* = 1745.99, *SE* = 83.81, 95% CI [1573.71, 1918.27]) and PM Block 2 (*M* = 1715.88, *SE* = 80.09, 95% CI [=1551.25, 1880.51]). Pairwise comparisons were completed using a Bonferroni adjustment (see Table 3.6).

Table 3.6

Pairwise comparisons for block order 2

(I) block	(J) block	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
PM Block 1	PM Block 2	30.11	62.66	1	-130.23	190.44
	No PM	290.66	68.14	0.001	116.30	465.01
PM Block 2	PM Block 1	-30.11	62.66	1	-190.44	130.23
	No PM	260.55	82.79	0.012	48.69	472.41
No PM	PM Block 1	-290.66	68.14	0.001	-465.01	-116.30
	PM Block 2	-260.55	82.79	0.012	-472.41	-48.69

The third simple effects test was a 3 (Task Block: No PM/PM 1, PM 2) x 2 (Condition: Experimental/Control) repeated measures ANOVA, with block as the within-participants factor and valence as the between-participants factor. There was no within-participants main effect for block, $F(2,114) = 1.91$, $p = .153$, $\eta_p^2 = .03$, or interaction, $F(2,114) = 0.43$, $p = .958$, $\eta_p^2 = .001$. There was also no between-participants effect for control, $F(2,57) = .29$, $p = .59$, $\eta_p^2 = .005$. Without the order factor, the blocks have similar RTs (see Table 3.7).

Table 3.7

Block means by condition

Block	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PM Block 1	1569.325	53.693	1461.806	1676.844
PM Block 2	1664.549	92.532	1479.256	1849.841
No PM	1738.061	88.695	1560.452	1915.669

Emotional and Difficulty Ratings

At the end of each block of trials, participants were asked to rate how pleasant the images were and how difficult the task was, both with ratings from one to seven. With pleasantness, the more pleasant the higher the rating, while for difficulty, the easier the task was to the participant, the higher the rating. Average ratings and frequencies were calculated. A 3 (Task Block: No PM/PM 1, PM 2) x 2 (Condition: Experimental/Control) x 2 (Block order: No PM first/No PM last) repeated-measures ANOVA was used for both types of ratings, with task block as the within-participants factor and the control and block order as between-participants factors. For pleasantness, there was a within-participants main effect for block, $F(2,110) = 60.34$, $p < .001$, $\eta_p^2 = .52$, an interaction between block and condition, $F(2,110) = 56.81$, $p < .001$, $\eta_p^2 = .51$, but no interaction between block and order, $F(2,110) = .57$, $p = .57$, $\eta_p^2 = .10$. By block, the no-PM block a similar rating (*M* = 4.10, *SE* = .11, 95% CI [3.87, 4.33]) to the first PM block (*M* = 4.29, *SE* = .16, 95% CI [3.97, 4.60]), but both were higher than the second PM block *(M* = 2.80, *SE* = .10, 95% CI [2.60, 3.00]). The control group had a higher rating overall (*M* = 4.23, *SE* = .13, 95% CI [3.98, 4.50]) in comparison to the experimental group (*M* = 3.22, *SE* = .13, 95% CI [2.97, 3.49]). There was a between-participants effect for control, $F(1,55) = 30.42$, $p < .001$, $\eta_p^2 = .36$, but no main effect for block order, $F(1,55) = .61$, $p = .44$, $\eta_p^2 = .01$, or an interaction between the two factors, $F(1,55) = .04$, $p = .85$, $\eta_p^2 = .001$. When examining the block x condition interaction, as expected, the emotional group's negative block of trials had the lowest rating (*M* = 1.39, *SE* = .14, 95% CI [1.11, 1.66]). Unexpectedly, however, the positive block ratings (*M* = 4.26, *SE* = .22, 95% CI [3.83, 4.70]) were not higher than the neutral PM Block 1 ratings (*M* = 4.31, *SE* = .22, 95% CI [3.87, 4.75]). See Table 3.8.

Table 3.8

Pleasantness ratings of block by condition

Valence Condition	Block	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Neutral	PM Block 1	4.31	0.218	3.872	4.747
	PM Block 2	4.21	0.137	3.936	4.483
	No PM	4.176	0.163	3.849	4.504
Emotional	Positive	4.264	0.219	3.825	4.703
	Negative	1.389	0.137	1.114	1.663
	No PM	4.028	0.164	3.699	4.356

For difficulty, there was a within-participants main effect for block, $F(2,110) = 9.25$, $p < .001$, $\eta_p^2 = .14$, block x condition interaction, $F(2,110) = 5.33$, $p = .006$, $\eta_p^2 = .09$, and block x order interaction, $F(2,110) = 6.14$, $p = .003$, $\eta_p^2 = .10$. The blocks were rated consistently, with the no-PM block being rated, on average as easier than the PM blocks (*M* = 4.18, *SE* = .18, 95%

CI [3.82, 4.54]). Additionally, this rating pattern was consistent across conditions, but the no-PM block was rated the easiest when it was first (see Tables 3.9 and 3.10). However, there were no between-participants main effects (condition, $F(1,55) = 1.31$, $p = .26$, $\eta_p^2 = .02$; order, $F(1,55) = .4$, $p = .84$, $\eta_p^2 = .001$) or interactions, $F(1,110) = .03$, $p = .86$, $\eta_p^2 = .001$.

Table 3.9

Difficulty ratings of block by condition

Valence Condition	Block	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Neutral	PM Block 1	3.71	0.24	3.22	4.20
	PM Block 2	3.97	0.25	3.47	4.46
	No PM	4.08	0.26	3.57	4.59
Emotional	Positive	3.44	0.25	2.95	3.94
	Negative	3.04	0.25	2.54	3.54
	No PM	4.28	0.26	3.77	4.79

Table 3.10

Difficulty ratings of block by order

Order	Block	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
No PM First	PM Block 1	3.33	0.23	2.86	3.80
	PM Block 2	3.50	0.24	3.02	3.98
	No PM	4.53	0.24	4.04	5.02
No PM Last	PM Block 1	3.83	0.26	3.32	4.34
	PM Block 2	3.51	0.26	2.99	4.03
	No PM	3.83	0.27	3.30	4.37

Mood Disorders, Medication, and Performance

Participants were asked if they were diagnosed with a mood disorder, and if so, if they were taking any medications for that disorder. Answers to both questions were coded as “yes” and “no” responses. Although less than half of participants stated they had a mood disorder (n = 22), even fewer stated they were taking medication (n = 8). Given the emotional nature of the stimuli, Pearson’s r correlation was conducted to see if there was a relationship between a mood disorder diagnosis, medication use, and performance on both the PM task and the ongoing task. As expected, there was a moderate, positive correlation between mood disorder diagnosis and medication use, r =.51, p < .001. There was also a small, negative correlation between mood disorder diagnosis and PM performance, r = -.30, p = .02. However, there was no correlation between diagnosis and ongoing task performance, or medication use and performance on either task.

CHAPTER IV

DISCUSSION

Overall, prospective memory performance was negatively impacted by the use of emotional stimuli; those that were in the all-neutral control group had higher prospective memory performance than those who were in the emotionally-valenced experimental group. The order in which the task blocks were presented influenced ongoing task cost and performance. As such, the current results contradict the hypotheses of this study, as well as many current studies and theories regarding the benefits of emotional stimuli on PM performance. Although some previous studies found that using emotional images as target cues leads to stronger benefits to PM performance in comparison to emotional word cues (Hostler et al., 2018), the current study's results instead show that those who received the positive and negative images performed worse than those in the all-neutral image group. These results add to the inconsistent findings observed throughout the PM literature regarding the influence of emotional stimuli on PM performance (Ballhausen et al., 2015; Clark-Foos et al., 2009; Henry et al., 2015; Hostler et al., 2018; Kliegel & Jäger, 2006)

Although other studies suggest emotional stimuli improves PM performance, the current study aligns with results that suggest these stimuli are a detriment to PM performance. For example, Graf and Yu (2015) found that, despite the use of emotional images, those in the emotional cue conditions had worse performance than those in the neutral cue condition. The researchers theorized that this result may be an issue of attention or context. They argue that when the cues are emotional, the scope of one's attention is narrowed, so their ability to process more information within a task becomes limited. In turn, performance suffers, as participants would be less able to process all the necessary information to correctly recognize target cues. Ballhausen et al. (2015) and Clark-Foos et al. (2009) found a similar detriments as the current study, where they theorize that the emotional aspect of the stimuli leads attention away from the task and toward thoughts and feelings associated with the emotional cue. In turn, this reduced attention could weaken the strength of the encoding process and reduce later PM performance.

Interestingly, although there were no differences in ongoing task performance by condition, there were differences in block order, aligning with previous studies. In the groups where the no-PM block was first, the PM block trials had higher performance, with lower reaction times. This suggests that cognitive costs were low when the no-PM block was first, despite the PM targets in the PM blocks. Lower RTs during the PM blocks runs counter to previous studies, as typically no-PM blocks have faster RTs than PM blocks (Ballhausen et al., 2015; Henry et al., 2015). However, when the no-PM block was last, accuracy in PM block 1 (the positive block in the emotional condition) had lower accuracy with costs like PM block 2 (the negative block in the emotional condition). The no-PM block in this group also had worse accuracy with faster reaction times. This is counter to the other no-PM block, where the accuracy was similar, but with slower RTs. This seems to suggest that when participants start with the no-PM block, there are higher costs. Based on the simple-effects tests conducted, these results are due to practice effects, as participants who received the no-PM block first were faster to respond than those who received the no-PM block last. And, when order is removed from analyses, the difference in costs between blocks disappears. Even though the benefits of using these valenced images may not have been seen with PM performance, they might have been with ongoing task cost when given a "practice" block to understand the ongoing task.

Rather than observing any cognitive costs being incurred, there were practice effects in place. In comparison to the no-PM block, ongoing task performance was higher in the PM block, which is an indicator of spontaneous retrieval processes at work (Einstein et al., 2005; Shelton & Scullin, 2017). As such, spontaneous retrieval processes appear to be the central mechanism supporting PM in this paradigm. Additionally, given that the ongoing task accuracy followed a similar trend as cost, both performance and reaction time are influenced by the order in which the blocks are presented. Interestingly, the negative impact of emotional stimuli on PM performance did not lead to a difference in costs, as RTs were consistent between the PM blocks. This suggests that the spontaneous retrieval processes used are compromised by the emotional aspect of the stimuli in this task. So, even though there is no difference between positive and negative stimuli in regard to task performance or costs, the inclusion of emotional stimuli in general appears to have influence on cognitive processes like spontaneous retrieval.

The current study also had an unusually large number of excluded participants by retrospective memory check failure in comparison to other studies (Ball & Bugg, 2018) . Of all 11 participants that were excluded due to retrospective memory failure, 10 were from the emotionally-valenced experimental group. Historically, emotional stimuli have influenced performance on retrospective memory tasks (Isen et al., 1978; Moran, 2016). The emotional aspect of the cues may have drawn their attention away from the details of which cues to respond to. The explanation by Clark-Foos et al. (2009) regarding reduced attention influencing task performance may also explain the number of excluded participants and the differences in the groups in terms of exclusion. The emotional nature of the stimuli may have reduced the strength of the encoding process, a strong emotional response in the moment may have distracted participants and reduced performance for the emotional group. Had a mood manipulation been put in place and altered whether participants were in a "pleasant" mood or an "unpleasant" mood prior to the task, participants may have been better acclimated to the feelings, and led to results that reflect past mood studies (Isen et al., 1978). Additionally, as the retrospective memory check questions were given after the "somewhat difficult" PM task, the excluded participants might have reduced or limited cognitive resources to retrieve the necessary details to answer the question correctly.

Although many PM studies use words as the stimuli of choice (Altgassen et al., 2011; Ballhausen et al., 2015; Clark-Foos et al., 2009; May et al., 2015), the current study used images. The use of images or words as stimuli have both been effective as an emotional manipulation to influence PM performance, however the use of images has shown more benefits to PM performance (De Houwer & Hermans, 1994; Hostler et al., 2018). The current study is also not unique in using an image-based n-back task, but studies that have used image-based n-backs use only one-back tasks (Altgassen et al., 2010; Henry et al., 2015). The paradigm used in this study is novel in that it used a two-back format, making the task more difficult, as reflected in the difficulty ratings and the lack of ceiling effects among groups. The difficulty, along with the emotional aspect of the images, may have led to the detriment seen in this study.

Limitations

There were several limitations to this study. Given that the cognitive task was developed during the height of the coronavirus pandemic, data collection occurred online, as opposed to in the laboratory. As such, participants were not able to ask the experimenter questions if they were confused about any of the instructions for the task. Any confusion participants may have had might have influenced some to misremember the PM target images, and in turn, fail the retrospective memory check questions during their respective PM blocks. Seeing as exclusions from a sample are low, particularly with young adults (Ball & Bugg, 2018) this may have unnecessarily reduced the number of participants that were available for this sample. Finally, as almost all the excluded participants were from the experimental group, the emotional aspect of the stimuli was possibly detrimental to their ability to recall the PM targets when asked.

Future Directions

Future studies using this task could be done in the laboratory. Although online and laboratory data collection tend to yield similar results (Dandurand et al., 2008; Germine et al., 2012), there are benefits (as listed above), that may help tease out the issue regarding the excluded participants. Additionally, using more emotionally arousing (yet appropriate) positively valenced images may provide more salient cues that would influence cognitive processes, as seen in the negative stimuli. Because the current study did not ask participants to specify the type of mental illness and/or medications they were taking, future studies could also explore the effects of specific mental illnesses (e.g., anxiety and depression) and medications (e.g., SSRIs) would have on performance with this specific task. Future studies could also focus not only on the valence of the images, but also arousal, as emotional arousal can influence the effects these emotional stimuli have on performance (Hostler et al., 2018). Context of instructions and the scope of attention within the task itself could also be examined.

Conclusion

This study investigated the effects of emotional stimuli on prospective memory performance using emotional images. PM performance was lower for the emotional group in comparison to the neutral control group, contradicting both the hypotheses and previous studies. Interestingly, although use of the emotional PM cues was a detriment to PM performance, these cues appeared to be beneficial to ongoing task performance. When compared to the all-neutral control, ongoing task performance was higher with overall lower costs, suggesting less effortful processing when emotional cues are used during the ongoing task. However, the use of emotional images did not influence ongoing task performance, and rather than observing ongoing task costs, practice effects were observed. Additionally, there was a negative correlation between mood disorder diagnosis and PM performance, suggesting that history with a mood disorder may impact PM performance. Future studies could focus on cue arousal along with valence, context of the emotional cues, as well as the effects of different mood disorders on PM performance.

REFERENCES

Altgassen, M., Henry, J. D., Bürgler, S., & Kliegel, M. (2011). The influence of emotional target cues on prospective memory performance in depression. *Journal of Clinical and Experimental Neuropsychology*, *33*(8), 910-916. https://doi.org/10.1080/13803395.2011.574607

Altgassen, M., Phillips, L. H., Henry, J. D., Rendell, P. G., & Kliegel, M. (2010). Emotional target cues eliminate age differences in prospective memory. *Quarterly Journal of Experimental Psychology, 63*(6), 1057-1064. https://doi.org/10.1080/17470211003770920

Ball, B. H., & Bugg, J. M. (2018). Aging and the strategic use of context to control prospective memory monitoring. *Psychology and Aging, 33*(3), 527-544.

Ballhausen, N., Rendell, P. G., Henry, J. D., Joeffry, S., & Kliegel, M. (2015). Emotional valence differentially affects encoding and retrieval of prospective memory in older adults. *Aging, Neuropsychology, and Cognition, 22*(5), 544-559. https://doi.org/10.1080/13825585.2014.1001316

Bower, G. H. (1981). Mood and memory. *American Psychologist, 36*(2), 129-148.

Clark-Foos, A., Brewer, G. A., Marsh, R. L., Meeks, J. T., & Cook, G. I. (2009). The valence of event-based prospective memory cues or the context in which they occur affects their detection. *The American Journal of Psychology*, 89-97.

Cona, G., Kliegel, M., & Bisiacchi, P. S. (2015). Differential effects of emotional cues on components of prospective memory: An ERP study. *Frontiers in Human Neuroscience, 9*, 1-15. https://doi.org/10.3389/fnhum.2015.00010

Dandurand, F., Shultz, T. R., & Onishi, K. H. (2008). Comparing online and lab methods in a problem-solving experiment. *Behavior Research Methods, 40*(2), 428-434.

De Houwer, J., & Hermans, D. (1994). Differences in the affective processing of words and pictures. *Cognition & Emotion, 8*(1), 1-20.

Duchene, A., Graves, R. E., & Brugger, P. (1998). Schizotypal thinking and associative processing: A response commonality analysis of verbal fluency. *Journal of Psychiatry and Neuroscience, 23*(1), 56-60.

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: Factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General*, *134*(3), 327-342. https://doi.org/10.1037/0096-3445.134.3.327

Ellis, H. C., & Ashbrook, P. W. (1988). Resource allocation model of the effect of depressed mood states on memory. *Affect, Cognition, and Social Behavior*, 25-43.

Ellis, H. C., & Ashbrook, P. W. (1989). The" state" of mood and memory research: A selective review. *Journal of Social Behavior and Personality, 4*(2), 1-21.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition & Emotion, 6*(6), 409-434.

Germine, L., Nakayama, K., Duchaine, B. C., Chabris, C. F., Chatterjee, G., & Wilmer, J. B. (2012). Is the Web as good as the lab? Comparable performance from Web and lab in cognitive/perceptual experiments. *Psychonomic Bulletin & Review, 19*(5), 847-857. https://doi.org/10.3758/s13423-012-0296-9

Graf, P., & Yu, M. (2015). Valenced cues and contexts have different effects on event-based prospective memory. *PLoS ONE, 10*(2), 1-17.

Harris, L. M. (1999). Mood and Prospective Memory. *Memory (Hove), 7*(1), 117-127. https://doi.org/10.1080/741943717

Henninger, F., Shevchenko, Y., Mertens, U. K., Kieslich, P. J., & Hilbig, B. E. (2020). *lab.js: A free, open, online study builder*.

Henry, J. D., Joeffry, S., Terrett, G., Ballhausen, N., Kliegel, M., & Rendell, P. G. (2015). Prospective memory function in late adulthood: Affect at encoding and resource allocation costs. *PLoS ONE, 10*(4), 1-11. https://doi.org/10.1371/journal.pone.0125124

Hostler, T. J., Wood, C., & Armitage, C. J. (2018). The influence of emotional cues on prospective memory: A systematic review with meta-analyses. *Cognition and Emotion, 32*(8), 1578-1596. https://doi.org/10.1080/02699931.2017.1423280

Isen, A. M., Shalker, T. E., Clark, M., & Karp, L. (1978). Affect, accessibility of material in memory, and behavior: A cognitive loop? *Journal of Personality and Social Psychology, 36*(1), 1-12. https://doi.org/10.1037/0022-3514.36.1.1

Kensinger, E. A., Garoff-Eaton, R. J., & Schacter, D. L. (2007). How negative emotion enhances the visual specificity of a memory. *Journal of Cognitive Neuroscience, 19*(11), 1872-1887.

Kensinger, E. A., & Schacter, D. L. (2006). Processing emotional pictures and words: Effects of valence and arousal. *Cognitive, Affective, & Behavioral Neuroscience, 6*(2), 110-126. https://doi.org/10.3758/CABN.6.2.110

Kliegel, M., & Jäger, T. (2006). The influence of negative emotions on prospective memory: A review and new data. *International Journal of Computational Cognition, 4*(1), 1-17.

Kliegel, M., Jäger, T., Phillips, L., Federspiel, E., Imfeld, A., Keller, M., & Zimprich, D. (2005). Effects of sad mood on time-based prospective memory. *Cognition and Emotion, 19*(8), 1199-1213. https://doi.org/10.1080/02699930500233820

Lang, P., & Bradley, M. M. (2007). The International Affective Picture System (IAPS) in the study of emotion and attention. *Handbook of Emotion Elicitation and Assessment, 29*, 70-73.

Lange, G., & Carr, A. (1999). Mood congruent memory bias of individuals with depressed mood and anxiety. *Irish Journal of Psychology, 20*(1), 28-38.

May, C., Owens, M., & Einstein, G. O. (2012). The impact of emotion on prospective memory and monitoring: No pain, big gain. *Psychonomic Bulletin & Review, 19*(6), 1165-1171. https://doi.org/10.3758/s13423-012-0301-3

May, C. P., Manning, M., Einstein, G. O., Becker, L., & Owens, M. (2015). The best of both worlds: Emotional cues improve prospective memory execution and reduce repetition errors. *Aging, Neuropsychology, and Cognition, 22*(3), 357-375. https://doi.org/10.1080/13825585.2014.952263

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: a multiprocess framework. *Applied Cognitive Psychology, 14*, S127-S144. https://doi.org/10.1002/acp.775

Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. *Psychological Bulletin, 142*(8), 831-864. https://doi.org/10.1037/bul0000051

Nigro, G., & Cicogna, P. (1999). Comparision between time-based and event-based prospective memory tasks. *Ricerche di Psicologia, 23*(3), 55-70.

Rendell, P. G., Phillips, L. H., Henry, J. D., Brumby-Rendell, T., de la Piedad Garcia, X., Altgassen, M., & Kliegel, M. (2011). Prospective memory, emotional valence and ageing. *Cognition and Emotion, 25*(5), 916-925. https://doi.org/10.1080/02699931.2010.508610

Scullin, M. K., McDaniel, M. A., & Shelton, J. T. (2013, 2013/08/01/). The Dynamic Multiprocess Framework: Evidence from prospective memory with contextual variability. *Cognitive Psychology, 67*(1), 55-71. https://doi.org/https://doi.org/10.1016/j.cogpsych.2013.07.001

Seo, D., Olman, C. A., Haut, K. M., Sinha, R., MacDonald, A. W., & Patrick, C. J. (2014). Neural correlates of preparatory and regulatory control over positive and negative emotion. *Social Cognitive and Affective Neuroscience*, *9*(4), 494-504. https://doi.org/10.1093/scan/nst115

Shelton, J., Scullin, M., & Hacker, J. (2019). The multiprocess framework: Historical context and the "dynamic" extension. In J. Rummel & M. McDaniel (Eds.), *Prospective Memory* (pp. 10-26). Routledge.

Shelton, J. T., & Scullin, M. K. (2017). The dynamic interplay between bottom-up and top-down processes supporting prospective remembering. *Current Directions in Psychological Science : A Journal of the American Psychological Society*, *26*(4), 352-358. https://doi.org/10.1177/0963721417700504

Smith, R. E., Hunt, R. R., McVay, J. C., & McConnell, M. D. (2007). The cost of event-based prospective memory: Salient target events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(4), 734-746. https://doi.org/10.1037/0278-7393.33.4.734

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, *80*(5), 352-373. https://doi.org/10.1037/h0020071

Wood, E., Zivcakova, L., Gentile, P., Archer, K., De Pasquale, D., & Nosko, A. (2012). Examining the impact of off-task multi-tasking with technology on real-time classroom learning. *Computers and Education*, *58*(1), 365-374. https://doi.org/10.1016/j.compedu.2011.08.029

Wood, N., & Cowan, N. (1995). The cocktail party phenomenon revisited: How frequent are attention shifts to one's name in an irrelevant auditory channel? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*(1), 255-260. https://doi.org/10.1037/0278-7393.21.1.255

APPENDIX A

IRB APPROVAL LETTER

THE UNIVERSITY OF TENNESSEE CHATTANOOGA

Institutional Review Board
Dept 4915
615 McCallie Avenue
Chattanooga, TN 37403
Phone: (423) 425-5867
Fax: (423) 425-4052
instrb@utc.edu
http://www.utc.edu/irb

TO: Danielle Gershman **IRB # 20-136**
Mia Melone, Khushi Dipesh Dhruv, Dr. Ashley Howell, Dr. Jill Shelton

FROM: David Deardorff, Interim Director of Research Integrity
Dr. Susan Davidson, IRB Committee Chair

DATE: 11/2/2020

SUBJECT: IRB #20-136: Examining the Effects of Emotion on Prospective Memory Performance

Thank you for submitting your application for exemption to The University of Tennessee at Chattanooga Institutional Review Board. Your proposal was evaluated in light of the federal regulations that govern the protection of human subjects.

Specifically, 45 CFR 46.104(d) identifies studies that are exempt from IRB oversight. The UTC IRB Chairperson or his/her designee has determined that your proposed project falls within the category described in the following subsection of this policy:

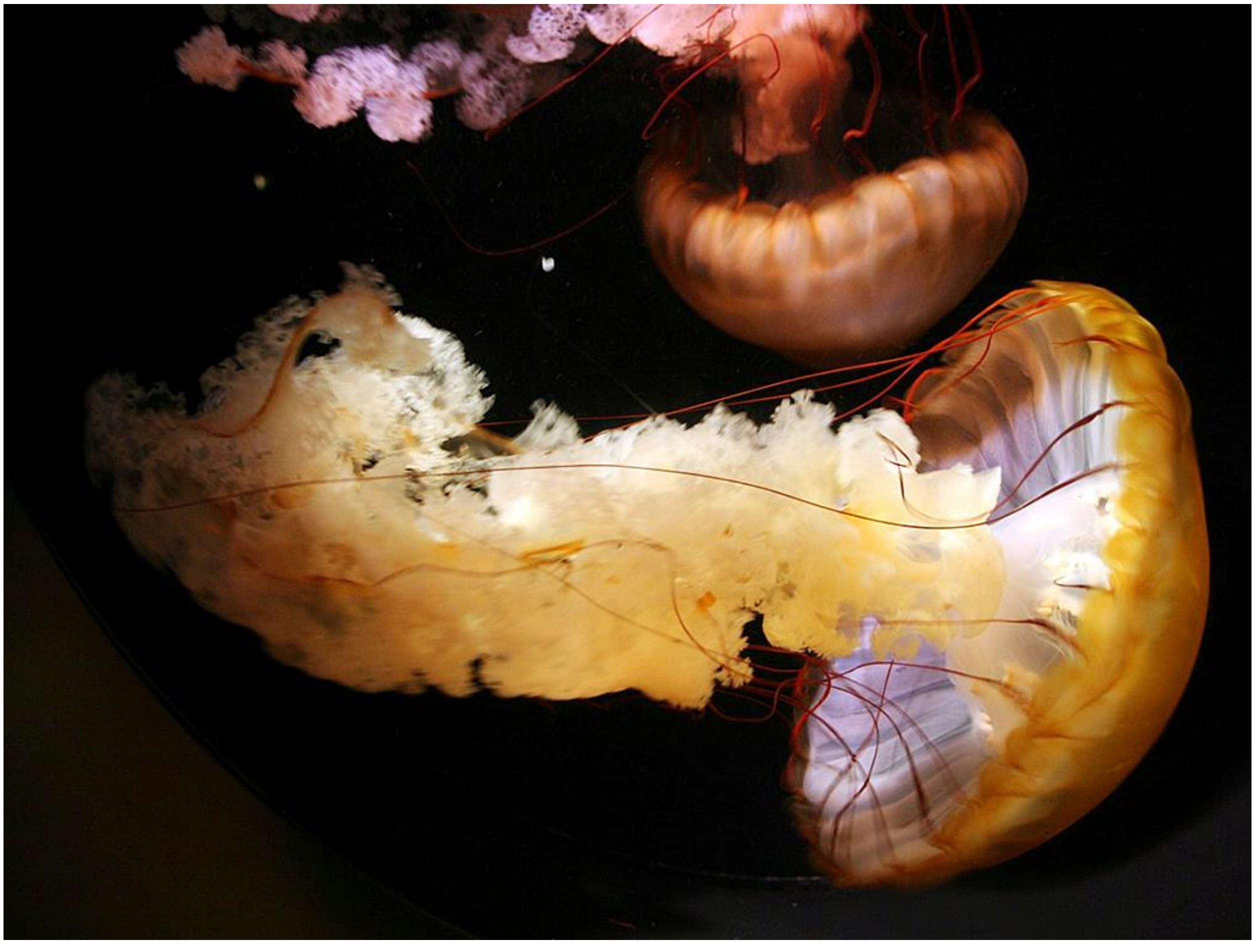
46.104(d)(3)(i)B: Research involving benign behavioral interventions (BBI) through verbal, written responses, (including data entry or audiovisual recording) from adult subject who prospectively agrees and any disclosure of responses outside of the research would NOT reasonably place subject at risk

Even though your project is exempt from further IRB review, the research must be conducted according to the proposal submitted to the UTC IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an Application for Changes, Annual Review, or Project Termination/Completion form to the UTC IRB. Please be aware that changes to the research protocol may prevent the research from qualifying for exempt review and require submission of a new IRB application or other materials to the UTC IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite our best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the UTC IRB as soon as

APPENDIX B

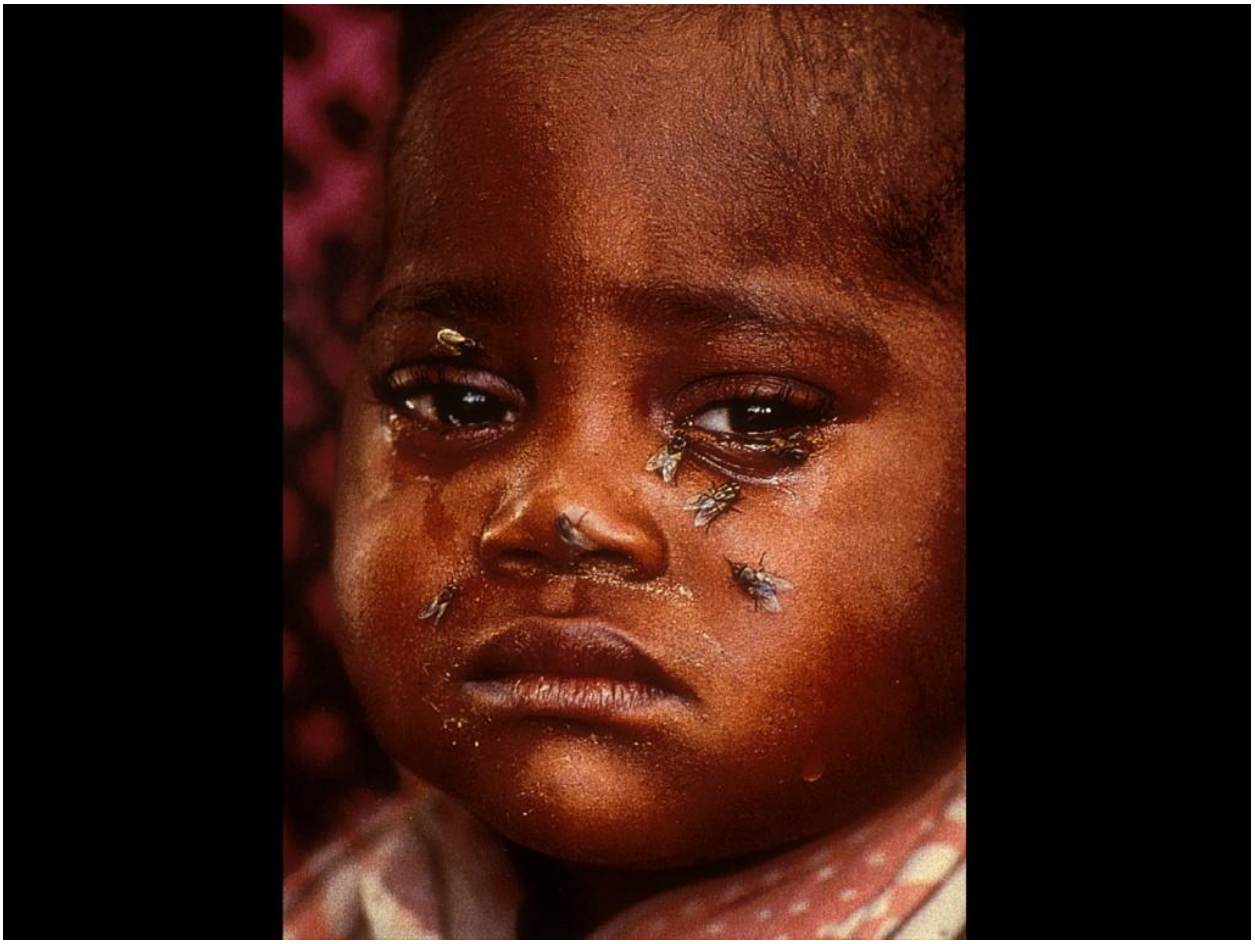
EXAMPLE POSITIVE, NEGATIVE, AND NEUTRAL ONGOING TASK IMAGES



APPENDIX C

EXAMPLE POSITIVE, NEGATIVE, AND NEUTRAL PROSPECTIVE MEMORY TARGET

IMAGES



VITA

Danielle Gershman was born in Warminster, Pennsylvania to Frederick and Elizabeth Gershman. She is the youngest of three children, with two older brothers, Jason, and Joshua. She graduated from Perryville High School, in Perryville, Maryland. After graduation, Danielle attended Stevenson University where she studied Psychology. In her junior year, she developed an interest in research, specifically in cognitive science. In her undergraduate years, Danielle completed multiple research projects, and as a result, she was able to attend and present at the Psychonomic Society's annual conference in November 2018 and the Southeastern Psychological Association's annual conference in March 2019. She then completed her Bachelor of Science degree in Psychology in May 2019. After completing her Bachelor's, Danielle went on to begin a graduate assistantship at the University of Tennessee at Chattanooga in the Research Psychology program. Throughout her graduate career, Danielle worked as the manager for the Cognitive Aging, Learning, and Memory (CALM) Lab and taught multiple undergraduate courses for the Psychology department. Danielle graduated with a Master of Science degree in Psychology in August 2021.