

Understanding emotional memory trade-offs: Considering the effect of trait anxiety and posttraumatic stress disorder

Author: Katherine Ruth Mickley Steinmetz

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Boston College

The Graduate School of Arts and Sciences

Department of Psychology

UNDERSTANDING EMOTIONAL MEMORY TRADE-OFFS: CONSIDERING THE
EFFECT OF TRAIT ANXIETY, AND POSTTRAUMATIC STRESS DISORDER

a dissertation

by

KATHERINE RUTH MICKLEY STEINMETZ

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Understanding emotional memory trade-offs: Considering the effect of trait anxiety, and
Posttraumatic Stress Disorder

Katherine Ruth Mickley Steinmetz

Advisor: Elizabeth A. Kensinger

Though people tend to remember emotional information with extreme vividness, this vividness often comes at the cost of memory for surrounding information. The goal of this dissertation is to investigate this *memory trade-off* and how it is influenced by focused attention, trait anxiety, and posttraumatic stress disorder (PTSD). In each study, participants were shown composite pictures that included an emotional or neutral item placed on a neutral background. Later, they were shown the same items and backgrounds separately. A memory trade-off occurred when participants were more likely to remember emotional items and forget the associated backgrounds as compared to equivalent memory for neutral items and backgrounds. The results from the first chapter revealed that the amount of overt visual attention on an emotional item did not predict the presence of the memory trade-off. However, when it was task relevant to disengage one's attention from the emotional item, the memory trade-off was dampened. Further, dividing attention had no effect on the memory trade-off. The results of the second chapter demonstrated that the memory trade-off was enhanced for emotional items with high levels of arousal as compared to low arousal items. This enhancement was especially strong for individuals with high trait anxiety, when this information was negative and arousing, and when the scene was remembered with a sense of familiarity. Further, for items and backgrounds that were vividly recollected, individuals with higher levels of anxiety were less likely to be able to modulate the memory trade-off, even when it was

task relevant to attend to background information. The third chapter revealed that people with PTSD have a larger memory trade-off for both positive and negative information, despite the lack of overall item memory differences. These studies reveal that attention may not be the only factor that influences the memory trade-off and that the memory trade-off may be influenced by trait anxiety and PTSD.

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INTRODUCTION

Emotional items tend to be remembered with enhanced vividness. Although emotional items are sometimes remembered along with elements of their context (e.g., Brown & Kulik, 1977; Doerksen & Shimamura, 2001), the enhanced memory for emotional items often comes at a cost of memory for surrounding visual elements (Brown, 2003; Burke, Heuer, & Reisberg, 1992; Kensinger, Garoff-Eaton, & Schacter, 2007; Levine & Edelman, 2009; Safer, Christianson, Autry, & Osterlund, 1998; Strange, Hurlman, & Dolan, 2003). Within investigations of eyewitness memory, this kind of phenomenon has also been described as the “weapon focus effect,” referring to the fact that crime victims are more likely to remember the emotional object (the weapon) but not other surrounding visual details such as their robber’s face or clothing (Brown, 2003; Deffenbacher, 1983; Pickel, French, & Betts, 2003; Shaw & Skolnick, 1994).

More broadly, this effect has been referred to as the *emotion-induced memory trade-off* (Kensinger, Garoff-Eaton, et al., 2007; Waring, Payne, Schacter, & Kensinger, 2010). A number of different laboratory studies have found that when an emotional item is present in a complex visual scene, people are more likely to remember that item, but are also more likely to forget the surrounding visual elements (Kensinger, Garoff-Eaton, et al., 2007; Kensinger, Gutchess & Schacter, 2007; Payne, Stickgold, Swanberg & Kensinger, 2008; Waring et al., 2008).

Attention and the Memory Trade-off

Though the presence of these memory trade-offs have been shown to be a robust effect, it is still unclear what mechanism is driving this phenomenon. Most have assumed that attention at encoding may be one factor that causes memory trade-offs (see Reisberg & Heuer, 2004). Our environment contains more information than we can process simultaneously, requiring us to

selectively attend to only a fraction of the information in our world. Because we cannot attend to all of the information that surrounds us, emotional information is often prioritized. We are more likely to notice emotional information and process it (see Dolan & Vuilleumier, 2003 for review); we are also less likely to disengage our attention from it in order to process less salient surrounding stimuli (e.g., Koster, Crombez, Verschuere, & De Houwer, 2004; Sarter, Givens & Bruno, 2001). Further, high arousal stimuli may lead to the narrowing of attention (Easterbrook, 1959). This attentional prioritization and focus may lead to decreased encoding of surrounding information and a memory trade-off. However, the extent to which deployment and maintenance of attentional resources influences the memory trade-off has not been systematically examined. The first chapter of this dissertation examines the hypothesis that focused attention influences the emotion-induced memory trade-off.

Anxiety and the Memory Trade-off

It is not fully understood how individual differences in trait anxiety may influence the memory trade-off. People with high levels of trait anxiety are more likely to attend to emotional information and have difficulty disengaging their attention from the emotional information (see Mogg & Bradley, 1999). Though the results of studies on the effects of anxiety on memory have been mixed, at least in some cases, individuals that are higher in trait anxiety may be more likely to remember threatening emotional information (see Eysenck, & Mogg, 1992 for review). It is possible that only some studies have found memory biases for those with high anxiety because people with higher levels of anxiety may be more likely to exhibit a memory trade-off, remembering the emotional parts, but forgetting surrounding details. This could lead to seemingly contradictory findings in the literature based on the type of stimuli that are studied. For example, if people with higher levels of anxiety are asked about their memory for details

about the emotional component of the scene, they may exhibit better memory than those with lower levels of anxiety. However, if the memory test focuses on more contextual details of the scene, memory enhancement may not be revealed for those with higher anxiety. In support of this hypothesis, one study found that the level of anxiety in a sub-clinical population was correlated with the magnitude of the memory trade-off effect (Waring, et al., 2010). In other words, people with higher levels of anxiety were more likely to remember the emotional component of a scene and to forget the neutral background (i.e. exhibiting a larger memory trade-off) than were people with lower anxiety levels. The second chapter of this dissertation examines the hypothesis that trait anxiety may affect the magnitude of the emotion-induced memory trade-off.

PTSD and the Memory Trade-off

Posttraumatic stress disorder (PTSD) is an anxiety disorder that develops in response to a traumatic event (Breslau, 2002). It is characterized by automatic re-experiencing of the trauma (e.g., flashbacks), avoiding situations associated with the trauma, numbing of responsiveness and affect, and hypervigilance, or increased sensitivity to detecting threat (APA, 2000). Further, some research has indicated that people with PTSD have fragmented and disjointed memories of their trauma, even when they voluntarily recall them (Foa, Molnar, & Cashman, 1995; Halligan, Michael, Clark & Ehlers, 2003; Nijenhuis & van der Hart, 1999; Tromp, Koss, Figueredo & Tharan, 1995; van der Hart, van der Kolk, & Boon, 1998; van der Kolk and Fisler, 1995). Many of these cognitive symptoms seem to indicate possible differences in attentional processing towards stimuli associated with their trauma, and perhaps to emotional stimuli more generally. However, few studies have focused on differences in emotional memory, beyond memory just for stimuli associated with the traumatic event. Further, though we know that people with PTSD

have missing pieces of information from their trauma memories, it is unclear if this fragmentation is linked to the memory trade-off, as this hypothesis has not been examined. Chapter 3 of the dissertation explores the hypothesis that the memory trade-off may be greater in individuals with PTSD than those without PTSD, despite overall group differences in memory for positive and negative stimuli.

The Current Studies

In the first chapter I investigated the effect of attention on the memory trade-off in three ways. First, eye-tracking analyses were used in order to examine the effect of overt visual attention at encoding on the memory trade-off at retrieval. Because emotionally arousing stimuli at encoding may attract and narrow attention, leading to decreased processing of surrounding information (e.g., Dolan & Vuilleumier, 2003; Easterbrook, 1959), I hypothesized that more attention on the emotional item at encoding would lead to a greater memory trade-off.

Second, the relative salience of emotional items and background contexts was manipulated by asking participants to selectively attend to one or the other in order to successfully answer true/false questions. This allowed me to investigate the ability to disengage attentional resources from emotional items which usually naturally capture attention. In line with previous research that has suggested individuals can modulate the strength of the memory trade-off when instructed to attend to non-emotional details of the scene (Kensinger, Garoff-Eaton, et al, 2007), I hypothesized that participants would be able to disengage their attention from emotional items to process the background. This would serve to dampen the memory trade-off.

Third, I examined the effects of limiting attentional resources through a divided attention task. Because previous research has indicated that divided attention, or limiting attentional resources, may cause people to have a more narrowed focus of attention on negative arousing

information (Kern, Libkuman, Otani & Holmes, 2005), I hypothesized that participants would have a greater trade-off under divided attention than under full attention.

The second chapter focuses on understanding the influence of trait anxiety on the memory trade-off. First, I examined the effect of valence (positive/pleasant vs. negative/unpleasant information) and arousal (exciting/agitating vs. calming/soothing information). Because previous studies have shown that people with high trait anxiety may be more likely to attend to negative high arousal information (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenberg, & van IJzendoorn, 2007; Eysenck & Mogg, 1992), I hypothesized that people with high levels of trait anxiety would exhibit a larger memory trade-off for negative high arousal information than for positive or low arousal information. Second, I examined the ability of individuals with high anxiety to allocate attentional resources when encoding complex emotional scenes. Because previous studies have indicated that people with high levels of trait anxiety may have difficulty disengaging their attention from emotional information (see Mogg & Bradley, 1999), I hypothesized that people with high levels of trait anxiety would be unable to eliminate the memory trade-off even when it was task relevant to process the surrounding information.

The third chapter focuses on emotional memory and the memory trade-off in individuals with PTSD. First, I examined memory for emotional stimuli in people with PTSD. Because some studies have found that people with PTSD may be no more likely to remember *traumatic* information than people without PTSD (Bremner, et al., 2003; Dickie, Brunet, Akerib, & Armony, 2008), I first hypothesized that regardless of whether individuals had PTSD or were healthy controls, they would have similar memory for negative and positive items. Second, I examined the emotional memory trade-off in individuals with PTSD. Because people with PTSD

have reported “tunnel memory” or fragmented memory for their trauma (LaBar, 2007), I hypothesized that people with PTSD would exhibit a greater memory trade-off than those without PTSD.

CHAPTER 1: EFFECTS OF ATTENTION ON THE MEMORY TRADE-OFF

It has often been suggested that the emotion-induced memory trade-off is influenced by focused attention on emotional items at encoding (see Reisberg & Heuer, 2004 for review). The rationale behind this idea is based on the fact that high arousal emotional items tend to be prioritized for processing; they are more likely to be detected and to provoke sustained attention (Christianson, 1992; Dolan & Vuilleumier, 2003; Easterbrook, 1959; Shimmack, 2005). These effects of emotion in capturing attention may influence the emotion-induced memory trade-off by biasing attention at encoding, leading to a detailed memory for the emotional component, but not for the surrounding scene. Participants may be more likely to encode those components of the scene and to later remember them, as opposed to the neutral background components that were not prioritized at encoding.

However, the influence of attention on the memory trade-off has yet to be systematically tested. The current chapter investigates the role of attention in three different ways: by examining eye gaze as a measure of overt visual attention (Experiment 1), by examining the effect of attentional disengagement (Experiment 1) and by examining the effect of divided attention (Experiment 2) on the emotion-induced memory trade-off.

Many studies have provided evidence for the prioritization of emotional information as the focus of attention. People are quicker to notice emotional information within a visual array (Ohman, Flykt & Esteves, 2001), are more likely to notice emotional than neutral words that are presented very quickly (Anderson & Phelps, 2001), and are more susceptible to interference by

emotional distracters than neutral distracters (McKenna & Sharma, 1995; Shimmack, 2005). These effects of emotion on attention have also been shown in studies that have investigated eye gaze as a measure of overt visual attention. People tend to fixate first and look longer at emotional pictures than neutral pictures when emotional and neutral pictures are presented side by side or when emotional pictures are presented as distracters (Bannerman, Milders & Sahraie, 2009; Calvo & Lang, 2004; Nummenmaa, Hyönä, & Calvo, 2006). Thus, attention may initially be focused on emotional information, and it may be harder for participants to disengage attention from that information.

The influence of attention at encoding on the weapon focus effect was investigated by Loftus, Loftus & Messo (1987). In this study, participants' eye gaze was monitored while they were presented with slides in which a person entered a bank with either a gun or a check. This study found that people made more fixations on the gun than on the check when viewing the slides. In addition, memory for surrounding elements in the "weapon" condition was poorer than in the "check" condition. This is compelling evidence that attention at encoding may be allocated differently depending on the presence of an emotional item. However, this study looked at eye gaze and memory results separately and did not directly relate eye gaze and memory. In other words, there was no indication that the increased fixation on the weapon at encoding was what led to an increased likelihood of the weapon focus effect in memory. Therefore, it is still unclear if there is a causal link between attention allocation at encoding and the memory trade-off and if so, whether it extends to positive as well as negative emotional stimuli or if it is specific to negative threat-related stimuli such as weapons.

It is also unclear if the emotion-induced memory trade-off is influenced solely by the effects of attention prioritization or if difficulty in disengaging one's attention from emotional

items to process surrounding elements may also influence the trade-off. As mentioned previously, people attend longer to emotional information (Calvo & Lang, 2004; Nummenmaa, et al., 2006) and are less likely to be able to disengage attention from emotional information (Koster, et al., 2004; Sarter, et al., 2001). This difficulty in disengaging attention may or may not be under volitional control. Nummenmaa et al. (2006) found that participants looked longer at emotional pictures even when they were told not to. However, Kensinger, Garoff-Eaton, & Schacter (2007) found that by varying encoding instructions to direct attention towards backgrounds in scenes that included emotional items, young adults were able to dampen the emotion-induced memory trade-off (e.g., were more likely to remember the neutral background paired with an emotional item). Thus, difficulty in disengaging attention from emotional items may influence the emotion-induced memory trade-off, but one may be able to overcome this tendency when it is task relevant.

If attention at encoding influences the emotion-induced memory trade-off, a remaining question is what will happen if only limited attentional resources are available. Some divided attention studies looking at differences in memory for negative and neutral pictures have found that memory for negative information is enhanced as compared to neutral information, even when attention is divided at encoding (Harris & Pashler, 2005; Hulse, Allan, Memon & Read, 2007). Other divided attention studies have found that dividing attention may actually be less likely to decrease memory for negative items than that of positive or neutral information (Kern et al., 2005; Talmi, Schimmack, Paterson & Moscovitch, 2007). However, these studies have not considered the memory trade-off (e.g., memory for both the item and the background). In the current study, I hypothesized that the prioritization of emotional information in concert with

limited attention may lead to a larger memory trade-off: increased strength of item memory at the expense of the background memory.

The present study tested these effects of attention at encoding on the emotion-induced memory trade-off. Specifically, I examined the effect of overt visual attention (eye gaze) on the emotion-induced memory trade-off (Experiment 1A), the effect of controlled attentional disengagement on eye gaze and the emotion-induced memory trade-off (Experiment 1B), and the effect of divided attention on the emotion-induced memory trade-off (Experiment 2).

Experiment 1

Method

Participants. Data from forty-three Boston College students (ages 18-21, 22 men) were analyzed for this study. For four of the participants, no eye-tracking data was collected due to eye-tracker malfunction (though they completed the task with the eye-tracker set up in the same way as the other participants). Therefore, for the behavioral analyses all forty-three participants are included and for the eye-tracking analyses, thirty-nine participants are included (ages 18-21, 21 men). Participants included in the analyses for this study were a subset of those tested as part of a larger study examining individual differences in anxiety levels (see Chapter 2). The participants included in the present analyses were those who had a Beck Depression Inventory (BDI-II) (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) score under ten and a Beck Anxiety Inventory (BAI) (Beck, Epstein, Brown, & Steer, 1988) score under nineteen. These cutoffs were chosen according to normative data to exclude BDI scores at or above the ninety-ninth percentile (i.e., a cut-off score of 10, Knight, 1984) and BAI scores at or above the ninetieth percentile (i.e., a cut-off score of 19, Gillis, Haaga & Ford, 1995). The anxiety score cutoff was deliberately more conservative (i.e., excluded a greater proportion of participants) to make sure

that the high anxiety participants recruited as part of the larger sample were not included. All participants had normal or corrected-to-normal vision, were native English speakers, and had no history of a neuropsychological or psychiatric disorder. No participant listed that he or she was taking medications that affect the central nervous system.

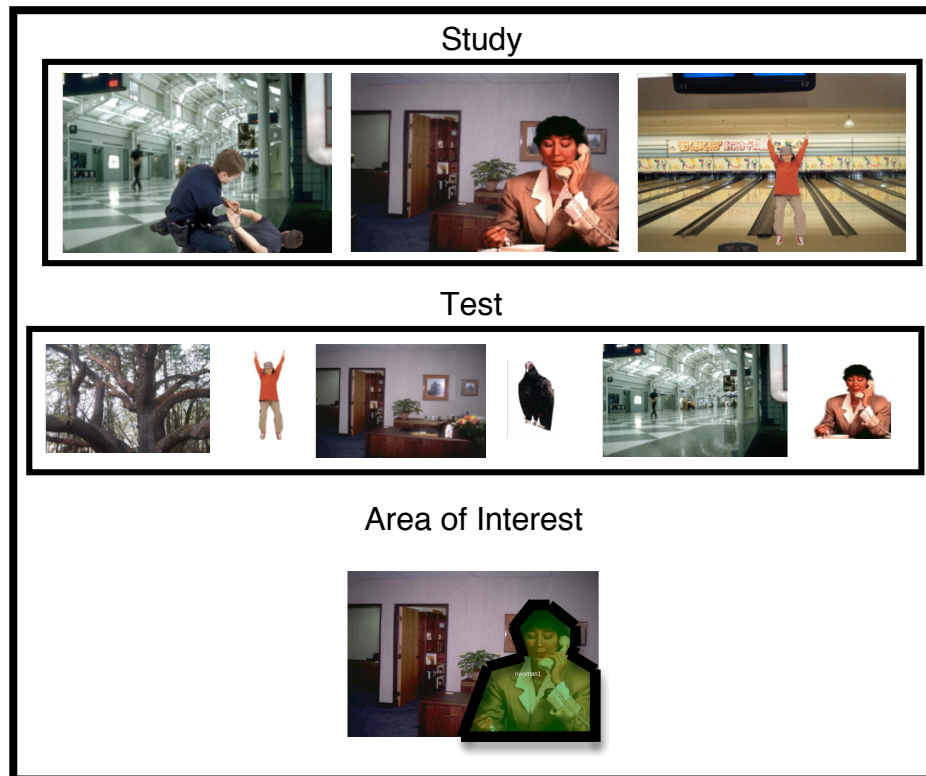


Figure 1. Samples of the composite study stimuli (a negative, neutral or positive item on a neutral background), the recognition test stimuli (the item and background presented separately), and the area of interest selection for the eye-tracking analyses.

Materials. Stimuli consisted of complex visual scenes that were created by placing images of positive, negative and neutral items onto neutral background scenes (See Figure 1, “Study” Panel). The stimulus set included objects and backgrounds used in prior studies (Kensinger, Garoff-Eaton, et al., 2007; Waring & Kensinger, 2009; Waring, et al., 2010). Composite images

were created by placing an item onto a plausible background scene. Care was taken to make sure that positive, negative, and neutral objects were of comparable size and were placed in the same approximate location across scenes. Each picture was approximately 10x13 in. and 700x550 pixels.

Items were 180 nameable, photographic-quality, color images that were taken from photo clip art packages (Hemera Technologies, Quebec, Canada), from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1999) and from other online databases of images. The pictures were broken down by valence according to ratings gathered in previous studies (and confirmed by ratings collected in Experiment 2). Valence was rated on a 9-point scale with 9 being the most positive and 1 being the most negative. There were 60 positive images (mean valence = 6.02, $SE = .81$), 60 negative images (mean valence = 3.80, $SE = .82$) and 60 neutral images (mean valence = 5.29, $SE = .75$). Arousal was rated on a 5-point scale, with low numbers indicating soothing or subduing images and high numbers indicating exciting or agitating images (arousal mean (SD): Positive = 3.02 (0.57); Negative = 3.19 (0.66); Neutral = 2.35 (0.61)). Valence was rated on a larger scale than arousal, because while arousal is often divided into two categories (high arousal and low arousal), valence is often split into three categories (positive, negative, neutral). The positive and negative images were matched on arousal and absolute valence (i.e., distance from neutral, all $p > .30$) and neutral images were considered less arousing than both positive and negative images (all $p < .05$). Across emotion categories, scenes were also matched for visual complexity, congruency between item and background, and number of people, animals and buildings as judged by two raters.

Stimuli were split in half to create two different study sets with 90 scenes per list (30 with a negative item, 30 with a positive item and 30 with a neutral item). Those sets were either

presented in forward order or in reverse order, yielding four total study lists that were counterbalanced across participants. It was never the case that more than three scenes of the same emotion category appeared in a row.

Equipment and Procedure

The eye-tracking apparatus was a SensoMotoric Instruments (SMI) Eye Tracker. Participants' left eye gaze patterns were tracked at 500 Hz by a SMI iView X Hi-Speed 1250 tracking column. Prior to the eye-tracking session, participants filled out the consent form, a demographics questionnaire, an assessment of their state and trait anxiety and an assessment of their depressive symptoms (e.g., the BAI, the BDI-II, and the State-Trait Anxiety Inventory (STAI [Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983])). Participants then completed the tasks described below.

Encoding task 1: View Condition. Participants were seated two feet away from a 14 in. computer screen, with the center of the computer screen at eye level. Each participant's eye-gaze was first tracked during a calibration phase. For the calibration, participants were asked to shift their gaze to each of 17 points on a computer screen to ensure that the eye-tracker was accurately tracking the pupil of the left eye. Once calibrated, participants were given the task instructions. Participants were asked to look naturally (as if they were watching television) at the screen as each picture appeared and to look at a fixation cross in between trials. During this incidental encoding session, each trial began with a white fixation cross presented on a black screen for 4,000 ms. This fixation was followed by the appearance of a composite picture for 5,000 ms. After a short practice (3 pictures), the participants viewed 45 pictures (15 from each emotion category).

Encoding task 2: Attentional Disengagement Condition. Once the first set was completed, instructions came up on the screen for the second incidental encoding task. Participants were instructed to look at each different complex visual scene carefully while it was on the screen (for 5,000 ms). They were then told that after the picture had been removed from the screen, two true/false questions would be presented one at a time. Participants were told that one true/false statement was about the item in the scene (e.g., “The dog does not have a collar.”) and one was about the background (e.g., “There are clouds in the sky.”). Participants gave their true or false responses verbally while an experimenter recorded their responses, so that participants did not need to remove their gaze from the computer monitor.

Each participant then completed a short practice version of the encoding task (5 trials) and then proceeded to view the next 45 pictures (15 from each emotion category). The order of the encoding tasks was always constant, with the Attentional Disengagement condition administered after completion of the View condition, to avoid concerns that answering the true/false questions would alter the way in which participants would view and elaborate upon the scenes in the View condition.

Delay and Test Phase. After participants completed both phases of the encoding session, a battery of standardized cognitive tasks was administered, creating a retention delay of approximately 30 minutes. The tests included: the Shipley Vocabulary Test (Shipley, 1986), Wechsler Adult Intelligence Scale Backwards Digit Span Test (Wechsler, 1997), The Wechsler Adult Intelligence Scale Digit Symbol Test (Wechsler, 1997), The FAS Test of verbal fluency (Spreeen & Benton, 1977) and the Stroop task (Stroop, 1935).

Following neuropsychological testing, participants were presented with a surprise recognition task in which they viewed items and backgrounds extracted from the studied

composite scenes in addition to new items and backgrounds. Images included 90 studied items (30 of each valence), 90 studied backgrounds (30 studied with an item of each valence), 90 new items (30 of each valence), and 90 new backgrounds, for a total of 360 images (see Figure 1, “Test” Panel).

These items were presented in four different orders (two randomized lists were presented either in forward or reverse order), and the order was counterbalanced across participants. The different list orders ensured that the placement of a certain picture in relation to another picture did not influence memory across participants (e.g., one item happened to be remembered better because of its placement after the corresponding background).

Half of the studied items and backgrounds from each valence category had been presented in the “View” condition and half in the “Attentional Disengagement” condition. The particular items and backgrounds that were “old” vs. “new” were counterbalanced across participants based on the study list that they viewed. For each item or background, participants were asked to indicate whether they believed the picture was new, whether they “remembered” it (recalled specific details of its presentation during the encoding session) or “knew” it (felt a sense of familiarity with the picture, without remembering details from the encoding session). This test was self-paced and the slide moved on when participants had made their response. For the behavioral results, all “remember” and “know” responses were collapsed to assess memory for all items rated as old.

A pilot study (N=14) was conducted to assess whether there was any difference in memorability for the backgrounds paired with each category of emotional item. This study was conducted because it was not possible to fully counterbalance the category of emotional item presented with each background (i.e., each background could not always be plausibly presented

with a neutral, a negative, and a positive item between subjects). The pilot study revealed that there were no differences in memory for any of the backgrounds based on the valence of the item that it would be paired with in the study session, mean (*SD*) hits: positive = 0.82 (0.15), negative = 0.80 (0.13), neutral = 0.83 (0.14), all $p > 0.28$.

Data Analysis.

Behavioral Data Analysis. For behavioral memory data, false alarms (new pictures that were incorrectly cited as being old) were subtracted from hits (pictures that were correctly recognized as being old) in order to correct for any bias to call a picture “old.” These corrected recognition scores were computed separately for each item type (positive, negative, neutral) and for each background type. Note that only one false alarm rate could be ascertained for backgrounds: by definition new backgrounds are neutral because the emotionality of a background relates to the type of item with which it had been studied.

The memory data were then analyzed to determine the difference in memory for emotional items and backgrounds as compared to neutral. The emotion-induced memory trade-off is defined as the combined increase in memory for emotional items as compared to neutral items and decrease in memory for backgrounds accompanying emotional items compared to neutral items. Thus, to calculate a memory trade-off score, corrected recognition scores for neutral items were subtracted from corrected recognition scores for positive or negative items, and corrected recognition scores for backgrounds paired with neutral items were subtracted from corrected recognition scores for backgrounds paired with positive or negative backgrounds (see Leclerc & Kensinger, 2008; Waring & Kensinger, 2009, for use of these types of difference scores).

To then calculate the magnitude of the trade-off effect (e.g., the discrepancy between item and background memory), these corrected scores for the backgrounds were subtracted from the corrected scores for the items. The overall formula was:

$$\begin{aligned} \text{Memory trade-off score} = & \\ & (\text{memory for emotional item} - \text{memory for neutral item}) - \\ & (\text{memory for background paired with emotional item} - \text{memory for background paired with} \\ & \text{neutral item}) \end{aligned}$$

The largest trade-off occurs when there is both better memory for the emotional item and worse memory for the accompanying background as compared to neutral (see Waring et al., 2010 for use of this composite trade-off score).

Eye-tracking Data Analysis. For the eye-tracking results, the dependent variable was the percentage of scene viewing time that participants spent fixated on the item. Emotional or neutral items within the scene were defined as areas of interest (see Figure 1, “Area of Interest” Panel). Fixation percentage was calculated by measuring the amount of time that a participant fixated on that predetermined area of interest and dividing that by the total amount of time that the participant fixated on any area of the scene. A fixation was defined as the maintenance of eye gaze on a particular point on the screen for 50 ms or more. As recommended by eye-tracking software manufacturers, the first fixation for each slide was excluded from the analysis, as the first fixation actually reflects the last fixation from the previous trial (i.e., the participant is usually still looking where the fixation cross or text was on the previous screen). BeGaze software was used to record the appearance and duration of the visual stimuli, as well as fixations on the stimuli.

The eye-tracking results were analyzed in two different ways. To determine how item fixation time was affected by the emotionality of the item, the first analysis considered only item fixation time for all correctly remembered items (“hits”) regardless of whether the background was remembered or forgotten. The second analysis allowed examination of item fixation time in relation to whether there was selective item memory¹.

For this analysis, percent fixation time was considered separately when there was selective item memory (e.g., the item was remembered and the background was forgotten) versus when there was not selective item memory (e.g., the item was remembered as well as the background or the item was forgotten and the background was remembered). Both of these latter trial types were collapsed together in order to give sufficient power to estimate the eye gaze patterns for the no selective item memory condition. It should be noted that different trials are included in these two analyses because, while the first analysis only includes fixation time for item hits, the second analysis also includes times when the item was forgotten as part of the no selective item memory condition.

Results

Behavioral Results: View Condition

First, a t-test was conducted to compare the memory trade-off for positive and negative items under the View condition. This t-test revealed no significant difference in trade-off scores between positive and negative items, $t < .3, p > .7$ (see Figure 2 black bars).

¹ The term “selective item memory” is used for these analyses instead of the “emotion-induced memory trade-off” because these analyses consider memory for items and backgrounds that are neutral as well as emotional. The emotion-induced memory trade-off refers to a specific difference in item and background memory for emotional information that differs significantly from neutral.

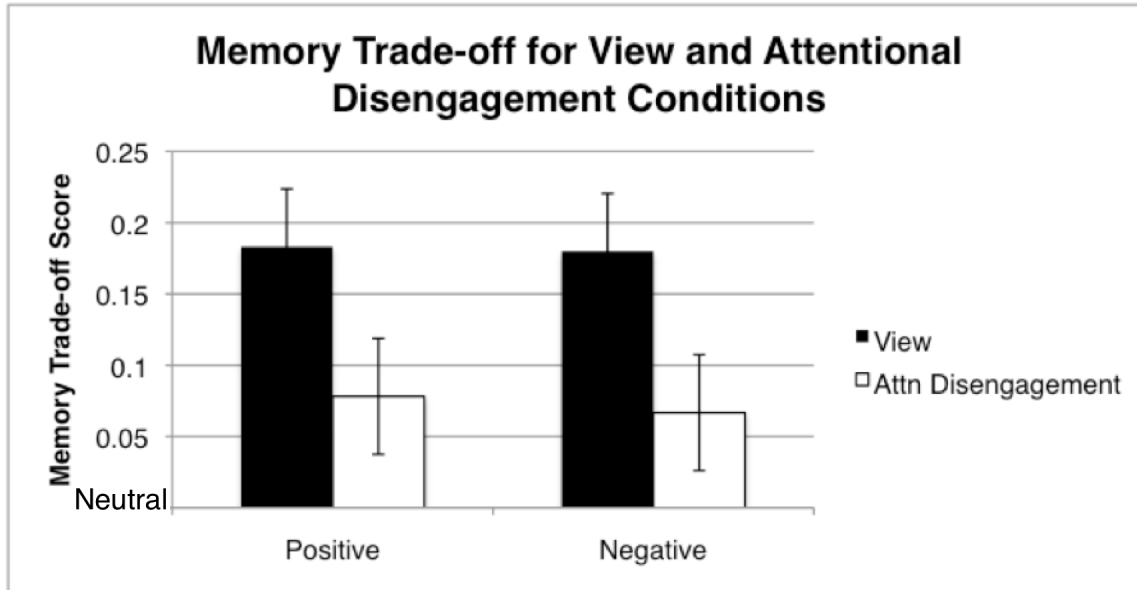


Figure 2. Behavioral memory data considering the attentional disengagement condition. Memory trade-off scores (calculated as [emotional item-neutral item]-[emotional background-neutral background]) for the view and the attentional disengagement condition.

Eye Gaze Results: View Condition

To determine how the percent item fixation differed by emotion type, the first eye-tracking analysis considered percent item fixation at encoding for items that were later remembered. A one-way ANOVA revealed a main effect of emotion (positive, negative, neutral; $F(2,76) = 7.19, p < .01, \eta_p^2 = .159$). Subsequent t-tests revealed that a larger percentage of time was spent fixating on positive, $t(38) = 3.427, p < .01$, and negative, $t(38) = 3.552, p < .01$ items than neutral ones. There was no significant difference in fixation time for positive and negative items, $t < 0.05, p > 0.5$ (see Figure 3A, black bars).

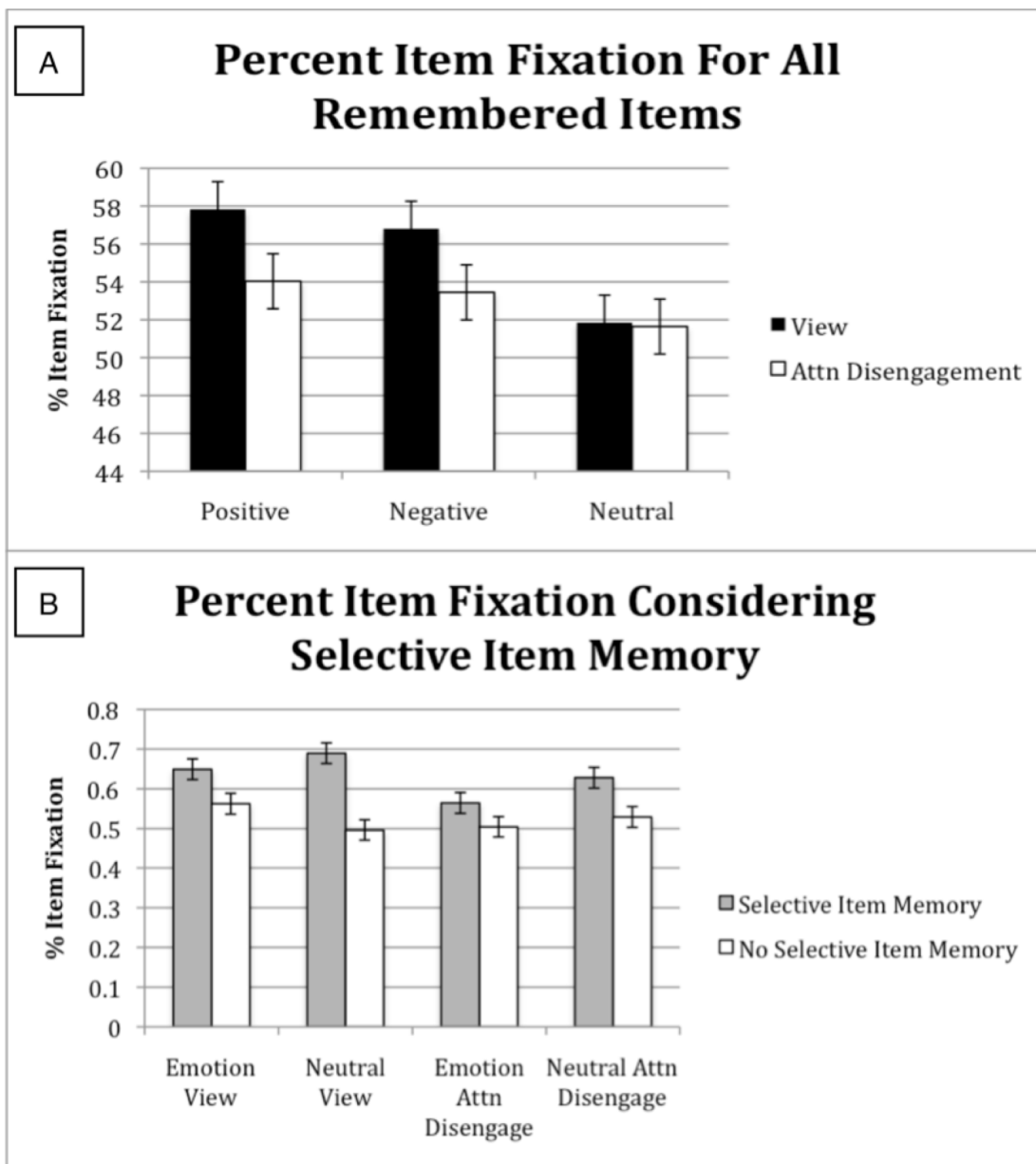


Figure 3. Eye-tracking data considering the attentional disengagement condition. A) Percent fixation at encoding for all remembered items for the view and the attentional disengagement condition. B) fixation times at encoding considering if there was later selective item memory (the item was remembered, but the background was forgotten) or if there was not selective item memory (the item and the background were both remembered or the item was forgotten, but the background was remembered) for the view and the attentional disengagement condition.

In order to determine the relationship between percent item fixation and the emotion-induced memory trade-off, a second analysis considered item fixation at encoding separately depending on the presence or absence of later selective item memory. Selective item memory

occurred when the item was remembered and the background was not, and it was considered not to have occurred when either only the background was remembered or both the item and the background were remembered. Scenes for which both item and background components were forgotten were not included in these analyses. Therefore, these second analyses included a broader set of the encoding trials than did the first eye-tracking analysis; these second analyses included fixation time for all scenes in which any component was remembered, not only those scenes in which the item was remembered. I used this broader set of trials to be able to include data from the largest subset of participants; there were too few trials for some participants if only conditions in which the item was remembered were analyzed.

In this second analysis, a Selective Item Memory (present, absent) x Emotion (positive, negative, neutral) ANOVA was conducted. Thirty-six participants were included in this analysis due to missing data (e.g., three participants never exhibited selective item memory for scenes of a certain valence). This analysis revealed a main effect of selective item memory, $F(1,35) = 56.271, p < .001, \eta_p^2 = .617$, and a main effect of emotion, $F(2,70) = 4.028, p < .05, \eta_p^2 = .103$, but not a valence x selective item memory interaction ($F < 1.9, p > .15$)². Subsequent t-tests revealed that the percent item fixation was greater for scenes in which there was a later selective item memory as compared to those in which there was not, $t(35) = 6.149, p < .001$. The effect of emotion was such that people fixated longer on positive items than on negative items, $t(35) = 2.112, p < .05$, and marginally longer on positive items than on neutral ones, $t(35) = 1.718, p < .1$. Although there was no emotion x selective item memory interaction, the results suggest that

² There was also no valence x selective item memory interaction when ‘no selective item memory’ was defined as times when both the item and background were remembered (instead of defining ‘no selective item memory’ as *either* when only the background was remembered or when both the item and background were remembered), although only 33 participants were able to be included in this alternate analysis due to missing data.

the effect of emotion was, if anything, more pronounced when there was *not* selective item memory, with the difference between positive and neutral looking time differing only in that condition, $t(35) = 2.692, p < .05$ and not in the selective item memory condition ($t < 1, p > .1$; see left portion of Figure 3B).

Behavioral Results: Attentional Disengagement Condition

In order to examine the effect of the Attentional Disengagement Condition (answering the true/false questions about the item and the background), a 2 x 2 ANOVA was conducted with the factors of valence (positive, negative) x disengagement condition (view, disengagement). This analysis revealed a main effect of disengagement, $F(1,42) = 7.201, p < .05, \eta_p^2 = .146$ (see Figure 3). Post hoc t-tests revealed that there was a larger emotion-induced memory trade-off for items encoded under the View Condition than those under the Attentional Disengagement Condition ($t(42) = 2.683, p < .05$, see Figure 2). The difference in the trade-off for positive and negative items under the Attentional Disengagement Condition was not significantly greater than the item-background trade-off for neutral items ($t < .9, p > .38$)

Eye Gaze Results: Attentional Disengagement Condition

In order to examine the effect of attentional disengagement on the time spent fixating on items within scenes, an emotion (positive, negative, neutral) x disengagement condition (view, disengagement) ANOVA was conducted (see Figure 3A). This analysis revealed a main effect of emotion, $F(2,75) = 4.335, p < .05, \eta_p^2 = .102$, a marginal main effect of disengagement condition, $F(1,42) = 3.918, p < .06, \eta_p^2 = .093$ and a marginal emotion x disengagement condition interaction, $F(2,76) = 2.573, p < .09, \eta_p^2 = .063$.

Post hoc t-tests revealed that for negative items, people fixated longer on items encoded under the View condition than those under the Attentional Disengagement Condition, $t(38) =$

4.221, $p < .001$. This effect was also marginally significant for positive items, $t(38) = 1.793$, $p < .09$ but was not significant for neutral items ($t < 1$, $p > .1$). Under the View Condition, there were longer fixations for both positive, $t(38) = 3.552$, $p < .01$ and negative items, $t(38) = 3.427$, $p < .01$ than neutral items, and fixation times did not differ for positive and negative items (all $t < 0.5$, $p > 0.5$). There were no significant emotion differences under the Attentional Disengagement Condition (all $t < .1$, $p > .2$).

To better understand these effects, and since there were no significant differences between fixation time for positive and negative pictures, I collapsed across items of positive and negative valence to conduct an ANOVA with factors of emotion (emotional [positive and negative collapsed], neutral) and disengagement condition (view, disengagement). This analysis revealed a main effect of emotion, $F(1,38) = 11.676$, $p < .01$, $\eta_p^2 = .235$ and an emotion x disengagement condition interaction, $F(1,38) = 4.604$, $p < .05$, $\eta_p^2 = .108$, such that there were greater item fixation times for emotional items than neutral items under the View Condition, $t(38) = 4.311$, $p < .001$, but there was no effect of emotion on fixation times in the Attentional Disengagement Condition ($t < 1.5$, $p > 0.1$). In other words, participants fixated longer on emotional items than neutral ones under the View condition, but not under the disengagement condition.

I then examined whether this effect varied by the presence of selective item memory. An emotion (emotional, neutral) x disengagement condition (view, disengagement) x selective item memory (present, absent) ANOVA was conducted (see Figure 3B). Only 28 participants could be included in this analysis due to missing data (e.g., there were some people who never exhibited selective item memory for neutral scenes under the Attentional Disengagement Condition). This analysis revealed a main effect of selective item memory, $F(1, 27) = 37.99$, $p <$

.001, $\eta_p^2 = .585$ and a main effect of disengagement condition, $F(1, 27) = 4.148, p = .052, \eta_p^2 = .133$. There were longer fixation times for the item when selective item memory occurred, $t(27) = 5.589, p < .001$, and there were longer fixation times for the item under the View condition than in the Attentional Disengagement Condition, $t(27) = 2.037, p = .052$.

These main effects were qualified by a selective item memory x disengagement condition interaction, $F(1, 27) = 4.289, p < .05, \eta_p^2 = .137$ and by a selective item memory x emotion interaction, $F(1, 27) = 3.955, p = .057, \eta_p^2 = .128$. The selective item memory x attentional disengagement interaction was such that the difference in item fixation percentages was significantly greater when selective memory would result in the View condition (comparison of selective item memory to non-selective memory: $t(27) = 6.068, p < .001$) than in the Attentional Disengagement Condition, $t(27) = 3.216, p < .01$. In other words, participants looked especially long at the item when it was presented under the View Condition and when selective item memory occurred.

The selective item memory x emotion interaction was such that the difference in item fixation percentages was significantly greater if there was later selective item memory for neutral items (comparison of selective item memory to non-selective memory: $t(27) = 5.003, p < .001$) than for emotional items, $t(27) = 3.479, p < .01$. In other words, participants looked especially long at neutral items if selective item memory occurred.

Discussion

The goal of the first experiment was to test the role of attention and attentional disengagement in the memory trade-off. These investigations revealed that overt visual attention at encoding (measured as item fixation time) did not predict the presence of the emotion-induced trade-off. However, attentional disengagement was able to dampen the memory trade-off effect.

These results suggest that an attention focus explanation may not be sufficient in order to explain why this effect occurs more for emotional items than for neutral items.

Effects of Overt Visual Attention. I first found that for items later remembered, people fixated longer on emotional rather than neutral items. This goes along with previous literature that suggests that people attend longer to emotional information than neutral information (Bannerman, et al., 2009; Calvo & Lang, 2004; Nummenmaa, et al., 2006). This analysis included only item hits. Thus, even though participants remembered all of these items, they still looked longer at the emotional items than the neutral items. The difference in fixation time existed even without a difference in subsequent memory for these particular items. Perhaps for the neutral items a certain threshold of attention was crossed such that participants remembered rather than forgot these items. The added fixation time for the emotional items may have lead emotional item to be remembered more vividly.

I also investigated differences in eye fixation depending on whether there was later selective item memory (the item but not the background was remembered) or no selective item memory (the item and the background were remembered or the background but not the item were remembered). These analyses indicated that regardless of valence, longer fixation time on the item lead to a greater likelihood of having an item-background memory trade-off. This is consistent with studies that have indicated that increased fixation time on a certain part of a complex scene may lead to better memory for that particular item (Krugman, Fox, Fletcher, Fischer & Rojas, 1994).

These data support the theoretical background that attention at encoding can influence what is remembered. However, the data also revealed that attention during encoding did not lead to a more pronounced selective benefit for emotional items than for neutral items (i.e., to the

emotion-induced memory trade-off). In other words, there was no emotion x valence interaction, and, as can be seen in Figure 3B, the disparity in fixation times between the emotional and neutral items presented in the View Condition was greater when there was *not* a selective item memory effect. These results suggest that, although people both fixate longer on emotional items than on neutral items and also show a more pronounced selective-memory effect for the emotional items, there is not a causal relation between these two factors.

As mentioned in the introduction, Loftus et al. (1987) found that when eye gaze and memory data were considered separately, participants both looked longer at weapons than a neutral stimulus (a check) and also were more likely to remember weapons at the expense of the surrounding information. The current study found similar results when the eye gaze data and memory data were considered separately, but overt visual attention (eye gaze) did not seem to be the dominant predictor of whether an emotion-induced trade-off would occur. This might be because other factors, besides attention at encoding, are playing a role to enhance the emotion-induced memory trade-off. These possible factors, such as increased post-stimulus processing for emotional items, will be discussed in detail in the general discussion of this chapter.

It is interesting to note that there was some suggestion that positive items were fixated upon longer than negative or neutral items, when both item hits and item misses were considered. There is some evidence that attention at encoding can account for the memory enhancement for positive information more than negative information (Talmi, et al., 2007). Thus, it may be worthwhile for future research to more closely examine whether there is a more dominant role for overt attention at encoding in eliciting a trade-off for positive stimuli than for negative stimuli. Other factors, such as post-encoding elaboration, may be more likely to drive

the emotion-induced memory trade-off for negative items (and see Libkuman, Stabler, & Otani, 2004), while increased attention at encoding may play a larger role for positive items.

Effects of Attentional Disengagement. The goal of the Attentional Disengagement Condition for Experiment 1 was to determine if people are able to disengage their attention from emotional information and if this change in attention may be linked to differences in the emotion-induced memory trade-off. The results revealed that when asked true/false questions about both the background and the item people were more likely to direct their overt visual attention towards the background. In addition, the memory scores show that there was less of an emotion-induced memory trade-off for the pictures under the Attentional Disengagement Condition. This seems to indicate that attentional disengagement may be related to the strength of the emotion-induced memory trade-off.

This also suggests that there is some amount of volitional control such that when it is task relevant, people are able to disengage their attention from emotional items to some extent. This idea is consistent with Levine and Edelstein's (2009) suggestion that the emotion-induced memory trade-off may be due to emotion's enhancement of memory for information that is relevant to one's current goals.

The participants in this study may have been able to dampen the memory trade-off by using cognitive control abilities. One indication that a certain level of executive function comes from a study in which people who had less cognitive control ability were less able to dampen the memory trade-off. Kensinger, Gutchess, & Schacter (2007) varied encoding instructions for younger and older adults by asking them to tell a story that incorporated all of the elements or the scene, or answer questions about both the item and the background. Here, executive control was moderated by using two different age groups since older adults have weaker executive control

abilities than younger adults (Braver & Barch, 2002; Gutchess et al., 2007). This study found that younger, but not older, adults were more likely to be able to dampen the trade-off when it was task relevant. Thus, a certain level of cognitive control ability may be necessary in order to process both the emotional item and the background. Indeed, Waring et al. (2010) found that even within a young adult population, decreased cognitive control ability was positively correlated with the emotion-induced memory trade-off. In other words, people who had lower cognitive control ability were more likely to have a greater emotion-induced memory trade-off even under passive viewing conditions. Thus, when it is task relevant in order to correctly answer the true/false questions, participants may have used cognitive control to process both the emotional items and backgrounds and dampen the emotion-induced memory trade-off.

The original motivation for the divided attention study was based upon the hypothesis that attention drives the memory trade-off. We now have seen that attention does not predict the memory trade-off. However, dividing attention may place a fundamentally different burden on the attentional system than is measured in analyses of overt visual attention without any additional cognitive load. If the use of executive control processes are important for the memory trade-off, dividing attention may still play a role by taxing cognitive control processes. Cognitive control processes may be necessary to process both items and backgrounds and to continue to elaborate on items and backgrounds equally. Thus, it is possible that when these cognitive control processes are taxed, there may be a greater memory trade-off. On the other hand, because attention does not predict the memory trade-off, it is also possible that dividing attention may not enhance the memory trade-off. The second experiment taxed participants' cognitive control and attentional processes via a divided attention study to directly test these competing hypotheses.

Experiment 2: Divided Attention Study

Method

Participants. Data from forty-two Boston College students (ages 18-22, 20 male), meeting the criteria outlined for Experiment 1 were analyzed for this study. As in Experiment 1, participants included in the analyses for this study were a subset of those tested as part of a larger study examining individual differences in anxiety levels (see Chapter 2).

Stimuli. Stimuli were a larger subset of pictures than used for Experiment 1 in order to confirm previous ratings for the emotional pictures by the current participants. Valence was rated on a 9-point scale and arousal was rated on a 5-point scale as described for Experiment 1. There were 80 positive images (valence = 5.92 [.90], arousal = 2.37 [.72]), 80 negative images (valence = 3.82[1.02], arousal = 3.78 [.77]), and 60 neutral images (mean valence = 5.18 (.90), arousal = 2.29 (0.64)). Stimuli were split to create three different study lists with 100 items per list (80 negative, 80 positive and 40 neutral). Those lists were then also presented in reverse order, yielding six total study lists that were counterbalanced across participants. It was never the case that more than three of the same emotion category appeared in a row.

At test, composite scenes from the study sessions were broken down into the isolated item and background components and these two elements were shown independently in the recognition memory test, just as in Experiment 1. The studied items and backgrounds were mixed with new non-studied lures to yield a total of 300 items and 300 backgrounds at test. Two different, randomized list orders were created to make the first two test lists. The second two test lists were the same as the first two lists only presented in reverse order. This yielded a total of four test lists. These test lists were counterbalanced across participants. In addition, items and

backgrounds which were “old” vs. “new” were counterbalanced across participants by switching the study list that they viewed.

From all of the pictures used in this study, only a subset of pictures was used in the analyses. This subset was chosen so that the positive and negative images were matched on arousal and absolute valence (all $p > .05$) and neutral images were considered less arousing than both positive and negative images both for the predetermined ratings and the ratings from the participants in this experiment. Across emotion categories, scenes were also matched for visual complexity, congruency between item and background, and number of people, animals and buildings. The subset of pictures used for analyses were 55 positive (valence = 6.06 [1.15], arousal = 2.99 [.58]), 55 negative pictures (valence = 3.64 [1.35], arousal = 3.19 [.68]) and 59 neutral pictures (valence = 5.31 [.92], arousal = 2.37 [.62]).

Procedure. Just as in Experiment 1, participants first filled out the consent and payment form, a demographics questionnaire, an assessment of their state and trait anxiety (STAI-S and STAI-T) and an assessment of their depressive symptoms (BDI-II).

Encoding Tasks. Participants completed two incidental encoding tasks: a full attention task and a divided attention task. For both tasks, participants saw each image for 5 seconds and were asked to rate the picture’s valence on a 9-point scale (9 being intensely positive and 1 being intensely negative) while viewing the scene. After the 5 seconds, the picture went off the screen and the participant was asked to press the space bar to move onto the next picture. For half of the pictures, presented with the full attention instructions, this was their only task.

In the divided attention condition, participants performed a second task while rating the pictures. Participants listened to two different 1.5 sec auditory patterns (created using Sound Edit; MacroMedia, Inc., San Francisco, CA) while they viewed the pictures. These two different

patterns changed randomly throughout the task. The participants were asked to press the space bar if the pattern changed from pattern A to pattern B or vice versa. The order of the full attention and the divided attention conditions was counterbalanced across participants, with some participants doing the divided attention task first and some doing the full attention task first. Before beginning each task, participants completed a short practice with five trials.

Delay and test phase. After participants completed the encoding session, a variety of standardized cognitive tasks were administered, creating a retention delay of approximately 30 minutes (Stroop, Backward Digit Span, FAS, Shipley, Digit Symbol). The delay and test phases were the same as in Experiment 1. Also as in Experiment 1, “remember” and “know” responses were collapsed for the current analyses, see Appendix A for the discussion of the significant “remember” responses.

Results

To examine the effect of divided attention on emotion-induced memory trade-off, a valence (positive, negative) x attention (full attention, divided attention) ANOVA was conducted. The memory trade-off scores were used in this Experiment, just as in Experiment 1. This ANOVA revealed no significant effects (all $F < 2.5$, $p > .1$).

Item and background memory for positive, negative and neutral items was also examined to see if memory for emotional items was consistent with previous studies conducted using divided attention paradigms that did not examine the emotion-induced memory trade-off. A scene component type (item, background) x emotion (positive, negative, neutral) x attention (full attention, divided attention) ANOVA was conducted. This ANOVA revealed a main effect of divided attention, $F(1,41) = 34.171$, $p < .001$, $\eta_p^2 = .455$, such that there was better memory under the full attention condition than the divided attention condition, $t(41) = 5.846$, $p < .001$.

There was also a main effect of emotion $F(1,41) = 5.329, p < .01, \eta_p^2 = .115$ and a main effect of scene component type $F(1,41) = 107.75, p < .001, \eta_p^2 = .724$, that was qualified by a scene component type x emotion interaction $F(2,82) = 4.734, p < .01, \eta_p^2 = .104$. There was significantly better memory for positive, $t(41) = 4.416, p < .001$ and negative, $t(41) = 3.287, p < .01$ items than neutral, but there were no significant differences in memory between the backgrounds that had been paired with these items (all $t < 1.5, p > .2$)

Discussion. The goal of Experiment 2 was to examine the effect of limiting attentional resources on the emotion-induced memory trade-off for positive and negative information. I found that the effect of dividing attention at encoding did not influence the emotion-induced memory trade-off. Item memory did remain stronger for emotional items as compared to neutral items, even under divided attention. This is consistent with some studies which have suggested that there is greater memory for negative items than neutral event items even when divided attention (Harris & Pashler, 2005; Hulse, et al., 2007). Other divided attention studies have found that dividing attention may actually be less likely to decrease memory for negative items than that of positive or neutral information (Kern et al., 2005; Talmi et al., 2007). However, the current study did not find this emotion x attention interaction. Further, none of these prior studies considered the effect of divided attention on the emotion-induced memory trade-off. The lack of modulation of the trade-off under divided attention may suggest that participants are just as likely to have enhanced item memory and decreased background memory when attentional resources are compromised, as when they have more resources available.

As this is a null result, there is still the possibility that if even less attentional resources were available, the memory trade-off would have been modified. However, if this effect is true, it may indicate that the amount of attentional resources available is not what drives the memory

trade-off. Perhaps even under divided attention, post-stimulus elaboration may be increased for emotional items. This may be what is driving the memory trade-off. This idea is contrary to the previous assertions that have linked the Easterbrook hypothesis (1959) to the memory trade-off, suggesting that arousal induces focused attention which leads to the memory trade-off. Even if emotional arousal may lead to more focused attention, this does not seem to be what is driving the memory trade-off.

General Discussion

The effect of attention on the emotion-induced memory trade-off was examined by looking at the effects of eye gaze at encoding, attentional disengagement, and divided attention. These investigations revealed that the amount of overt visual attention does not explain why selective item memory occurs more for emotional items than neutral items. Further, dividing attention in the current study did not affect the emotion-induced memory trade-off. Other factors besides attention that may influence the memory trade-off are discussed below.

Though most studies on the emotion-induced memory trade-off have assumed that the emotion-induced memory trade-off is driven by focused attention, Christianson (1992) suggested that in addition to attention, post-stimulus elaboration should be considered as another possible influence on the emotion-induced memory trade-off. The basis of the claim that post-stimulus elaboration may be one factor driving the memory trade-off rests upon the levels of processing framework (Craik & Lockhart, 1972). This framework suggests that people remember information better when it is processed at a deep level, with reference to the meaning of the information. Emotional information may be more likely to be elaborated upon in a deeper fashion than non-emotional information, and this may lead to enhanced memory for the emotional information. For example, Heuer & Reisberg (1990) found that participants thought

more about emotional events than non-emotional events. Further, they were more likely to think about emotional events in a deep, personally relevant way, while neutral events were thought about in a more abstract, shallow manner. Based on these data, Christianson (1992) suggested that perhaps the enhanced elaboration that goes on after the encoding of emotional items (as opposed to non-emotional items or backgrounds) may lead to this trade-off in memory for emotional items and peripheral contexts. The importance of elaboration in the emotional memory enhancement effects has been discussed in a number of studies (e.g., Hamann, 2001; Harris & Pashler, 2005; Libkuman, et al., 2004; Schmidt & Saari, 2007). However, the hypothesis that post-stimulus elaboration is driving the memory trade-off has not yet been systematically studied.

In the Attentional Disengagement Condition, post-stimulus elaboration was increased for both items and backgrounds: when people answered true/false questions they were forced to think more deeply for both the item and background data. If post-stimulus elaboration was indeed a factor in influencing the emotion-induced memory trade-off, one would expect there to be no memory trade-off under the Attentional Disengagement Condition. This was what happened in the current study. When considering item and background memory separately, there was not a decrement in background memory for backgrounds that were paired with emotional scenes under the Attentional Disengagement Condition.

Lastly, there was no evidence that the memory trade-off was enhanced when attentional resources were limited. One may have expected that if attention was the main factor in the emotion-induced memory trade-off that divided attention would have lead to a more narrow focus on the emotional information and an increased emotion-induced memory trade-off. This was not the case under this particular divided attention manipulation. As this is a null result,

more research is needed to fully understand the effects of limiting attention on the emotion-induced memory trade-off. However, if these results are true, it provides further evidence for the suggestion that attention is not what is driving the memory trade-off. Even when attentional resources are limited, individuals may engage more post-stimulus elaboration for the emotional, but not the neutral items.

It is also important to highlight the two different measures of attention in Experiment 1 and Experiment 2. While eye-tracking in Experiment 1 provided a measure of overt visual attention, dividing attention in Experiment 2 was influenced by central executive resources and the demands of task coordination. These different measures provide complementary pieces of evidence. Though we saw that cognitive control abilities could be used to dampen the memory trade-off, the trade-off was not enhanced when these cognitive control abilities were taxed. Together, these two experiments suggest that there may be factors other than attention that influence the memory trade-off.

Appendix A

To consider the effect of recollection, for Experiment 2, an ANOVA Valence (positive, negative) x Attention (full attention, divided attention) was conducted. This analysis revealed a main effect of valence, $F(1,41) = 4.704, p < .05, \eta_p^2 = .103$ such that there was a greater trade-off for negative scenes than for positive scenes, $t(41) = 2.169, p < .05$. For items that were vividly recollected, there was a greater trade-off for negative scenes than for positive scenes. Perhaps there was greater post-encoding processing for negative items than for positive ones, leading positive items to be remembered with more details. Though we now know that attention does not predict the trade-off, this pattern of results is consistent with the literature that suggests that negative information and negative moods may focus attention while positive information may

broaden it (Anderson, 2005; Fredrickson, & Branigan, 2005; Gasper, 2004; Gasper & Clore, 2002; Rowe, Hirsh & Anderson, 2007).

Interestingly, there was still a significant trade-off for the positive items. People remembered the positive item significantly more than the background as compared to neutral. However, even though participants may be more likely to have broader attention for positive information than for negative, other factors such as post-stimulus elaboration may still lead to the emotion-induced memory trade-off.

CHAPTER 2: EFFECTS OF ANXIETY ON THE MEMORY TRADE-OFF

Trait anxiety refers to a general pattern of anxiousness over time (Eppley, Abrams, & Shear, 1989). There have been mixed results regarding memory for emotional information in individuals with high trait anxiety. While some studies suggest that people with high trait anxiety may exhibit superior memory for threatening information rather than non-threatening information when compared to low anxiety individuals (Byrne & Eysenck, 1995; Nugent & Mineka, 1994; Reidy & Richards, 1997), other studies have not found evidence of this bias (Daggleish, 1994; Oldenburg, Lundh, & Kivisto, 2002; Richards & French, 1991). In addition, most of the previous literature has focused on memory for threatening information. Thus, it is unclear if these memory biases are specific to threatening information or if they extend to other types of negative information, positive information, and low arousal information. The goal of the current study is to 1) determine how trait anxiety affects the memory trade-off for stimuli that vary by valence and arousal, and 2) determine if people with high levels of trait anxiety are able to dampen the memory trade-off when it is task relevant.

Part of the reason for the mixed emotional memory findings in individuals with high trait anxiety could be because anxiety may be more likely to affect the quality of the emotional

memory as opposed to the quantity of emotional stimuli that are remembered. One way to consider the qualitative subcomponents of recognition memory is by looking at recollection and familiarity (Inaba & Ohira, 2009). Previous studies have found that people may either base recognition judgments on recollection of specific previous study events, or simply on stimulus familiarity (see Yonelinas, 2002 for review).

Anxiety may be especially likely to affect the qualitative nature of memory. Even in the absence of overall group differences, it has been suggested that attentional differences in people with high anxiety may lead to differences in recollection and familiarity for positive and negative information. Previous studies have shown that people with high levels of anxiety have difficulty discriminating negative or threatening items (Amir & Kozak, 2002; Kverno, 2000; Nugent & Mineka, 1994). In other words, people with high levels of trait anxiety may have a bias to say “old” for negative information. This difficulty in discriminating old from new negative information may come from relying more on familiarity-based processes than recollection-based processes to recognize negative information (Amir & Kozak, 2002; Kverno, 2000). This suggests that increased recognition memory for negative information may be primarily due to familiarity in high anxiety individuals (Inaba & Ohira, 2009).

On the other hand, some studies have shown that anxiety may be more likely to affect recall memory than recognition memory (Mitte, 2008). Since recall draws upon recollective processes, it has also been proposed that enhanced memory for negative information in high anxiety individuals may be more likely to be an effect of recognition-based processes. Thus, though anxiety likely affects the qualitative nature of emotional memories, it is unclear if recollection or familiarity processes would be affected more. The current study seeks to examine the effect of valence and arousal on the memory trade-off in high and low trait anxious

individuals when recollection and familiarity are considered.

Another possible explanation for the mixed trait anxiety memory results is that people with higher levels of anxiety may be more likely to remember the emotional parts, but forgetting surrounding details, thus exhibit a greater memory trade-off than those with low anxiety. As mentioned in the introduction, this could lead to seemingly contrary findings in the literature based on the type of stimuli that are studied. People with high levels of anxiety may do better than those with low anxiety on memory tests that focus on the emotional item, but not have this bias when background information in emotional pictures is tested.

In support of the hypothesis that the memory trade-off may be enhanced in individuals with high anxiety, one study found that the level of anxiety in a sub-clinical population was correlated with the magnitude of the memory trade-off effect (Waring, et al., 2010). In other words, people with higher levels of anxiety were more likely to remember the emotional component of a scene but forget the neutral background. The first goal of this chapter is to determine if people with high levels of anxiety are more likely to have an enhanced memory trade-off for different types of emotional stimuli as compared to those with low levels of anxiety, when recollection and familiarity are considered.

The memory biases that have been found for threatening information have been explained by the fact that individuals with high levels of anxiety may be more likely to attend to threatening information and may have more difficulty disengaging their attention from threatening information than individuals with lower anxiety (e.g, Derryberry, & Reed, 2002; Eysenck, Derakshan, Santos & Calvo, 2007; Yiend & Mathews, 2001). This difficulty in disengaging attention may be due to an inability to use cognitive control to inhibit attention to threat-related distracters (Bishop, Duncan, Brett & Lawrence, 2004; Eysenck, 1997). The

second goal of the current chapter is to determine if people with high trait anxiety are able to dampen the memory trade-off when they are asked to process both items and backgrounds at encoding.

The current study investigates two key questions focusing on the impact of emotion type and attentional control on the memory trade-off. Experiment 1 is designed to determine the influence of valence and arousal on the memory trade-off for individuals with high and low anxiety. This study will help to determine if these anxiety-based memory biases impact the memory trade-off and if they are unique to negative and high arousal information or if the biases extend to other valence and arousal types. Experiment 2 will consider if individuals with high anxiety are able to disengage their attention to modulate the memory trade-off when it is task relevant to do so. This experiment will help to determine if the memory trade-off can be overridden in individuals with high anxiety.

Experiment 1

Method

Participants. Fifty-two Boston College students (ages 18-22, 25 Men) were recruited for this study. Participants were divided into equal high and low anxiety groups using a median split according to a composite anxiety score which took into account the BAI score (Beck, et al., 1988) and STAI score (Spielberger, et al., 1983). The low anxiety group included twenty-six participants (15 Males, anxiety $M[SD] = 16 [4.88]$) and the high anxiety group included twenty-six participants (10 Males, anxiety $M[SD] = 35.07 [13.72]$). All participants had normal or corrected-to-normal vision, were native English speakers, and had no history of a neuropsychological or psychiatric disorder. No participant listed taking medications that affect the central nervous system.

Materials and Procedures. Materials were the same as used in Experiment 2 of Chapter 1 of this dissertation. However, a wider range of pictures were included in these analyses in order to look at differences for a variety of different arousal levels. The full stimulus set included 60 pictures in each category for a total of 300 pictures. A slightly restricted group of pictures was used for the analyses in order to make sure that the positive and negative moderate arousal pictures were matched on arousal. Within each valence category (positive and negative), a median split by arousal was applied to yield a higher and lower arousal group. Valence was rated on a 9-point scale (with one being extremely negative and nine being extremely positive) and arousal was rated on a 5-point scale (with one being low in arousal and five being high in arousal) as described in Chapter 1. The valence ratings were collected in the current experiment while the arousal ratings were predetermined norms. The categories of stimuli included in the analyses were 60 negative high arousal pictures (valence = 3.27[1.48], arousal = 4.33 [0.39]), 55 negative moderate arousal pictures (valence =3.98 [1.11], arousal = 3.15 [0.67]), 55 positive moderate arousal pictures (valence = 6.03 [0.99], arousal = 2.96 [0.57]), 60 positive low arousal pictures (valence =6.07 [1.30], arousal = 1.88 [0.37]) and 60 neutral (valence =5.31 [0.92], arousal = 2.35 [0.61]). Across all emotion categories, scenes were matched for visual complexity, congruency between item and background, and number of people, animals and buildings.

The procedures were also identical to those of Chapter 1, Experiment 2: participants viewed composite pictures under full and divided attention. For the current chapter, I will focus on the differences between high and low arousal stimuli for the full attention condition.

Data Analysis. Memory trade-off scores were calculated in the same manner as in Chapter 1. However, in the current study, “remember” and “know” responses were analyzed to

investigate whether anxiety affects memory specificity. For the “know” responses, independent know scores were used. These were calculated as [$\text{“Know”} / (1 - \text{“Remember”})$]. This accounts for the fact that the two response types were mutually exclusive, yielding the probability that an item received a “know” response given that it did not receive a “remember” response (Yonelinas & Jacoby, 1995)

Results

In order to determine the effect of valence and arousal on the emotion-induced memory trade-off a 4 x 2 ANOVA was conducted with the factors of emotion (negative high arousal, negative moderate arousal, positive moderate arousal, positive low arousal) and anxiety (high anxiety, low anxiety). This analysis revealed a main effect of emotion, $F(3, 150) = 11.287, p < .001 \eta_p^2 = .184$ such that there was a larger memory trade-off for negative high arousing items than for any other category (positive moderate arousal, $t(51) = 2.987, p < .01$, positive low arousal, $t(51) = 6.055, p < .01$, and marginally larger than negative moderate arousal, $t(51) = 1.703, p < .1$. Negative moderate arousal items had a larger memory trade-off than positive low arousal items, $t(51) = 4.04, p < .01$. Positive moderate arousal had a larger memory trade-off than positive low arousal items, $t(51) = 2.753, p < .01$. There was no emotion x anxiety interaction (all $F < 1, p > .1$).

However, because anxiety may affect recollection and familiarity differently, I also conducted this emotion x anxiety ANOVA based on whether the participant had either had a vivid recollection of the item (“remember”) or had a sense of familiarity (independent “know”). The ANOVA conducted with recollection scores included the factors of emotion (negative high arousal, negative moderate arousal, positive moderate arousal, positive low arousal) and anxiety (high, low). This ANOVA revealed a main effect of emotion, $F(3, 150) = 21.796, p < .001 \eta_p^2 =$

.304 that was similar to the pattern of the previous analysis when “remember” and “know” responses were combined (see Figure 4A). There was a larger memory trade-off for negative high arousal items as opposed to negative moderate arousal items, $t(51) = 2.4, p < .05$, positive moderate arousal items, $t(51) = 3.784, p < .01$, and positive low arousal items, $t(51) = 5.471, p < .01$. There was also a larger trade-off for negative moderate arousal items as opposed to positive moderate arousal items, $t(51) = 1.937, p < .01$ and positive low arousal items, $t(51) = 1.937, p < .01$ and there was a greater trade-off for positive moderate arousal items as opposed to positive low arousal items, $t(51) = 3.886, p < .01$.

When only items that were “known” with a sense of familiarity were included in the ANOVA, both a main effect of emotion, $F(3, 150) = 3.423, p < .05, \eta_p^2 = .064$ and an emotion x anxiety interaction, $F(3, 150) = 3.33, p < .05, \eta_p^2 = .062$ emerged (see Figure 4B). There was a higher memory trade-off for high anxiety individuals than low anxiety individuals for negative high arousal items, $t(50) = 2.079, p < .05$.

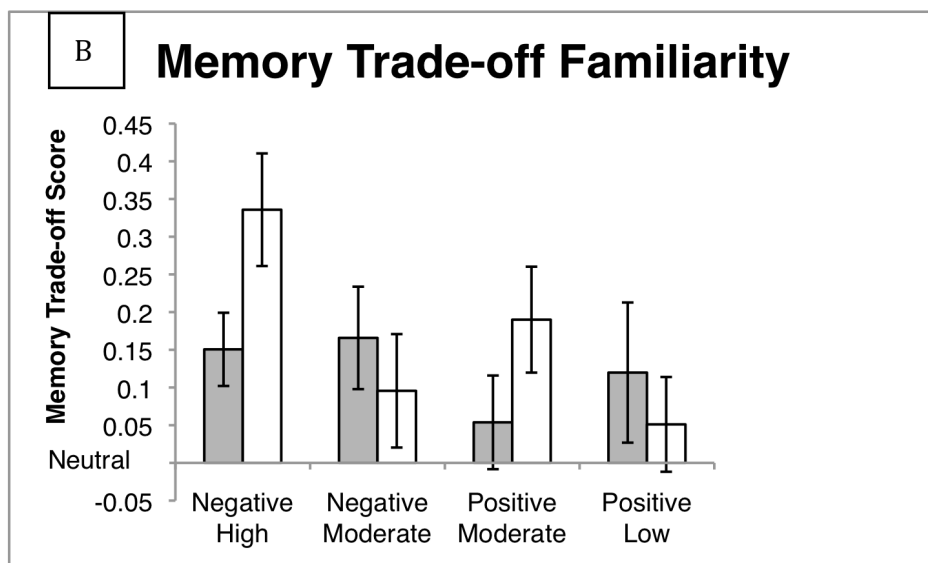
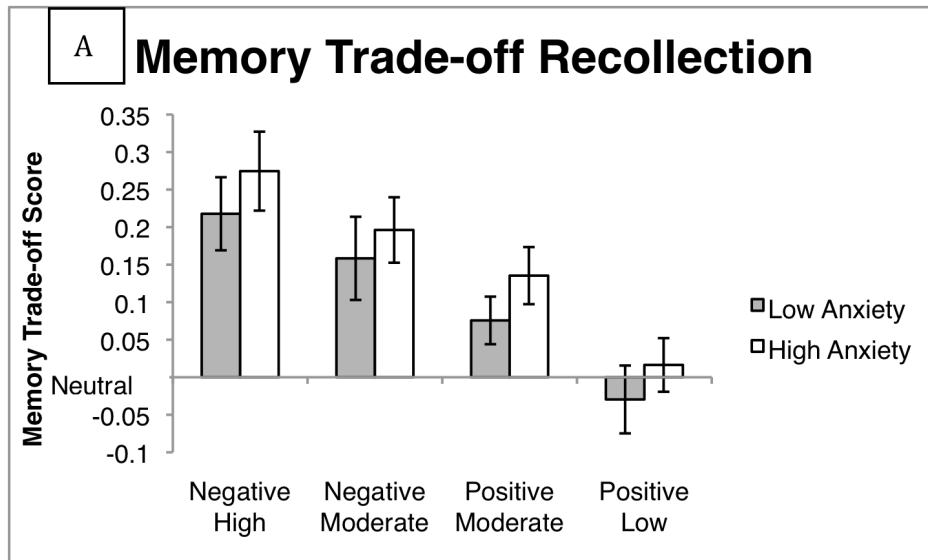


Figure 4. The memory trade-off considering valence and arousal. A) The effect of stimulus emotion type for items and backgrounds that were vividly recollected (“remember” response) in high and low anxiety individuals. B) The memory trade-off for high and low anxiety individuals for items and backgrounds that were remembered with a sense of familiarity (“know” response).

Discussion

When overall memory was considered, the largest memory trade-off occurred for high arousal items. This is consistent with previous studies which have suggested that high arousal items may be especially likely to influence the memory trade-off (Waring & Kensinger, 2009;

Waring & Kensinger, under review). This is also consistent with predictions that high arousal may narrow attention, leading to an enhanced memory trade-off (Easterbrook, 1959; Reisberg & Heuer, 2004), though attention narrowing may not lead to the enhancement of the memory trade-off (see Chapter 1). Arousal may also increase other processes such as post-stimulus elaboration, which may have led to the increase in the trade-off for high arousal items. Interestingly, when arousal was matched (for the positive and negative moderate arousal items) there was no effect of valence. This may indicate that arousal may have a greater effect on the memory trade-off than valence when recognition and familiarity are collapsed.

Recollection and familiarity were then considered separately in order to determine if there was a qualitative difference in memory between anxiety groups. Whenever only recollection was considered, there was a similar pattern as the collapsed data, with no anxiety interaction and an enhancement in the memory trade-off for arousing items. However, one difference from the collapsed trade-off scores was the effect of valence. The positive and negative items that were matched on arousal did differ in the strength of the memory trade-off. There was a greater memory trade-off for the negative moderate arousal scenes than the positive moderate arousal scenes. As mentioned in Chapter 1, there is some evidence that negative information may be more likely to be elaborated upon than positive information (Talmi et al., 2007). If participants did indeed engage in more post-stimulus elaboration processes for negative information than positive information, this may have been reflected in the effect of recollection. This effect may not have been strong enough to affect overall memory, but may have played a role in the amount of detail remembered for negative information. In other words, people may have been more likely to vividly “remember” negative information, and less likely to vividly remember the accompanying backgrounds than for positive information.

When familiarity was considered we did see an interaction with anxiety. For negative high arousal items there was a greater trade-off for individuals with high anxiety than those with low anxiety. This is consistent with studies that have suggested that individuals with high anxiety may be more likely to remember negative and high arousal information specifically (Bar-Haim et al., 2007). It is also consistent with the suggestion that this memory enhancement for negative items may be due to more familiarity-based processes (Amir & Kozak, 2002; Kverno, 2000).

The original motivation of this chapter focused on the idea that the memory trade-off would be driven by attention. Thus, Experiment 2 was set up in order to determine if there would be differences in high or low anxiety individuals' ability to disengage attention. However, we discovered in Chapter 1 that attention does not predict the memory trade-off. Given this knowledge, Experiment 2 will now help to explain the influence of anxiety on the memory trade-off when participants' attention is guided by asking true/false questions at encoding.

Experiment 2

Method

Participants. Fifty-three Boston College students (ages 18-22, 25 Men) were recruited for this study. As in Experiment 1, participants were divided into a high and low anxiety group using a median split according to a composite anxiety score which took into account the BAI score (Beck, et al., 1988) and STAI score (Spielberger, et al., 1983). The median score was twenty-one. Since there were four people with a score of twenty-one they were all included in the low anxiety group. This left twenty-eight participants (15 Males, anxiety $M[SD] = 14.25 [5.37]$) in the low anxiety group and twenty-five participants (10 Males, anxiety $M[SD] = 35.72 [11.53]$) in the high anxiety group. All participants had normal or corrected-to-normal vision,

were native English speakers, and had no history of a neuropsychological or psychiatric disorder. No participant listed taking medications that affect the central nervous system.

Materials and Procedures. Materials were the same as used in Experiment 1 of Chapter 1 of this dissertation. The procedures are also identical: participants viewed composite pictures under passive viewing or Attentional Disengagement Conditions (where true/false questions were asked about the item and the background). For the current chapter, I will focus on the behavioral effects for the view and the Attentional Disengagement Condition.

Data Analysis. Memory trade-off scores were calculated in the same manner as Experiment 1 of this chapter.

Results

To determine the effect of valence, attentional disengagement and anxiety on the memory trade-off an emotion (positive, negative) x attentional disengagement (view, disengagement) x anxiety (high anxiety, low anxiety) ANOVA was conducted. This ANOVA revealed a main effect of attentional disengagement, $F(1, 51) = 8.431, p < .01, \eta_p^2 = .142$ such that there was a larger trade-off for the view as opposed to the disengagement condition.

To further explore these effects based on recollection and familiarity, this 2x2x2 ANOVA was also conducted for “remembered” and “known” items separately (see Figure 5A). For recollection, this analysis revealed a disengagement x anxiety interaction, $F(1, 51) = 9.266, p < .01, \eta_p^2 = .154$. While people with high anxiety have a larger trade-off than low anxiety under the Attentional Disengagement Condition, $t(51) = 2.152, p < .05$, that is not the case for the view condition. In fact, under the view condition there was a marginally significant effect indicating a larger trade-off for low anxiety as opposed to high anxiety individuals, $t(51) = 1.745, p < .09$.

For familiarity, this analysis revealed a marginal main effect of attentional disengagement, $F(1, 40) = 3.203, p < .09, \eta_p^2 = .074$ such that there was a numerically larger trade-off for the view than the Attentional Disengagement Condition, though this t-test did not reach significance, $t < 1.5, p > .15$, see Figure 5B. There was also a significant main effect of emotion, $F(1, 40) = 5.391, p < .05, \eta_p^2 = .119$ which was qualified by an emotion x anxiety interaction, $F(1, 40) = 4.813, p < .05, \eta_p^2 = .107$. There was a larger trade-off for negative items than positive items for low anxiety individuals, $t(26) = 2.339, p < .05$, but there was no difference based on valence for high anxiety individuals ($t < .5, p > .5$).

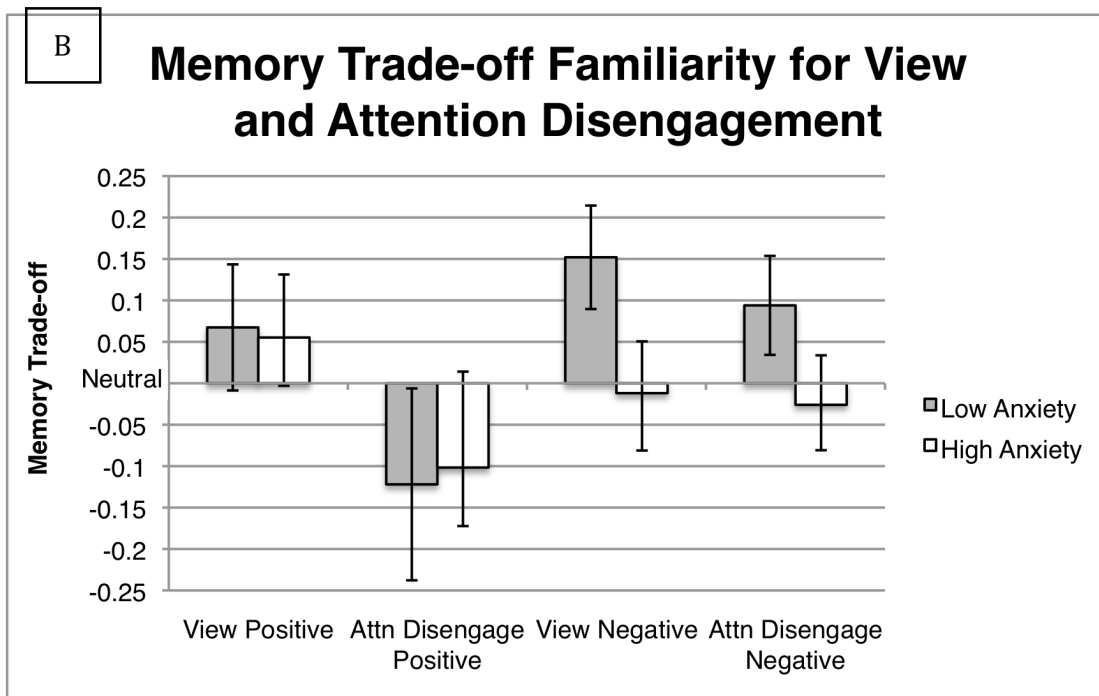
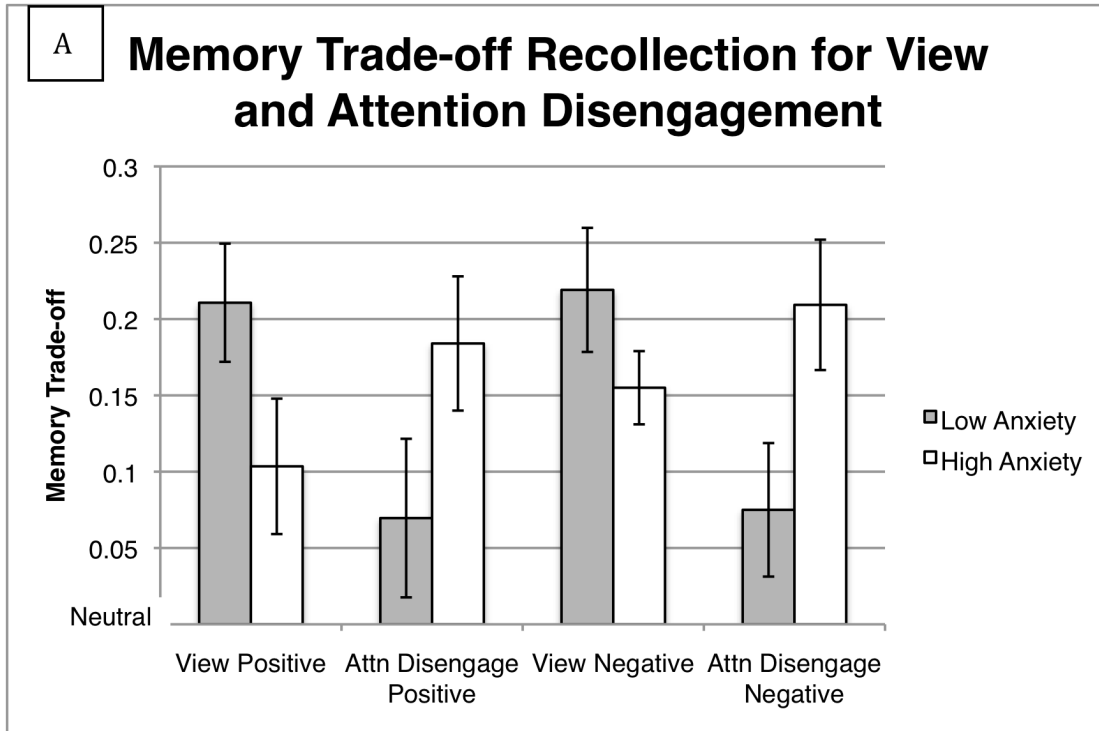


Figure 5. The memory trade-off for the View and Attentional Disengagement Conditions considering anxiety. A) The memory trade-off in high and low anxiety individuals for items and backgrounds that were vividly recollected (“remember” response). B) The memory trade-off in high and low anxiety individuals for items and backgrounds that were remembered with a sense of familiarity (“know” response).

Discussion

When recollection and familiarity were collapsed, there were larger trade-offs for the view condition than the Attentional Disengagement Condition. Thus, we see a similar effect as found in Chapter 1 even when high anxiety individuals are considered. When recollection and familiarity were considered, just as in Experiment 1 we find differences depending on anxiety. For recollection, people with higher anxiety have a higher trade-off than low anxiety individuals during the Attentional Disengagement Condition. In other words, individuals with low anxiety are more successful at dampening the trade-off. This is consistent with studies that have indicated that individuals with high levels of anxiety may have lesser cognitive control abilities than individuals with low levels of anxiety (Bishop, et al., 2004; Eyesenck, 1997). Perhaps people with high levels of anxiety are less likely to be able to override the impulse to elaborate only on the emotional information.

Indeed, level of cognitive control ability has been shown to be negatively correlated with the memory trade-off (Waring et al., 2010). Older adults who typically have lower levels of cognitive control abilities may have difficulty dampening the tradeoff when it is task relevant (Kensinger, Gutchess, et al., 2007). This anxiety difference may be especially revealed when items are vividly recollected because this increased post-stimulus elaboration may lead to vivid recollection of details about the negative items for the high trait anxiety individuals.

For familiarity, there was also an interaction with anxiety. This analysis revealed an effect of valence that was present in individuals with low anxiety but not high anxiety. While low anxiety individuals had a larger trade-off for negative scenes than positive scenes, high anxiety individuals had an equally high trade-off regardless of valence. It is difficult to determine what might have caused this effect, as little research has focused on anxiety differences in post-

stimulus elaboration. However, it is possible that for the high anxiety group, the trade-off was driven by recollective memory for negative information. For the low anxiety individuals, familiarity may allow for more of an equalization of the trade-off between valences, leading to no valence differences when recollection and familiarity are not considered separately.

General Discussion

Taken together these studies indicate that the effects of anxiety are most likely to be revealed in the memory trade-off when recollection and familiarity are considered separately. In Experiment 1 where arousal levels were manipulated, we saw that the trade-off was strongest for high arousal items. Thus, arousal may play a greater role in modulating the magnitude of the memory trade-off than valence.

Unexpectedly, the effect of valence differed between the experiments when recollection and familiarity were considered. For recollection, there was a significant effect of valence such that there was a larger trade-off for negative as opposed to positive items matched on arousal. However, this was not the case for Experiment 2. There was no valence effect for recollection. For familiarity in Experiment 2, there was a larger trade-off for negative as opposed to positive items, but only for low anxiety individuals. In Experiment 1 when familiarity was considered, there was a numerical trend such that there was a larger trade-off for negative as opposed to positive items for low anxiety individuals. Perhaps, adding the additional trials in the Experiment 2 added the strength needed to make this effect significant. Though these results seem to suggest that there are differences in the trade-off for positive and negative information when recollection and familiarity are considered, these inconsistent results provide avenues for future research in order to determine what might be driving possible valence differences in the memory trade-off.

The current study also found that anxiety was more likely to influence familiarity when the memory trade-off is considered. It has been suggested that anxiety may influence recollection more because anxiety is more likely to influence recall than recognition memory (Mitte, 2008). Thus, one might assume that anxiety would affect recollection more than familiarity. However, within the current memory trade-off paradigm, which is based upon a recognition memory test, anxiety differences emerged more under the familiarity condition. Others have suggested that individuals with high levels of anxiety may have a bias to say that negative information is familiar (Amir & Kozak, 2002; Inaba & Ohira, 2009; Kverno, 2000). The current studies did not find this bias. However, these studies provide evidence that familiarity responses may be affected by anxiety even in the absence of a negative familiarity bias. Future research is needed to determine how anxiety may lead to differences in recollection and familiarity.

In sum, the current study revealed that high levels of arousal enhance the memory trade-off. This enhancement may be especially strong in high anxiety individuals when this information is negative and arousing and when it is remembered with familiarity. Further, when recollection is considered, individuals with higher levels of anxiety are less likely to be able to disengage their attention to modulate the memory trade-off even when it is task relevant to attend to background information. These findings suggest that anxiety may modulate the strength of the memory trade-off. Further, anxiety may also affect the ability to modulate this strength when it is task relevant.

CHAPTER 3: EFFECTS OF PTSD ON THE MEMORY TRADE-OFF

Posttraumatic stress disorder (PTSD) is an anxiety disorder that develops in response to a traumatic event (Breslau, 2002). PTSD is characterized by differences in memory and attention (American Psychiatric Association, 2000). Individuals with PTSD have difficulty concentrating

on or attending to neutral stimuli, while at the same time exhibiting hypervigilance, or increased sensitivity to detecting threat (see Vasterling & Brewin, 2005). People with PTSD also exhibit involuntary re-experiencing of their trauma (flashbacks) despite intentionally avoiding stimuli associated with the trauma.

Though PTSD is defined by these cognitive changes in regards to the involuntary memory for a traumatic incident (APA, 2000), few studies have explored if there are also differences that extend to voluntary memory. Most studies that have looked at voluntary memory have looked at changes in memory for the traumatic event (as opposed to more general emotional memory). These studies have yielded mixed results as to whether people with PTSD remember stimuli that are related to their trauma better than people who have experienced trauma but do not have PTSD.

Some studies have found that when participants are asked to freely recall trauma-related and non-trauma-related words that were embedded in an attentional task (such as an emotional Stroop task), people with PTSD remember proportionally more traumatic words than do non-patient controls (Chemtob et al., 1999; Kaspi, McNally, & Amir, 1995; Vrana, Roodman, & Beckman, 1995). Although one interpretation of these findings is that PTSD enhances memory for trauma-related words, an important caveat is that these studies did not report the occurrence of false positives (i.e., reporting trauma words that were not presented in the Stroop task). Thus, it is difficult to determine if the increased free recall for trauma words reflected a response bias rather than a difference in memory accuracy. Litz et al. (1996) found that in recognition memory tests, people with PTSD did not exhibit an increase in memory discrimination for trauma-related words, but instead showed an increased bias to say that they have seen trauma words, regardless

of whether they were previously presented. Therefore, it is currently unclear whether PTSD enhances memory accuracy for trauma-related words or has an effect on response bias.

Another alternate explanation is that PTSD patients may show differential enhancement in memory for words related to their own trauma as compared to non-trauma words because they are particularly bad at remembering non-trauma words instead of being particularly good at remembering trauma words. Indeed, studies have shown that PTSD patients have memory deficits for non-trauma-related words (Golier, Yehuda, Lupien & Harvey, 2003; McNally, Metzger, Lasko, Clancy & Pitman, 1998; Paunovic, Lundh & Ost, 2002). Thus, people with PTSD may simply be less impaired in their memory for trauma-relevant stimuli than in their memory for trauma-irrelevant stimuli.

Paunovic et al. (2002) found that while crime victims with PTSD were equally as likely as people without PTSD to recognize faces that were perceived as threatening, they were less likely than people without PTSD to recognize non-hostile faces. These studies taken together indicate that there may not be a quantitative benefit for trauma related stimuli in people with PTSD than those without PTSD, though more systematic research is necessary to strengthen this claim.

Though most of these studies have focused on voluntary memory for stimuli related to the trauma, few studies have looked at differences in memory for emotional information that is not related to the trauma. Most studies that have looked beyond trauma-related stimuli have focused on memory for fear stimuli. The majority of these studies have found no particular enhancement in memory for fear stimuli in people with PTSD than in those without PTSD (e.g., Bremner, et al., 2003; Dickie, Brunet, Akerib, & Armony, 2008). Even fewer studies have looked at memory differences in PTSD for other types of negative stimuli, though one study that

looked at negative stimuli did not find group differences (Brohawn, Offringa, Pfaff, Hughes & Shin, 2010). Thus, more research is necessary to fully understand the extent of the differences in negative emotional memory in people with PTSD.

Most studies have also not considered memory for positive information in individuals with PTSD. As one of the symptoms of PTSD is emotional numbness to positive stimuli, it is possible that people with PTSD may experience changes in memory for positive information (Jatzko, Schmitt, Demirakca, Weimer, & Braus, 2006). Very few studies have examined memory for positive information in individuals with PTSD. Brohawn, et al. (2010) tested memory for positive, negative, and neutral images in individuals with and without PTSD. However, for this study the positive images were significantly less arousing than the negative images. This study found that there was no difference between memory for positive and neutral images for both the PTSD and the non-PTSD group. Since the pictures were not matched on arousal, this study suggests that positive valence alone does not lead to altered memory in PTSD. However, those results cannot speak to potential differences in memory for positive images that are also high in arousal.

Another study examined memory for positive information in people with acute stress disorder, finding that there was no difference in memory for positive information between people with and without PTSD (Paunovic, et al., 2002). Acute stress disorder is a similar diagnosis to PTSD, except that acute stress disorder is circumscribed to the first four weeks after a traumatic event whereas PTSD is longer lasting (APA, 2000). Therefore, the performance of patients with acute stress disorder is likely to be similar to the performance of patients with PTSD. However, in Paunovic and colleague's study, positive items were not matched on arousal level with

negative items, and false alarms were not measured. Thus, it is still an open question as to how PTSD would affect memory for positive stimuli.

No study has looked at memory for positive information that is properly matched in arousal in PTSD. The lack of research on differences in memory for positive and negative emotional stimuli leaves many open questions about the extent of the differences in people with PTSD. The first goal of the present study is to consider differences in item memory for emotional items in individuals with PTSD.

Despite the confusion surrounding these quantitative differences in emotional memory, people with PTSD have consistently reported qualitative differences in their memory for their trauma. These qualitative differences provide a clue as to what deficits may appear in voluntary emotional memory in individuals with PTSD. Trauma memories in people with PTSD are often cited as being fragmented (i.e., disjointed and disorganized, with missing pieces of information; Foa, Molnar, & Cashman, 1995; Halligan, et al., 2003; Nijenhuis & van der Hart, 1999; Tromp, et al., 1995; van der Hart, Van der Kolk, & Boon, 1998; van der Kolk and Fisler, 1995; but see Berntsen, Rubin, & Bohni, 2008 for evidence against fragmentation in PTSD). In addition, anecdotally, patients with PTSD often report “tunnel memory,” or a detailed memory for the emotional element or gist of the scene without much memory for the surrounding elements or contextual details (LaBar, 2007). For example, someone with PTSD might have a vivid memory of a body in combat, but they may not remember the details of where the body was found.

This “fragmentation,” resulting in a memory that has missing pieces of information, may also be caused in part by similar mechanisms that evoke memory trade-offs in those individuals without PTSD. Higher anxiety levels and lower levels of cognitive control (e.g., lower ability to manage other cognitive processes, leading to poorer ability to plan, think abstractly, etc.) have

been correlated with a stronger memory trade-off (Waring et al., 2010). Because those who develop PTSD tend to have higher levels of anxiety and lower levels of cognitive control than those who do not develop PTSD (see van der Kolk, 2004), it would make sense that people with PTSD may show more of a trade-off.

However, the magnitude of the trade-off effect has not been systematically tested in a population with PTSD, and so the validity of this hypothesis is unknown. The second goal of the current study is to determine if there are differences in the magnitude of the memory trade-off for individuals with PTSD.

Methods

Participants

Sixty-nine individuals were recruited via postings on the Internet, throughout the community, and at a local trauma center. Presence of PTSD was determined by diagnosis on the Structured Clinician Interview for the DSM-IV (SCID; First, Spitzer, Williams, & Gibbon, 1995), by a qualified clinician. Experience of trauma was determined by the SCID and the DSM-IV criteria. Of the sixty-nine individuals recruited for the study, 52 were used in the analysis. Ten participants were excluded from analysis because they had never experienced trauma, two were excluded due to psychotic disorders, one for current alcohol dependence, and three were excluded for failure to complete the second part of the study. Twenty-five participants met criteria for current PTSD (PTSD group, 8 Males), and twenty-seven had undergone trauma but did not meet criteria for current PTSD (non-PTSD, 14 Males). None of these 52 participants had a psychotic disorder or current alcohol or substance dependence. The groups did not differ on age or education level (see Table 1).

Table 1. Type of trauma and comorbidities for each participant.

| Participants | Sex | Trauma | Comorbidity |
|--------------|-----|---------------------------------------|---------------|
| PTSD Group | | | |
| 1 | F | Sexual assault | MDD, GAD, BED |
| 2 | M | Family tragedy | None |
| 3 | M | Physical assault | GAD |
| 4 | M | Sexual assault | MDD, GAD |
| 5 | F | Psychological abuse | MS, MDD, PD, |
| 6 | F | Arrest | None |
| 7 | M | Physical assault | None |
| 8 | F | Family tragedy | Pho |
| 9 | M | Physical and psychological abuse | None |
| 10 | F | Physical and sexual assault | MDD, Pho, OCD |
| 11 | M | Psychological abuse | MDD |
| 12 | F | Sexual assault | MDD, PD |
| 13 | F | Physical and sexual assault | None |
| 14 | F | Physical abuse | None |
| 15 | F | Sexual assault | Epi, MDD |
| 16 | F | Sexual assault | None |
| 17 | F | Family tragedy | None |
| 18 | F | Physical assault | MDD, PD, OCD |
| 19 | F | Captivity | None |
| 20 | M | Sexual assault | MDD |
| 21 | F | Sexual assault | None |
| 22 | F | Physical and psychological abuse | Epi |
| 23 | F | Family tragedy | None |
| 24 | F | Physical, sexual, psychological abuse | None |
| 25 | M | Physical and psychological abuse | BPD, BED |
| Non-PTSD | | | |
| 26 | M | Car accident | BPD, SP, OCD |
| 27 | M | Family tragedy | Pho |
| 28 | M | Witnessed death | Pho, BED |
| 29 | M | Captivity | None |
| 30 | M | Car accident | Epi |
| 31 | F | Physical assault | Pho |
| 32 | M | Physical assault | Pho |
| 33 | F | Sexual assault | None |
| 34 | M | Car accident | None |
| 35 | F | Sexual abuse, captivity | MDD, Pho |
| 36 | M | Car accident | None |
| 37 | F | Physical assault | PD |
| 38 | M | Physical assault | None |
| 39 | F | Car accident | None |
| 40 | M | Arrest | None |
| 41 | M | Family tragedy | GAD |
| 42 | M | Physical assault | BPD |
| 43 | F | Family tragedy | None |
| 44 | M | Arrest | GAD |
| 45 | M | Physical assault | GAD |
| 46 | F | Car accident | None |

| | | | |
|----|---|----------------------------------|----------|
| 48 | F | Physical and psychological abuse | MDD, Dys |
| 49 | F | Sexual abuse | None |
| 50 | F | Physical assault | None |
| 51 | F | Witnessed death | Dys |
| 52 | F | Physical and psychological abuse | Dys |

MDD=Major Depressive Disorder; GAD=Generalized Anxiety Disorder; BED =Binge Eating Disorder; PD=Panic Disorder; Pho=Phobia; OCD=Obsessive Compulsive Disorder; Epi=Epilepsy; BPD=Bipolar Disorder; Alc=Alcohol Dependence; Dys=Dysthymic Disorder

Stimuli

The stimuli were the same as described in previous chapters. There were 60 positive images (mean valence = 6.02, $SE = .81$), 60 negative images (mean valence = 3.80, $SE = .82$) and 60 neutral images (mean valence = 5.29, $SE = .75$). Arousal (rated on a five point scale, with low numbers indicating soothing or subduing images and high numbers indicating exciting or agitating images) ratings were as follows: mean (SD): Positive = 3.02 (0.57); Negative= 3.19 (0.66); Neutral = 2.35 (0.61)).

Just as in previous chapters, the positive and negative images were matched on arousal and absolute valence (all $p > .30$) and neutral images were considered less arousing than both positive and negative images (all $p < .05$). Across emotion categories, scenes were matched for visual complexity, congruency between item and background, and number of people, animals and buildings.

Stimuli were randomized to create two different study lists with 90 items per list (30 negative, 30 positive and 30 neutral). Those lists were then also presented in reverse order, yielding four total study lists that were counterbalanced across participants. It was never the case that more than three of the same emotion category appeared in a row.

At test, composite scenes from the study sessions were broken down into the isolated item and background components and these two elements were shown independently in the recognition memory test. The recognition memory test was also randomized for a total of four

test lists to make sure that there were not effects of placement of a certain picture in context to another picture. These test lists were counterbalanced across participants. In addition, which items and backgrounds were “old” vs. “new” were counterbalanced across participants based on the study list that they viewed.

Procedure

Participants first filled out the consent form, a demographics questionnaire, an assessment of their state and trait anxiety (BAI; STAI-S and STAI-T) and an assessment of their depressive symptoms (BDI-II).

Participants then took part in an incidental encoding session. They were told that this first part of the study was designed to measure their reactions to emotional images. During this session 90 pictures (30 from each emotion category) were shown on a white computer screen for 5 seconds each. While viewing the scene, participants were asked to rate the picture’s valence on a 9-point scale, 9 being the most intensely positive and 1 being the most intensely negative. After 5 seconds were up, the participant was asked to press the space bar to move on to the next picture. Each participant completed a short practice version of the task before performing the actual task.

After participants completed the encoding session, a variety of standardized cognitive tasks were administered, creating a retention delay of approximately 45 minutes: Rey–Osterrieth Complex Figure Test (Rey-O), Stroop Test, Backward Digit Span, FAS, Shipley Vocabulary, Digit Symbol, S.M.A.S.T. (Alcohol screening), Health Form. At this point participants were also given a 5-10 minute break.

During the unanticipated recognition testing phase, participants viewed items and backgrounds extracted separately from the studied composite scenes, as well as new items and

backgrounds (90 items and 90 backgrounds from the study list, 30 from each emotion category, and 90 new items and new backgrounds). For each item or background, participants were asked to indicate whether they believed the picture was new, whether they “remembered” it (recollected specific details of its presentation during the encoding session) or “knew” it (felt a sense of familiarity with the picture, without remembering details from the encoding session). Participants underwent an extensive practice and instruction phase to ensure their understanding of remember vs. know ratings. This test was self-paced and the slide moved on when participants had made their response.

After the test phase, participants were asked to fill out the PTSD checklist (PCL; Weathers, Litz, Herman, Huska & Keane, 1993) and the Life Events Checklist (Gray, Litz, Hsu, & Lombardo, 2004). In a separate session, the presence of PTSD as well as other comorbid disorders were assessed using the SCID. The severity of memory problems surrounding the trauma was also assessed using selected questions from the clinician administered PTSD scale (CAPS).

Data Analysis

The trade-off effect was calculated in the same manner as in Chapter 1.

Results

Participant Demographics and Cognitive Test Scores

Groups did not differ on any socio-demographic level (see Table 2). However, the PTSD group did have higher scores for the scales measuring the severity of the PTSD (PCL), level of depression and anxiety (BDI-II, BAI, STAI-T), and one measure of visual memory (Rey-O delayed). Overall, males had higher Shipley vocabulary scores, $t(50) = 2.254, p < .05$ and a

higher age of trauma, $t(47) = 2.313, p < .05$ than females. Females had higher Beck Anxiety scores than men, $t(50) = 2.741, p < .01$.

Table 2. Demographic, cognitive and psychopathological characteristics of the samples.

| | PTSD | Non-PTSD | Statistics | |
|----------------------------|---------------|-----------------|-------------------------|----------|
| | N=25 | N=27 | | |
| Sex (Male/Female) | (8/17) | (14/13) | $\chi^2(1) = 1.23, ns$ | |
| Age (years) | 39.8 (14.22) | 41.78 (15.26) | $t(50) = .48, ns$ | |
| Years of Education | 14.48 (3.25) | 14.44 (2.44) | $t(50) = .05, ns$ | |
| Age of Trauma | 20.76 (12.99) | 26 (13.99) | $t(50) = 1.36, ns$ | |
| Years Since Trauma | 17.04 (14.4) | 16 (13.53) | $t(50) = .26, ns$ | |
| PCL | 55.78 (13.04) | 36.74 (13.62) | $t(50) = 5.14, p < .01$ | PTSD>Non |
| BDI | 20.24 (10.61) | 11.89 (8.34) | $t(50) = 3.17, p < .01$ | PTSD>Non |
| BAI | 28.24 (10.72) | 18.78 (14.39) | $t(50) = 2.67, p < .01$ | PTSD>Non |
| STAI-T | 53.26 (10.83) | 42.33 (10.21) | $t(50) = 3.75, p < .01$ | PTSD>Non |
| STAI-S | 43.56 (11.78) | 37.93 (12.84) | $t(50) = 1.65, ns$ | |
| FAS | 45.28 (10.83) | 39.59 (12.64) | $t(50) = 1.74, ns$ | |
| FAS perseverations | 0.92 (1.29) | 1.56 (2.98) | $t(50) = .98, ns$ | |
| Stroop_Word | 96.4 (23.19) | 97.07 (18.32) | $t(50) = .12, ns$ | |
| Stroop_X | 68.88 (17) | 65.7 (12.76) | $t(50) = .77, ns$ | |
| Stroop_Color | 43.04 (14.46) | 38.81 (9.34) | $t(50) = 1.25, ns$ | |
| Digit Symbol | 36.16 (10.96) | 34.15 (8.08) | $t(50) = .76, ns$ | |
| Digit Span Backward | 7.24 (2.83) | 6.26 (2.19) | $t(50) = 1.40, ns$ | |
| Shipley | 31.04 (7.07) | 28.33 (7.05) | $t(50) = 1.38, ns$ | |
| Rey-O Copy | 34.4 (3.65) | 33.56 (3.03) | $t(50) = .91, ns$ | |
| Rey-O Immediate | 20.78 (7.09) | 17.33 (6.3) | $t(50) = 1.86, ns$ | |
| Rey-O Delayed | 21.54 (6.55) | 16.35 (6.5) | $t(50) = 2.87, p < .01$ | PTSD>Non |
| Rey-O Recognition | 19.92 (1.74) | 19.07 (1.75) | $t(50) = 1.72, ns$ | |
| SMAST | 1.84 (2.51) | 1.74 (2.6) | $t(50) = .14, ns$ | |
| CAPS Frequency | 1.34 (1.25) | 0.74 (1.29) | $t(50) = 1.59, ns$ | |
| CAPS Intensity | 2 (1.8) | 0.86 (1.55) | $t(50) = 2.24, p < .05$ | PTSD>Non |

ns = not significant

Picture Ratings

An analysis was conducted on the picture ratings at encoding in order to make sure that there were not differences in the way that the pictures were rated by the two different groups. These ratings were made on a nine-point scale, 1 being intensely negative and 9 being intensely positive. An emotion (positive, negative, neutral) x group (PTSD, non-PTSD) ANOVA was conducted. This analysis revealed a main effect of emotion, $F(2,49) = 62.222, p < .001$, but no

group effect or emotion x group interactions (all $F < 1.5, p > 1.3$). As expected, all valence types differed significantly from each other: Positive greater than negative: $t(51) = 10.516, p < .001$; Positive greater than neutral: $t(51) = 7.852, p < .001$; Neutral greater than negative $t(51) = 7.363, p < .001$.

Memory Analyses

To determine if there were overall memory differences that varied by emotion or group, separate ANCOVAs were conducted looking at item memory and background memory separately. These ANCOVAs included the factors of emotion³ (positive, negative, neutral) and Group (PTSD, non-PTSD) using the depression/anxiety and memory measures that differed between groups as covariates (BDI, BAI, STAI-T, and Rey-O delayed). Both ANCOVAs revealed no significant effects or interactions ($F < 1.6, p > .2$).

In order to determine differences in the emotion-induced memory trade-off a valence (positive, negative) x group (PTSD, non-PTSD) ANCOVA was conducted controlling for the same anxiety/depression and memory measures (see Figure 6). This analysis indicated a main effect of group; $F(1, 46) = 5.239, p < .05, \eta_p^2 = .102$ such that there were larger memory trade-off scores for the PTSD group than the non-PTSD group, $t(50) = 2.669, p < .02$. There was no significant effect of valence or any interactions (all $F < .2, p > .6$).

³ The factor of emotion for this ANCOVA included positive, negative and neutral items separately instead of the neutral difference scores used in the trade-off analyses. This was done to determine differences for each item type (not just differences in memory beyond that of neutral). However, analyses using positive and negative memory scores with a neutral baseline subtracted out revealed the same effects.

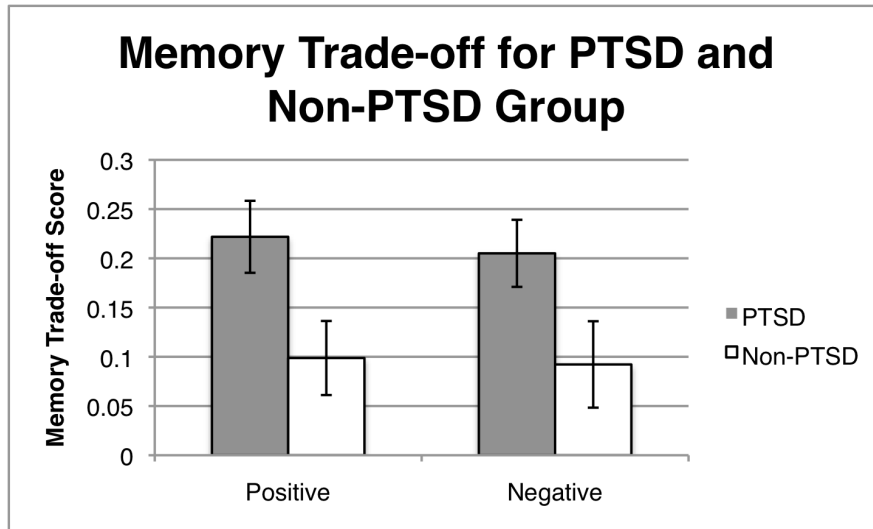


Figure 6. The memory trade-off for individuals with and without PTSD.

Discussion

The current study sought to look at memory for positive and negative stimuli in people with and without PTSD. First, there were no group differences in memory for positive, negative or neutral items. This adds to the scarce, but growing, literature that indicates that visual emotional stimuli are remembered equally as well in people with PTSD as those without PTSD. Group differences did emerge when the emotion-induced memory trade-off was considered. For individuals with PTSD, there was a larger memory trade-off both for positive and negative stimuli. Thus, despite overall differences in item memory for emotional stimuli, people with PTSD showed more focused memory when an emotional item is present.

When items and backgrounds were considered separately, there were no group differences in memory for emotional items. Previous studies that looked at memory for fear stimuli have also found that there are not particular memory enhancements for fear items in PTSD (Bremner, et al., 2003; Brohawn, et al., 2010; Dickie, et al., 2008). This study expands those findings to suggest that other types of negative and positive stimuli are also not enhanced for people with PTSD as compared to those without PTSD.

When considering overall item memory, one may have expected a detriment in memory, such that even neutral stimuli would be less likely to be remembered in individuals with PTSD than those without PTSD. This was not the case. In fact, the only memory test in which participants differed between groups was the delayed component of the Rey–Osterrieth Complex Figure Test, in which participants draw a complex figure from memory after a 30-minute delay. For this test participants with PTSD actually performed better than those without PTSD. Thus, in the current study there was no evidence of a decrement in overall memory in people with PTSD. Though some studies have found an overall decrement in memory for neutral items (e.g., Golier, et al., 2003; McNally, et al., 1998; Paunovic, et al., 2002), others have not (e.g., Bremner, et al., 2003; Brohawn, et al., 2010; Dickie, et al., 2008; Whalley et al., 2010). It is possible that I did not see the decrement in memory for neutral items because visual as opposed to verbal stimuli were used. A recent meta-analysis revealed that impairment in memory for neutral stimuli may be stronger for verbal than visual memory (Brewin, Kleiner, Vasterling, & Field, 2007). One account for this difference comes from the Dual Representation Theory (Brewin, 2001, 2003; Brewin, Dalgleish, & Joseph, 1996). According to this theory, people with PTSD have an intact visual memory system, allowing for vivid flashbacks and nightmares. However, it is the verbal system that is impaired, contributing to a disjointed, non-narrative based trauma memory. Thus, in the current study, it is possible that a higher functioning visual memory system may have contributed to the fact that there was no decrement in memory for the neutral complex visual scenes. This might also explain why the PTSD group did significantly better on the Rey–Osterrieth Complex Figure Test, a test of visual memory.

Group differences did emerge when the magnitude of the memory trade-off was considered. People with PTSD exhibited a larger memory trade-off than people without PTSD.

This memory trade-off is consistent with the symptoms of tunnel memory and memory fragmentation reported by some PTSD patients when remembering their trauma (e.g., Foa, et al., 1995; Halligan, et al., 2003). The memory fragmentation that is exhibited in remembering the trauma may be part of an overall inability to bind contextual information to emotional information.

This also indicates that though there might be fewer gross changes in item memory for positive and negative emotional items, there still may be differences in the increased focus of memory on emotional items. There could be multiple possible causes for this enhanced effect. People with PTSD are more likely to attend to emotional information and have more difficulty disengaging attention from emotional information (see Buckley, Blanchard, & Neill, 2000).

However, the results of Chapter 1 indicate that attention does not predict the memory trade-off. People with PTSD also may have deficient cognitive control processes (see van der Kolk, 2004). This may lead to difficulties keeping both the item and background in mind after it has left the screen. In addition, people with PTSD also have more ruminative thought processes (Halligan, et al., 2003) and may be more likely to engage in post-encoding processing. However, this increased rumination has typically been defined as dwelling on negative topics, thus it is unclear how post-encoding processing may function for positive information in individuals with PTSD. Future research should examine these potential causes for the increased memory trade-off in people with PTSD, especially for positive information.

This study is the first to reveal that, despite the lack of differences in overall memory for positive and negative items in those with and without PTSD, people with PTSD exhibit enhanced memory trade-offs for both positive and negative information. This indicates that there are more widespread memory changes in PTSD beyond that of the memory for the trauma, but these

changes are specific to difficulties encoding contextual elements presented with the emotional item.

OVERALL DISCUSSION

The studies discussed here added a number of new findings about the memory trade-off, and emotion's influence on memory in general. First, though overt visual attention may play a role in what is remembered, it does not predict the selective memory benefit for emotional items (Chapter 1, Experiment 1). This adds to the understanding of the mechanism behind the memory trade-off because we now know that attention is not the main factor that drives the trade-off as previously assumed.

Second, regardless of one's level of trait anxiety, the memory trade-off is most influenced by arousal rather than by valence (Chapter 2, Experiment 1). The largest memory trade-offs appeared when remembering information from scenes that included a positive or negative high arousal item. Taken together, these findings add new information to the understanding of the memory trade-off and the effect of arousal on memory for emotional information.

Though arousal may narrow attention in general (Easterbrook, 1953), it also may increase some other process that leads to the memory trade-off (such as increased post-encoding processing). These other processes may be the only things that are necessary for the memory trade-off to occur. On the other hand, the attention narrowing induced by high arousal may be necessary in combination with another process in order to induce the memory trade-off. Though the current study found no differences under divided attention, it is still unclear if some attentional resources are necessary for the trade-off. It could be that the memory trade-off exists even when attentional resources are exhausted or it could be that the divided attention task just did not engage enough attentional resources, leaving some attentional resources so that the trade-

off still existed. More research is needed to understand what all of the mechanisms are that influence the memory trade-off.

I also found that the memory trade-off can be manipulated (Chapter 1, Experiment 2). When it was task relevant, participants with low anxiety were able to dampen the memory trade-off. However, people with high levels of anxiety had more trouble dampening the memory trade-off - at least for vividly recollected items - even when it was task relevant (Chapter 2, Experiment 2). In light of the results of Chapter 1, which suggest that attention is not the main factor that led to the memory trade-off, it may be that people with high levels of anxiety may continue to elaborate/ruminate on the emotional item, leading them to later recollect it. These post-encoding processes may also lead to greater trade-off for familiar items that are high in arousal.

These effects of anxiety mapped onto the effects of the PTSD population in some ways. However, there were also distinct differences between trait anxiety and the anxiety disorder, PTSD. For people with high levels of trait anxiety, the enhancements in the memory trade-off were only apparent when recollection and familiarity were considered separately. Thus, trait anxiety induced a more nuanced effect on the memory trade-off. For the anxiety disorder PTSD, the enhancements in the memory trade-off were apparent without considering recollection and familiarity. Further, this effect was present even when the anxiety measures used to determine the high trait anxiety group (STAI-T and BAI) were used as covariates. This suggests that there may be something unique to individuals with PTSD that causes this overall enhancement in the memory trade-off. This is important for our understanding of PTSD and its relationship to anxiety. While anxiety alone has many of the same features as PTSD, there are distinct differences that lead to overall enhancements in the memory trade-off.

Future directions

Now that we know that attention at encoding may not be the main factor in inducing the memory trade-off, future research would do well to explore other factors. In addition to the post-stimulus elaboration which was mentioned earlier as a probable component, future research should explore the influences of consolidation and retrieval on the memory trade-off. While in my studies there was a 30-45 minute delay, longer delays (e.g., days to weeks) may influence the memory trade-off differently due to consolidation processes. Indeed, one recent study found that sleep over a consolidation period enhanced the memory trade-off (Payne et al., 2008). Thus, more research should be done to look beyond attention at encoding and determine how these other influences may affect the memory trade-off.

Future research would also do well to consider stress' role in the memory trade-off. I found that the more arousing an emotional stimulus , the more likely it was to induce the memory trade-off. However, a remaining question is whether stress would induce the memory trade-off even in the absence of an emotional stimuli. For example, would individuals who are experiencing arousal from psycho-social stress be more likely to have selective, more focused item memory for neutral items as well as emotional items? This research would help determine how physiological stress interacts with the encoding of emotional stimuli. This research would also speak to the current PTSD findings as people with PTSD have both experienced high levels of stress and also may have greater physiological reactions towards emotional stimuli.

Conclusions

The present experiments add to the current literature on 1) the effect of attention, 2) the effect of trait anxiety, and 3) the effect of PTSD on the memory trade-off. The results suggest that although the trade-off is enhanced in individuals with high anxiety and with PTSD, it may

be necessary to consider factors aside from attentional focusing in order to understand the prevalence of the trade-off in healthy individuals and in these clinically-relevant populations.

Although most studies have assumed that attention at encoding was the main factor in inducing the memory trade-off, this research suggests that attention is not the main factor that induces the memory trade-off; other factors, such as post-stimulus elaboration or rehearsal, may play a role.

References

- American Psychological Association. (2000). *Diagnostic and statistical manual of mental disorders (Text Revision)* (4th ed.). Washington, DC: American Psychological Association.
- Amir, N., & Kozak, M. J. (2002) Information processing in obsessive compulsive disorder. In R. O. Frost & Steketee, G. (Eds.), *Cognitive approaches to obsessions and compulsions: theory, assessment, and treatment*, (pp. 165-181). Oxford: Elsevier.
- Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, *134*, 258-261.
- Anderson, A. K., Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature*, *411*, 305-309.
- Bannerman, R.L., Milders, M. & Sahraie, A. (2009). Processing emotional stimuli: comparison of saccadic and manual choice reaction times. *Cognition and Emotion*, *23*, 930-954.
- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychological bulletin*, *133* (1), 1-24.
- Beck, A. T., Epstein, N., Brown, G., & Steer, R. A., 1988, An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology*, *56*, 893-897.
- Beck A. T., Ward, C. H., Mendelson, M., Mock, J., Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*, 561–71.
- Berntsen, D., Rubin, D. C., & Bohni, M. K. (2008). Contrasting models of posttraumatic stress disorder: Reply to Monroe and Mineka (2008). *Psychological Review*, *115*(4), 985-1011.

- Bishop, S., Duncan, J., Brett, M., & Lawrence, A. D. (2004). Prefrontal cortical function and anxiety: controlling attention to threat-related stimuli. *Nature Neuroscience*, 7(2), 184-8.
- Braver, T. S., & Barch, D. M. (2002). A theory of cognitive control, aging, cognition, and neuromodulation. *Neuroscience and Biobehavioral Reviews*, 26, 809–817.
- Bremner, J., Vythilingam, M., Vermetten, E., Southwick, S., McGlashan, T., Staib, L., et al. (2003). Neural correlates of declarative memory for emotionally valenced words in women with posttraumatic stress disorder related to early childhood sexual abuse. *Biological Psychiatry*, 53(10), 879-889.
- Breslau, N. (2002). Epidemiologic studies of trauma, PTSD, and other psychiatric disorders. *Canadian Journal of Psychiatry*, 47, 923-929.
- Brewin, C. R., Dalgleish, T., Joseph, S. (1996). A dual representation theory of posttraumatic stress disorder. *Psychological Review*, 4, 670 - 686.
- Brohawn, K. H., Offringa, R., Pfaff, D. L., Hughes, K. C., & Shin, L. M. (2010). The neural correlates of emotional memory in posttraumatic stress disorder. *Biological Psychiatry*, 68(11), 1023-30.
- Brown, J. M. (2003). Eyewitness memory for arousing events: Putting things into context. *Applied Cognitive Psychology*, 17, 93-106.
- Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, 5, 73-99.
- Buckley, T. C., Blanchard, E. B., & Neill, T. W. (2000). Information processing and PTSD: A review of the empirical literature. *Clinical Psychology Review*, 28, 1041-1065.
- Burke, A., Heuer, F., & Reisberg, D. (1992). Remembering emotional events. *Memory and Cognition*, 20, 277-290.

- Byrne, A. & Eysenck, M. W. (1995). Trait anxiety, anxious mood, and threat detection. *Cognition and Emotion, 9*, 549-562.
- Calvo, M.G., & Lang, P.J. (2004). Gaze Patterns When Looking at Emotional Pictures: Motivationally Biased Attention. *Motivation and Emotion, 28*, 221-243.
- Chemtob, C. M., Roitblat, H. L., Hamada, R. S., Muraoka, M. Y., Carlson, J. G., & Bauer, G. B. (1999). Compelled attention: the effects of viewing trauma-related stimuli on concurrent task performance in posttraumatic stress disorder. *Journal of Traumatic Stress, 12*, 309-26.
- Christianson, S. A. (1992). Emotional stress and eyewitness testimony: A critical review. *Psychological Bulletin, 112*, 284-309.
- Christianson, S-A, Loftus, E. F., Hoffman, H., & Loftus, G. R. (1991). Eye fixations and memory for emotional events. *Journal of Experimental Psychology: Learning Memory and Cognition, 17*, 693-701.
- Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671-684.
- Dalgleish, T. (1994). The relationship between anxiety and memory biases for material that has been selectively processed in a prior task. *Behaviour Research and Therapy, 32*, 227–231.
- Deffenbacher, K. A. (1983). The influence of arousal on reliability of testimony. In S. M. A. Lloyd-Bostock & B. R. Clifford (Eds.), *Evaluating Witness Evidence: Recent Psychological Research and New Perspectives*, (pp.235-251). Chichester: Wiley.
- Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology, 111*, 225–236.

- Dickie, E. W., Brunet, A., Akerib, V., & Armony, J. L. (2008). An fMRI investigation of memory encoding in PTSD: influence of symptom severity. *Neuropsychologia*, *46*(5), 1522-31.
- Doerksen, S., & Shimamura, A. (2001). Source memory enhancement for emotional words. *Emotion*, *1*, 5-11.
- Dolan, R. J., Vuilleumier, P. (2003). Amygdala automaticity in emotional processing. *Annals of the New York Academy of Sciences*, *985*, 348-355.
- Easterbrook, J. A. (1959). The effects of emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*, 183–201.
- Eppley, K. R., Abrams, A. I., & Shear, J. (1989). Differential effects of relaxation techniques on trait anxiety: A meta-analysis. *Journal of Clinical Psychology*, *45*(6), 957-974.
- Eysenck, M. W. (1997). *Anxiety and Cognition: a Unified Theory*. Psychology Press: Hove, England.
- Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, *7*(2), 336-53.
- Eysenck, M. W., & Mogg, K. (1992). Clinical anxiety, trait anxiety, and memory bias. In S. Christiansen (Ed.), *The handbook of emotion and memory: Research and theory* (pp. 429–450). Hillsdale, NJ: Erlbaum.
- First, M. B., Spitzer, R. L., Williams, J. B. W., Gibbon, M. (1995). *Structured Clinician Interview for the DSM-IV Axis I Disorders, Research Version (SCID-RV)*. Washington, DC: American Psychiatric Press.
- Foa, E. B., Molnar, C., & Cashman, L. (1995). Change in rape narratives during exposure therapy for posttraumatic stress disorder. *Journal of Traumatic Stress*, *8*, 675-690.

- Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion, 19*, 313–332.
- Gaspar, K. (2004). Do you see what I see? Affect and visual information processing. *Cognition & Emotion, 18*, 405 – 421.
- Gaspar, K. & Clore G. L. (2002). Attending to the big picture: Mood and global vs. local processing of visual information. *Psychological Science, 13*, 34-40.
- Gillis, M. M., Haaga, D. A. F., & Ford, G. T. (1995). Normative values for the Beck Anxiety Inventory, Fear Questionnaire, Penn Sate Worry Questionnaire, and Social Phobia and Anxiety inventory, *Psychological Assessment, 4*, 450-455.
- Golier, J. A., Yehuda, R., Lupien, S. J., & Harvey, P. D. (2003). Memory for trauma-related information in Holocaust survivors with PTSD. *Psychiatry Research, 121*, 133-143.
- Gray, M. J., Litz, B. T., Hsu, J. L., Lombardo, T. W. (2004). Psychometric properties of the life events checklist. *Assessment, 11* (4):330-341.
- Gutchess, A. H., Hebrank, A., Sutton, B., Leshikar, E., Chee, M. W. L., Tan, J. C., et al. (2007). Contextual interference in recognition memory with age. *NeuroImage, 35*, 1338–1347.
- Halligan, S. A., Michael, T., Clark, D. M., & Ehlers, A. (2003). Posttraumatic stress disorder following assault: The role of cognitive processing, trauma memory, and appraisals. *Journal of Consulting and Clinical Psychology, 71*, 419-431.
- Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Sciences, 5*, 394-400.
- Harris, C. R. & Pashler, H. (2005). Enhanced memory for negatively emotionally charged pictures without selective rumination. *Emotion, 5*, 191-199.

- Hulse, L. M., Allan, K., Memon, A., & Read, J. D. (2007). Emotional arousal and memory: A test of the poststimulus processing hypothesis. *American Journal of Psychology*, *120*, 73-90.
- Jatzko, A., Schmitt, A., Demirakca, T., Weimer, E., & Braus, D. F. (2006). Disturbance in the neural circuitry underlying positive emotional processing in post-traumatic stress disorder (PTSD). An fMRI study. *European Archives of Psychiatry and Clinical Neuroscience*, *256*(2), 112-4.
- Inaba, M., & Ohira, H. (2009). Reduced recollective memory about negative items in high trait anxiety individuals: an ERP study. *International Journal of Psychophysiology*, *74*(2), 106-13.
- Kaspi, S. P., McNally, R. J., & Amir, N. (1995). Cognitive processing of emotional information in posttraumatic stress disorder. *Cognitive Therapy and Research*, *19*, 433-444.
- Kensinger, E. A., Garoff-Eaton, R. J., & Schacter, D. L. (2007). Effects of emotion on memory specificity: Memory trade-offs elicited by negative visually arousing stimuli. *Journal of Memory and Language*, *56*, 575-591.
- Kensinger, E.A., Gutchess, A.H., & Schacter, D.L. (2007). Effects of aging and encoding instructions on emotion-induced memory trade-offs. *Psychology and Aging*, *22*, 781-795.
- Kern, R. P., Libkuman, T. M., Hajime, O., & Holmes, K. (2005). Emotional Stimuli, Divided Attention, and Memory. *Emotion*, *5*, 408-417.
- Koster, E. H. W., Crombez, G., Verschuere, B., De Houwer, J. (2004). Selective attention to threat in the dot probe paradigm: differentiating vigilance and difficulty to disengage. *Behaviour Research and Therapy*, *42*, 1183 – 1192.

- Knight, R. G. (1984). Some general population norms for the short form Beck Depression Inventory. *Journal of Clinical Psychology, 40*, 751-753.
- Krugman, D. M., Fox, R. J., Fletcher, Fischer, & Rojas (1994). Do adolescents attend to warnings in cigarette advertising? An eye-tracking approach. *Journal of Advertising Research, 34*, 39-52.
- Kverno, K. (2000). Trait anxiety influences on judgments of frequency and recall. *Personality and Individual Differences, 29*(3), 395-404.
- LaBar, K. S. (2007). Beyond Fear: Emotional memory mechanisms in the human brain. *Current Directions in Psychological Science, 16*, 173-177.
- Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1999). *International affective picture system (IAPS): Technical manual and affective ratings*. Gainesville, FL: The Center for Research in Psychophysiology.
- Leclerc, C. M. & Kensinger, E. A. (2008). Age-related differences in medial prefrontal activation in response to emotional images. *Cognitive, Affective, and Behavioral Neuroscience, 8*, 153-164.
- Levine, L. J. & Edelman, R. S. (2009). Emotion and memory narrowing: a review and goal relevance approach. *Cognition & Emotion, 23*, 833-875.
- Libkuman, T., Stabler, C., & Otani, H. (2004). Arousal, valence, and memory for detail. *Memory, 12*, 237-247.
- Litz, B. T., Weathers, F. W., Monaco, V., Herman, D. S., Wulfsohn, M., Marx, B., et al. (1996). Attention, arousal, and memory in posttraumatic stress disorder. *Journal of Traumatic Stress, 9*(3), 497-519.

- Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about “weapon focus.” *Law and Human Behavior, 11*, 55-62.
- McKenna, F. P. & Sharma, D. (1995). Intrusive cognitions: An investigation of the emotional Stroop task. *Journal of experimental psychology, 21*, 1595-1607.
- McNally, R. J., Metzger, L. J., Lasko, N. B., Clancy, S. A., & Pitman, R. K. (1998). Directed forgetting of trauma cues in adult survivors of childhood sexual abuse with and without posttraumatic stress disorder. *Journal of Abnormal Psychology, 107*, 596-601.
- Mitte, K. (2008). Memory bias for threatening information in anxiety and anxiety disorders: a meta-analytic review. *Psychological Bulletin, 134*(6), 886-911.
- Mogg, K., & Bradley, B. P. (1999). Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. *Cognition & Emotion, 13*(6), 713-740.
- Nugent, K., & Mineka, S. (1994). The effect of high and low trait anxiety on implicit and explicit memory tasks. *Cognition and Emotion, 8*(2), 147-163.
- Nijenhuis, E. R. S., & van der Hart, O. (1999). Forgetting and reexperiencing trauma. In J. Goodwin & R. Cittias (Eds.), *Splintered reflections: Images of the body in the trauma* (pp. 39–65). New York: Basic Books.
- Nummenmaa, L., & Hyönä, J., & Calvo, M.G. (2006). Eye movement assessment of selective attentional capture by emotional pictures. *Emotion, 6*, 257-268.
- Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*, 466–478.
- Oldenburg, C., Lundh, L.-G., & Kivisto, P. (2002). Explicit and implicit memory, trait anxiety, and repressive coping style. *Personality and Individual Differences, 32*, 107–119.

- Paunovic, N., Lundh, L. –G., & Ost, L. –G. (2002). Attentional and memory bias for emotional information in crime victims with acute posttraumatic stress disorder. *Journal of Anxiety Disorders, 16*, 675-692.
- Payne, J. D., Stickgold, R., Swanberg, K., & Kensinger, E. A. (2008). Sleep and memory consolidation for complex emotional scenes. *Psychological Science, 19*, 781-788.
- Pickel, K. L., French, T. A., & Betts, J. M. (2003). A crossmodal weapon focus effect: the influence of a weapon's presence on memory for auditory information. *Memory, 11*, 277–292.
- Reidy, J., & Richards, A. (1997). A memory bias for threat in high-trait anxiety. *Personality and Individual Differences, 23*(4), 653-663.
- Reisberg, D. & Heuer, F. (2004). Remembering emotional events. In D. Reisberg, and P. Hertel (Eds.), *Memory and emotion* (pp. 3-41). New York: Oxford University Press.
- Richards, A., & French, C. C. (1991). Effects of encoding and anxiety on implicit and explicit memory performance. *Personality and Individual Differences, 12*, 131–139.
- Rowe, G., Hirsh, J. B., & Anderson, A. K. (2007). Positive affect increases the breadth of attentional selection. *Proceedings of the National Academy of Sciences, USA, 104*, 383-388.
- Safer, M. A., Christianson, S. A., Autry, M. W. & Osterlund, K. (1998). Tunnel memory for traumatic events. *Applied Cognitive Psychology, 12*, 99-117.
- Sarter, M., Givens, B., Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: where top-down meets bottom-up. *Brain Research Reviews, 35*(2), 146-60.
- Schmidt, S. R., & Saari, B. (2007). The emotional memory effect: Differential processing or item distinctiveness? *Memory & Cognition, 35*, 1905-1916.

- Shaw, J. I., & Skolnick, P. (1994). Sex differences, weapon focus, and eyewitness reliability. *Journal of Social Psychology, 134*, 413–420.
- Shimmack, U. (2005). Attentional Interference Effects of Emotional Pictures: Threat, Negativity, or Arousal? *Emotion, 5*, 55-66.
- Shipley, W. C. (1986). *Shipley Institute of Living Scale*. Los Angeles: Western Psychological services.
- Spielberger, C.D., Gorsuch, R. L., Lushene, R. Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologist's Press.
- Spreen, O., & Benton, A. L. (1977). *Neurosensory Center Comprehensive Examination for Aphasia: Manual of instructions (NCCEA)* (rev. ed.). Victoria, BC: University of Victoria.
- Strange, B. A., Hurlleman, R., & Dolan, R. J. (2003). An emotion-induced retrograde amnesia in humans is amygdala- and beta-adrenergic dependent. *Proceedings of the National Academy of Sciences, USA, 13626–13631*.
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643– 662.
- Talmi, D., Schimmack, U., Paterson, T., & Moscovitch, M. (2007). The role of attention and relatedness in emotionally enhanced memory. *Emotion, 7*, 89-102.
- Tromp, S., Koss, M. P., Figueredo, A. J., & Tharan, M. (1995). Are rape memories different? A comparison of rape and other unpleasant, and pleasant memories among employed women. *Journal of Traumatic Stress, 8*, 607-627.
- van der Hart, O., van der Kolk, B. A., Boon, S. (1998). The treatment of dissociative

- disorders. In J. D. Bremner, C. A. Marmar , (Eds.) *Trauma, memory, and dissociation*. (pp. 253–283) Washington, DC: American Psychiatric Press, 1998.
- van der Kolk, B. A. (2000). The psychobiology of posttraumatic stress disorder. In Panksepp, J. (Ed.) *Textbook of Biological Psychiatry* (pp. 319-188) Hoboken: Wiley-Liss.
- van der Kolk, B. A. & Fisler, R. (1995). Dissociation and the fragmentary nature of traumatic memories: Overview and exploratory study. *Journal of Traumatic Stress*, 8, 505-525.
- Vasterling, J. J. & Brewin, C. R. (2005). *Neuropsychology of PTSD: Biological cognitive, and clinical perspectives*. New York: The Guilford Press.
- Vrana, S. R., Roodman, A., & Beckman, J. C. (1995). Selective processing of trauma-relevant words in posttraumatic stress disorder. *Journal of Anxiety Disorders*, 9, 515-530.
- Waring, J. D. & Kensinger, E. A. (2009). Effects of emotional valence and arousal upon memory trade-offs with aging. *Psychology and Aging*, 24, 412-422.
- Waring, J. D., Payne, J. D., Schacter, D. L., & Kensinger, E. A. (2010). Impact of individual differences upon emotion-induced memory trade-offs. *Cognition and Emotion*, 24, 150-167.
- Weathers, F., Litz, B., Herman, D., Huska, J., & Keane, T. (1993). The PTSD Checklist (PCL): Reliability, Validity, and Diagnostic Utility. Paper presented at the Annual Convention of the *International Society for Traumatic Stress Studies*, San Antonio, TX.
- Wechsler, D. (1997). Technical manual for the Wechsler Adult Intelligence and Memory Scale—Third Edition. New York: The Psychological Corporation.
- Yiend, J., & Mathews, A. (2001). Anxiety and attention to threatening pictures. *The Quarterly journal of experimental psychology. A, Human experimental psychology*, 54(3), 665-81.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language*, 46, 441-517.

Yonelinas, A., & Jacoby, L. L. (1995). The relation between remembering and knowing as bases for recognition: Effects of size congruency. *Journal of memory and language*, 34(5), 622-643.