Negative Encoding Contexts Create a Downstream Memory Advantage for Foils

by

Christopher Lee

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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Research has suggested that during a recognition test, we re-enter the mode of processing engaged at encoding to help constrain our memory search during retrieval (Jacoby, Shimizu, Daniels, & Rhodes, 2005). A by-product of such a constrained search is that new information (such as foils, or distractors) present on that recognition test inadvertently becomes encoded and tainted with this re-activated processing mode, reaping the benefits (or costs) of the re-activated processing mode on subsequent memory tests. Other research has shown that memory performance is enhanced for information encountered within an emotional relative to a neutral context (Erk et al., 2003). This thesis examined whether, in the process of remembering information learned within an 'emotional context', task-irrelevant information gets encoded with that same emotional valence, resulting in enhanced later memorability. We adapted Jacoby's (2005) memory for foils paradigm to determine whether the emotionality of the background visual context, upon which a target word was presented during encoding, influenced memory for foils on a subsequent recognition test. We also wanted to determine whether there were individual differences in the degree to which a negative or neutral visual context could influence subsequent memory for foils. Because some individuals, such those with high levels of anxiety, adopt an inherently negative mindset, this may particularly enhance memory for words overlayed on contexts that are the source of their anxiety (Coles & Heimberg, 2002; Rachman, 2004). Given this, we compared performance in individuals classified with high versus low levels of trait anxiety in Experiment 1, and high versus low fear of spiders in Experiment 2. We examined whether participants would better remember foils from a recognition test of 'negatively-tinged' targets, compared to 'neutrally-tinged' targets. In two experiments, participants studied words overlayed on either negative (negative valence IAPS pictures in Experiment 1; spider pictures in

Experiment 2) or neutral (neutral valence IAPS pictures in Experiment 1; animal pictures in Experiment 2) context pictures. Following study, participants completed a recognition test (Test 1) split into 2 blocks: one for words originally overlayed on to negative pictures, one for words overlayed onto neutral contexts. A final surprise recognition test (Test 2) was then administered containing all of the foil words from each of the Test 1 test blocks. In Experiment 1, we found a significant three-way interaction on Test 2, whereby individuals with high levels of anxiety, who initially studied target words using a 'shallow/perceptual' encoding instruction, demonstrated significantly higher recognition accuracy for foils derived from the negative, compared to the neutral, Test 1 block. In Experiment 2, all participants demonstrated a downstream memory advantage for foils derived from the negative compared to the neutral Test 1 block. Findings suggest that emotionality of the initial encoding context can create a downstream memory bias. Results extend Jacoby's (2005) source-constrained retrieval hypothesis, and suggest that negative encoding contexts produce a particularly salient bias for individuals with high anxiety.

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Chapter 1: General Introduction

When trying to retrieve information about our past, we do so by constraining our 'memory search' to the mode of processing we had engaged during initial encoding (Jacoby, Shimizu, Daniels, & Rhodes, 2005a). For example, if we focused on the meaning of words during encoding, we think about word meanings again when we later search our memory to determine whether a given word was part of a previously studied list. Conversely, if we focused on the perceptual characteristics of the word (e.g., font colour) then subsequent memory searches will target perceptual aspects. A by-product of such a search is that new information (such as foils, or distractors) present on that recognition test inadvertently becomes encoded, and tainted, reaping memory benefits (or costs) of the re-activated processing mode on subsequent tests. On a similar note, if we were to encounter words within an emotional context, we may think about those emotional aspects again when attempting to recognize the words during retrieval. Moreover, would this effect be different for those who more regularly display a negative mindset? This thesis examined whether, in the process of remembering information learned within an emotional context, task-irrelevant information gets encoded with that same emotional valence, resulting in enhanced later memorability.

Recapitulation and the Memory-for-foils Effect

According to the transfer appropriate processing principle (Morris, Bransford, & Franks, 1977), memory retrieval will be best when the processes invoked during retrieval match those undergone during encoding, consistent with these two processes being intimately linked and interdependent. In line with this, in the proceduralist perspective proposed by Kolers (1973; Kolers & Roediger, 1984, for a recent review, see Roediger, Gallo, & Geraci, 2002), encoding and retrieval are seen as extensively overlapping; as such, it becomes difficult, and ultimately meaningless, to identify discrete encoding and retrieval phases.

One of the most compelling lines of research demonstrating a link between encoding and retrieval processes is that using the memory-for-foils paradigm developed by Jacoby and colleagues (Jacoby et al., 2005a; see also Jacoby, Shimizu, Velanova, & Rhodes, 2005b; Shimizu & Jacoby, 2005). They proposed that when remembering previously encoded information, the mode of processing engaged during initial encoding is brought back online. In their research, they introduced a 'memory-for-foils' paradigm in which participants initially studied separate lists of words either under a deep (pleasantness judgment) or shallow (vowel judgment) level of processing. Following study, two recognition tests were administered (Test 1), and participants were told that each corresponded to either the deeply or the shallowly studied target words, intermixed among unique sets of foil (lure) words. Finally, in a third phase, participants were given a surprise recognition test assessing memory for the foil words (Test 2). The critical finding from this paradigm was that participants displayed better recognition for foil words that were derived from the recognition test of deep target words than of shallow target words.

To account for this effect, Jacoby and colleagues proposed that during retrieval (on Test 1) participants re-entered the original encoding mode (i.e., either deep encoding or shallow encoding) throughout that recognition test, so as to constrain their memory search. By re-engaging the encoding mode, at the time of retrieval, the same processing was applied to all words (both the old target words and the foils) on that recognition test. The end result was a benefit to memory on the subsequent recognition test (Test 2) for the foils initially contained within the 'deep' recognition test, as compared to the 'shallow' test. The benefit of deep processing had been conferred onto the foil words, thus producing a memory advantage for these foils.

If such a 'source-constrained retrieval' is indeed occurring, then the "memory-for-foils" effect should be apparent following any number of different encoding manipulations (not just a level of processing one), as long as those modes of processing can be reinstated at the time of retrieval. There have been a number of corroborating studies since 2005, confirming and extending the memory-for-foils paradigm (Alban & Kelley, 2012; Halamish, Goldsmith, & Jacoby, 2012; Kantner & Lindsay, 2013; Marsh et al., 2009) and providing evidence consistent with the reinstatement of encoding processes at the time of retrieval. Importantly, Danckert, MacLeod, and Fernandes (2011) showed that another encoding manipulation—other than the standard levels-of-processing manipulation—also produced the memory-for-foils pattern. In their study, imaging the referents of the words during encoding, as opposed to imaging the words transformed from lower to upper case, led to better memory for the foils (on Test 2) that came from the deep than shallow recognition test (i.e., from Test 1).

In related work, initial cognitive processes or neural regions initially active at encoding have been shown to become re-engaged when tested at retrieval, in a process known as recapitulation (Buckner, Wheeler & Sheridan, 2001; Rugg, Johnson, Park, & Uncapher, 2008). In a recent study, Vogelsang, Bonnici, Bergstrom, Ranganath, and Simons (2016) demonstrated the process of recapitulation using the memory-for-foils paradigm. Participants completed a version of the memory-for-foils paradigm (Jacoby, 2005a, 2005b; Shimizu & Jacoby, 2005), in which they were in an fMRI scanner throughout the study. Behavioural results replicated those of previous works. Interestingly, fMRI analysis also revealed that the left inferior frontal gyrus (a region active during a 'deep encoding' instruction at encoding and not during a 'shallow encoding' instruction) was active for foils that had been presented within a recognition test for deeply-encoded targets. Considering that this area was active during retrieval for deeply encoded words, but not for shallowly encoded words, suggests that constraining retrieval for a particular processing type does indeed reactivate that particular (deep) mode of processing.

One goal of this thesis was to extend the source-constrained retrieval paradigm to contrast effects from an emotionally negative to neutral context. We aimed to determine whether negative visual contexts experienced during an encoding phase for targets could later produce enhanced memory for 'foils' present during an initial test for that target information. Other research has shown that memory performance is enhanced for information encountered within an emotionally negative relative to neutral context (Erk et al., 2003). Given this, we reasoned that in the process of remembering information learned within a negative context, task-irrelevant information (the foils from the recognition test) would also be encoded and tagged with that same negative valence; the end result would be enhanced later memorability for these foils relative to foils encountered from a recognition test for neutral-context targets.

Memory Boost for Negative Material and from Negative Contexts

Numerous studies have demonstrated a memory advantage for emotional content, whether that content came in the form of pictures, statements, or words (Bradley, Greenwald, Petry, & Lang, 1992; Danion, Kauffmann-Muller, Grange, Zimmermann, & Greth, 1995; Cahill & McGaugh, 1996; Kensinger & Corkin, 2003a, 2003b; Bishop, Dalgleish, & Yule, 2004). However, the main goal of our research is to determine whether emotional processing can influence encoding of incidental, otherwise neutral, information. That is, instead of determining whether emotional content itself is more memorable, we sought to investigate whether neutral, incidental information can become more memorable through an association with emotional content. In a relatively recent study, Senn and Radomsky (2012) examined whether memory for neutral stimuli could be influenced by attributing new threatening contexts to otherwise neutral stimuli. In their study, participants with spider phobia studied objects placed in two boxes for two later memory assessments. Participants then completed a free recall test, providing a baseline of participants' memory performance. Following a break, the experimenter informed participants, randomly assigned to a 'threat' condition that a spider would often play in one of the two boxes. Conversely, participants in a 'non-threat' condition were told that the same box was used to store paper. Subsequently, a second free recall test for the objects was administered; results showed that individuals in the threat condition recalled a higher proportion of objects contained within the 'spider box', than those in the non-threat condition. Importantly, there was no difference between groups in memory for the objects on the first recall test, only a difference on the second test, following the 'threat' manipulation. Findings from this study suggest that the objects were not especially memorable until negative contextual information had been attributed to them, and this conferred a memory benefit on those objects. In other words, neutral objects became more memorable as a consequence of being associated with additional negative information.

More recently, Bowen and Kensinger (2017) have found evidence suggesting a neural explanation for the associated memory advantage. In their study, the researchers investigated the influence of emotional valence on recapitulation by pairing neutral words with either negative, positive, or neutral faces or scenes. Participants then completed a recognition test (remember-know-new paradigm) for the words presented alone. Both encoding and retrieval were completed in an fMRI scanner. Results revealed greater overlap in neural regions for words that had been studied in a negative context, as compared to positive and neutral contexts.

The process of recapitulation has been elicited using the memory-for-foils paradigm (Vogelsang et al., 2016). In this study, fMRI scans revealed reactivation of deep encoding regions at the time of retrieval when attempting to recognize foils intermixed among deeply studied targets. If the memory-for-foils paradigm can be used to induce recapitulation for words processed using a deep encoding instruction, this paradigm may also be able to induce recapitulation for words encoded with an emotional mode of processing.

Individual Differences in Anxiety and Memory Bias

Among high trait anxiety groups, it has been suggested that negative, threat-relevant stimuli recruit significant attentional resources (Bishop, Duncan, Brett, & Lawrence, 2004; Bishop, Jenkins, & Lawrence, 2007; Cisler & Koster, 2010) and are often characterized by intrusive or pervasive thoughts directed toward the source of anxiety (see Coles & Heimberg, 2002 for review). Research on mood-congruent memory (Bower, 1981) suggests that information is better remembered if one's current mood matches the valence of the to-be-remembered information. As such, individuals plagued by an inherently negative mindset, such as highly anxious individuals, may have better memory for negative information. Consequently, this negative mindset and directed attention toward negative stimuli may influence the perception of incidental, otherwise neutral, stimuli in the current environment.

Past research has suggested that anxious individuals may only exhibit the traditional emotional memory boost toward items that they find particularly threatening. In line with this, Radomsky and Rachman (1999) showed enhanced memory for items related to the threat of contamination in an obsessive-compulsive disorder (OCD) population. In another study, Ceschi, Van der Linden, Dunker, Perroud, and Brédart (2003) used a similar procedure, and showed a significant memory enhancement for contaminated objects. Radomsky, Rachman, and Hammond

(2001) also examined whether compuslvie checkers would exhibit a memory enhancement for threat-relevant information, with results again supporting the hypothesis that memory for threat-relevant information is enhanced in a population with high anxiety. In addtion to OCD populations, a memory bias for threat-relevant information has also been shown in individuals high in social anxiety (Ashbaugh & Radomsky, 2009; Cody & Teachman, 2010), in individuals with an eating disorders (Jiang & Vartanian, 2012), with a panic disorder (Cloitre & Liebowitz, 1991), and in those with a generalized anxiety disorder (Coles, Turk, & Heimberg, 2007). Importantly, these studies demonstrate that anxiety does not engender a memory bias for negative information in general. Instead, individual differences play a role in determining what information is attended to and eventually remembered.

The overall goal of this thesis was to determine whether initial encoding contexts can influence incidental, irrelevant stimuli (foil words), thus conferring a memory advantage to them. In our first experiment, we examined memory for foils (Jacoby 2005a; 2005b) in individuals with high and low trait anxiety to determine whether the targets encoded within a negative background context could confer a 'negative-tinge' to the foils on the recognition test for targets. Anxious individuals have demonstrated a tendency to attend to (Coles & Heimberg, 2002; MacLeod, Mathews, & Tata, 1986; Rinck & Becker, 2006) and difficulty disengaging attention from (Fox, Russo, & Dutton, 2002; Fox, Russo, Bowles, & Dutton, 2001; Huijding & de Jong, 2005) negative information. As such, we compared high and low anxiety groups in an attempt to identify any role that anxiety may play in downstream memory bias.

Anxious individuals may only exhibit a memory advantage for threat-relevant information (Radomsky & Rachman, 1999; Radomsky et al., 2001), as opposed to negative information in general. Additionally, the wide array of negative stimuli may have produced an inconsistent affect response between participants. In Experiment 2, to address this issue, we targeted individuals who reported a fear directed toward a specific phobic stimulus (i.e., spider phobia). Spider fearfuls, and a control group of non-spider fearful individuals, completed the memory-for-foils paradigm studying target words over threat-relevant spider background contexts or neutral animal backgrounds. The goal of our second research experiment then was to determine whether a threat-relevant encoding context would produce a more profound taint of incidental information, and hence, higher recognition accuracy for ‘threat-tinged’ foil words.

Chapter 2: Negative Context Influences Memory for Foils

One possibility that follows from the source-constrained hypothesis is that ruminating or dwelling on past events in a negative manner can influence encoding of objects or stimuli that are present in the current environment while in that mindset. Remembering events through a negative lens effectively re-activates the negative mode of processing initially engaged at encoding. In line with previous work (Bowen & Kensinger, 2017; Senn & Radomsky, 2012), this reactivated negative mindset could in turn taint current circumstances and incidental stimuli (e.g., foils) present within one's environment, conferring on them an unintentional memory benefit.

2.1 Experiment 1

In the current study, we adapted Jacoby's memory for foils paradigm to 1) extend the source-constrained retrieval hypothesis to contrast effects derived from a negative versus neutral encoding context, and 2) to determine whether there are individual differences in the degree to which a negative or neutral context can influence subsequent memory for foils. To investigate the latter, we compared performance in individuals classified with high versus low levels of trait anxiety. Such a finding would extend those of other work (Senn & Radomsky, 2012; Vogelsang et al., 2016) by suggesting that neutral information can become associated with, or tainted by, a negative context by virtue of invoking a constrained search of memory. As a consequence, the negatively-tainted information will be more memorable compared to information associated with a neutral context (Bishop, Dalgleish, & Yule, 2004; Bradley et al., 1992; Cahill & McGaugh, 1996; Danion et al., 1995; Kensinger & Corkin, 2003a, 2003b).

Based on past research, we anticipate a memory advantage on Test 1, for words studied in a negative context. Additionally, as a result of being associated with the negative information, a memory advantage may be conferred on the foil words within the negative Test 1 subtest block. As a consequence, recognition performance for the negative foil words, assessed on Test 2, will be higher than for foils derived from the neutral Test 1 subtest.

To make recognition judgments, the signal detection theory (Green & Swets, 1966) proposes that each individual selects a criterion level of familiarity and assumes that memory traces for each item have a quantified strength value associated with them. If the strength of the trace is above the criterion, then the item is registered as old; those that are below the criterion are deemed new. Past literature suggests that participants adopt a more liberal response bias when completing a recognition test for emotional, in comparison to neutral, information (Dougal & Rotello, 2007; Kapucu, Rotello, Ready, & Seidl, 2008). However, no research has explored whether response patterns or biases can also be reactivated or will influence how we perceive incidental stimuli. Hence, in addition to memory performance, we compared response bias patterns adopted by each anxiety group at both Test 1 and Test 2. We expected to see a more liberal response bias for the negative (Test 1) and negatively-tinged (Test 2) words, replicating findings from previous work (Dougal & Rotello, 2007; Kapucu et al., 2008). Moreover, we sought to determine what role individual differences might play in influencing the response criteria on either Test 1 or Test 2.

2.1.1 Method

Participants

Eighty undergraduate students from the University of Waterloo (64 females) completed the experiment for partial course credit. Forty participants were randomly assigned to a deep encoding instruction group (mean age = 19.98 years, SD = 2.03, range = 16-26) and 40 were randomly assigned to a shallow encoding group (mean age = 20.18 years, SD = 4.50, range = 17-46).

All participants completed the Depression Anxiety Stress Scales (Lovibond & Lovibond, 1995; DASS). The scales contains 42 items, 14 of which are dedicated to measuring each separate construct. An individual item consists of a statement that participants are instructed to provide a rating indicating how much the statement relates to them over the past week. Ratings are made on a 4-point scale ranging from 0 to 3, where 0 represents no relation to the statement, and 3 indicates that the statement relates to them a lot.

The participant sample was also divided into two separate groups based on the median of the sample anxiety ratings for the whole group. The median score for anxiety was 7.5 (*SD* = 8.27). Median scores for depression and stress were 4 (*SD* = 9.18) and 11.5 (*SD* = 8.99), respectively. Hence, the ‘high anxiety’ group consisted of participants with mean anxiety scores higher than 7.5 (deep encoding group N = 20; shallow encoding group N = 20), and the remainder were categorized into the ‘low anxiety’ group (deep encoding group N = 20; shallow encoding group N = 20).

We conducted independent sample t-tests to determine whether the high and low anxiety groups differed on depression or stress as reported on the DASS. Results of the t-test comparing mean trait depression indicated a significant difference in mean depression ($t(78) = 5.31$, $p < .001$), whereby the high anxiety group ($M = 12.83$, $SD = 10.26$) reported a higher depression level than the low anxiety group ($M = 3.43$, $SD = 4.44$). Similarly, there was a significant difference in trait stress levels ($t(78) = 5.51$, $p < .001$), whereby the high anxiety group (*M* =

17.73, *SD* = 8.84) reported a higher level of stress than the low anxiety group (*M* = 8.28, *SD* = 6.30).

Materials

Photos used as visual context. Pictures used as background visual context were taken from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008). The IAPS is a database of pictures with normative ratings for valence, arousal, and dominance based on a 9-point Likert scale. Two sets of pictures were created for the study. One set consisted of 36 pictures that were negative in valence (*M* = 2.51, *SD* = .46) and the other set consisted of 36 pictures that were neutral in valence (*M* = 5.06, *SD* = .56). Normative arousal ratings were matched across the negative (*M* = 5.01, *SD* = .63) and neutral pictures sets (*M* = 4.86, *SD* = .73). The selected pictures were re-sized to the dimensions of 11.7 cm x 8.8 cm from their original size of 26 cm x 19.5 cm to fit on the computer monitor.

Figure 1. Sample IAPS picture stimuli of negative (left) and neutral (right) context images.

Words used as targets and foils. Words were selected from the Affective Norms for English Words database (Bradley & Lang, 1999). The ANEW consists of a set of English words with normative ratings for valence, arousal, and dominance. All words selected from the database were concrete nouns. Two unique 36-item word lists were created as the study lists. For Test 1, each of these lists was intermixed among a different set of 36 foil words in separate subtests. A separate, unique set of 72 foils was used as lure words on Test 2. Word lists were matched on normative valence and arousal ratings across the negative (valence $M = 5.7$, $SD = 1.24$; arousal $M = 4.71$, $SD = .87$), and neutral (valence $M = 5.42$, $SD = 1.37$; arousal $M = 4.79$, $SD = .82$) target lists, and the negative (valence $M = 5.77$, $SD = .96$, arousal $M = 4.52$, $SD = .87$) and neutral (valence $M = 5.6$, $SD = .86$; arousal $M = 4.36$, $SD = .86$) foil lists. Word lists are shown in Appendix A.

Procedure

Participants completed the experiment individually using a desktop computer (19" monitor). Stimulus presentation and response recording were controlled using E-Prime 2.0 (E-prime v.2.2 software, Psychology Software Tools Inc., Pittsburgh, PA). Participants provided signed consent before providing demographic information, including age, gender, years of education, and age that the participant had learned English. Participants then completed the DASS (Lovibond & Lovibond, 1995) either as the first or final phase of the experiment to ensure the scales had no influence on test responses. For this scale, each item was displayed on the computer monitor. Participants were given a total of 5 seconds to respond to each statement with a keypress indicating their endorsement of the statement.

The study consisted of a 2 X 2 X 2 design, with Encoding Context Valence (negative or neutral) as a within-participant factor, and Encoding Instruction Group (shallow or deep) and Anxiety Group (low or high) as between-participant factors.

Encoding phase. Participants were presented with a set of 72 words (in 105 point white

Sans font with a .14 cm black border) overlayed onto individual IAPS pictures (26 cm by 19.5 cm) in sequential trials, and were informed that their memory for the words would later be assessed. The 72 word-picture set was divided into 2 separate sublists, one for words overlayed onto negative IAPS pictures and another for words overlayed onto neutral IAPS pictures. Henceforth, these sublists will be referred to as 'negative study words' and 'neutral study words'. The order in which the sublists were studied was counterbalanced across participants. For each trial, participants were instructed to study each word and to respond to two questions that appeared below the word-context pair, one at a time. For those in the shallow encoding group the first question asked them to indicate whether the word displayed on that trial contained the vowel 'a'. For the deep encoding group, the first question asked them to indicate whether the word displayed onscreen represented an object that was living or non-living. Responses for each group were made by pressing the A or D key on a QWERTY keyboard. To avoid the possibility that participants could evade or not attend to the picture that was used a context, participants in both encoding groups also answered a matching question; they indicated (arbitrarily) whether the word represented an object similar to the contents of the picture (by pressing the 4 or 6 key on the number pad of a QWERTY keyboard). Each question remained on the screen for 4 seconds, regardless of when the participant responded, thus providing 8 seconds in total, per study trial. A fixation cross was displayed between each trial for 250 msec.

Intentional Recognition Test 1. Following the Encoding Phase, participants completed an intentional recognition test for words presented alone (i.e. without picture context), divided into two subtests. Each subtest contained either the negative study words or neutral study words as targets, intermixed among a unique set of foil words. Thus, each subtest contained a total of 72 words (36 studied targets and 36 foils). The subtest containing the negative study words will be referred to as ‘negative recognition test’; and the subtest containing the neutral study words will be referred to as ‘neutral recognition test’. On each recognition test trial, a word (in white Courier New font at 26 point) was shown in the centre of the computer monitor. Participants were instructed to determine whether the word was ‘old’ or ‘new’, by pressing the J or L key on a QWERTY keyboard. Each word remained on the screen until a response was provided, followed immediately by the subsequent target word. Prior to beginning a subtest, participants were told whether the target words were derived from either the sublist of negative study words or of neutral study words. The order in which each recognition subtest was completed was counterbalanced across participants.

Incidental Recognition Test 2. A surprise recognition test was subsequently administered for the 36 foil words (same font and size as at encoding) from the negative and the 36 from the neutral recognition tests. These 72 foil words were intermixed among a brand new set of 72 foils, thus forming a recognition test totalling 144 words. Participants were told to identify a word as ‘old’ if they remembered seeing it in the previous phase, or ‘new’ (never seen in this experiment), by pressing the J or L key on a QWERTY keyboard.

2.1.2 Results

For Test 1, accuracy rates for target word memory were derived from the negative and neutral study sublists. Accuracy was calculated as hit rate (total hits divided by 36) minus false alarm rate (total false alarms divided by 36). For Test 2, accuracy rates were calculated as hit rate for foil words derived from the negative or neutral Test 1 subtest (total hits for each separate recognition test divided by 36) minus the overall false alarm rate on Test 2 (total false alarms divided by 72).

Test 1: Intentional Recognition of Studied Targets

We conducted a 2 (Recognition Test Valence: negative, neutral contexts) X 2 (Anxiety Groups: high, low trait anxiety groups) X 2 (Encoding Instruction Group: deep, shallow encoding groups) repeated measures ANOVA for accuracy rates on Test 1. Main effects were not significant for Recognition Test Valence, Anxiety Group, or Encoding Instruction Group. Two-way interactions were also non-significant.

The three-way interaction was marginally significant ($F(1, 76) = 3.08$, $MSE = .02$, $\eta_p^2 = .04$ $p = .08$). For the deep encoding instruction group, participants who were low in anxiety displayed significantly lower recognition accuracy ($t(19) = -2.5$, $p = .02$) on the negative recognition test ($M = .55$, $SD = 34$) than on the neutral recognition test ($M = .63$, $SD = .35$). Conversely, the opposite pattern materialized for the high anxiety group, whereby participants had a higher accuracy rate on the negative ($M = .55$, $SD = .40$) than on the neutral recognition test ($M = .50$, $SD = .55$), though this difference was non-significant. For the shallow encoding instruction group, there were no significant differences in recognition accuracy amongst the low anxiety group between the negative ($M = .64$, $SD = 16$) and the neutral ($M = 62$, $SD = .11$) recognition test, or among the high anxiety group for the negative ($M = .56$, $SD = .28$) and the neutral ($M = .59$, $SD = .28$) tests. See Table 1 for accuracy rate means.

Table 1

Experiment 1 Test 1: Memory Performance for Participants in the Deep and Shallow Encoding Conditions, with High versus Low Trait Anxiety

	Deep		Shallow	
	High	Low	High	Low
Hit Rate				
Negative	.70(.18)	.69(.21)	.70(.13)	.71(.15)
Neutral	.68(.24)	.73(.20)	.70(.18)	.68(.11)
False Alarm Rate				
Negative	.15(.24)	.14(.18)	.14(.21)	.08(.07)
Neutral	.19(.33)	.10(.19)	.12(.21)	.06(.05)
Accuracy Rate				
Negative	.55(.40)	.55(.34)	.56(.28)	.64(.16)
Neutral	.50(.55)	.63(.35)	.59(.28)	.62(.11)

Test 2: Incidental Memory for Foils

We conducted a 2 (Foil Valence: foils derived from the negative or neutral Test 1 blocks) X 2 (Anxiety Groups: high, low trait anxiety groups) X 2 (Encoding Instruction Group: deep, shallow encoding groups) repeated measures ANOVA for accuracy rate on Test 2. The main effect of Foil Valence was not significant. The main effects for Anxiety Group and Encoding Instruction Group were also non-significant. All two-way interactions were non-significant. There was, however, a significant three-way interaction (*F*(1, 76) = 4.46, *MSE* < .01, $\eta_p^2 = .06$, *p* < .04). For those in the shallow encoding condition, the effect of Anxiety Group interacted with

Foil Valence: High anxiety participants had higher recognition accuracy for foils derived from the negative Test 1 recognition subtest (*M* = .54, *SD* = .26) than from the neutral subtest (*M* = .50, *SD* = .28), and this difference was marginally significant (*t*(19) = 1.9, *p* = .07). In contrast, the low anxiety participants had a slightly lower accuracy rate on the negative (*M* = .55, *SD* = .14) recognition subtest, compared to the neutral (*M* = .59, *SD* = .14) subtest. Note that though accuracy rates differed by the same amount for both high and low anxiety groups, the difference was not significant for the low anxiety participants.

In the deep encoding condition, there were no differences in accuracy rate for high anxiety participants for negative (*M* = .48, *SD* = .29) and neutral (*M* = .48, *SD* = .28) foils. Similarly, recognition accuracy in the low anxiety group was about equal for negative (*M* = .56, *SD* = .21) and for neutral (*M* = .54, *SD* = .25) foils. See Table 2 for accuracy rate means.

Table 2

Experiment 1 Test 2: Memory for Foils and False Alarm Rate for Participants in the Deep and Shallow Encoding Condition, with High versus Low Trait Anxiety.

	Deep		Shallow	
	High	Low	High	Low
Hit Rate				
Negative	.72(.19)	.78(.17)	.75(.25)	.78(.18)
Neutral	.72(.21)	.76(.16)	.71(.25)	.81(.17)
False Alarm Rate	.24(.21)	.22(.20)	.22(.18)	.23(.10)
Accuracy Rate				
Negative	.48(.29)	.56(.21)	.54(.26)	.55(.14)
Neutral	.48(.28)	.54(.25)	.50(.28)	.59(.14)

Response Bias

Previous research has suggested that participants adopt a more liberal response bias when attempting to recall negative, in contrast to neutral, information (Dougal & Rotello, 2007; Kapucu, Rotello, Ready, & Seidl, 2008). To investigate response bias in our sample, we calculated criterion *C* for each participant for negative or neutral information on both Test 1 and Test 2.

Intentional Recognition Test 1. We conducted a 2 (Recognition Test Valence: negative, neutral contexts) X 2 (Anxiety Groups: high, low trait anxiety groups) X 2 (Encoding Instruction Group: deep, shallow encoding groups) repeated measures ANOVA for response bias measure *C*. Results of the analysis revealed a significant main effect of Recognition Test Valence on response bias (*F*(1,76) = 36.76, *MSE* = .04, η^2 = .33, *p* < .001), whereby participants adopted a more liberal response bias for the words studied in a negative context. However, there were no main effects for Anxiety Group or for Encoding Instruction Group. All two-way interactions between Encoding Instruction Groups and Recognition Test Valence were not significant. Three-way interaction between Recognition Test Valence, Anxiety Groups, and Encoding Instructions Groups was also not significant.

Incidental Recognition Test 2. We conducted a 2 (Foil Valence: foils derived from the negative or neutral Test 1 blocks) X 2 (Anxiety Groups: high, low trait anxiety groups) X 2 (Encoding Instruction Group: deep, shallow encoding groups) repeated measures ANOVA for response bias measure *C.* Results of the analysis revealed no significant main effect of Foil Valence, nor was there a significant main effect for Anxiety Group or for Encoding Instruction Group. All two-way interactions were also not significant. There was, however, a significant three-way interaction between Foil Valence, Anxiety Group, and Encoding Instruction Group (*F*(1,76) = 5.38, *MSE* = .02, η^2 = .07, *p* < .05). Paired samples t-test revealed that this interaction was mainly driven by high trait anxiety participants who had studied words using a shallow encoding instruction as this group adopted a significantly more conservative response bias for foils derived from the neutral test compared to those from the negative test (*t*(1, 19) = 2.27, *p* < .05). Criterion C scores for Test 2 are shown in Table 3.

Table 3

Experiment 2 Test 2: Response Bias Measure Criterion C for Participants with High versus Low Fear of Spiders (standard deviation in parentheses).

	Deep		Shallow	
	High	Low	High	Low
Negative	.05(.47)	-.01(.55)	.02(.59)	-.04(.46)
Neutral	.04(.53)	.03(.44)	.11(.58)	-.12(.45)

2.1.3 Discussion

The goal of this study was to investigate whether benefits offered by a constrained search to recognition memory could extend to information learned within that emotional context. Past work suggests that when making recognition memory decisions we re-enter the mode of processing engaged at encoding so as to constrain the memory search (Jacoby et al., 2005a; 2005b); As such, new information (foils) present during the recognition test is encoded using the same processing mode and reaps its benefits (or costs) on subsequent memory tests. Using the memory-for-foils paradigm, we examined whether foils from a recognition test of ‘negatively-tinged’ targets, compared to ‘neutrally-tinged’ targets, would later be better remembered. We also compared this effect across individuals high versus low in anxiety, based on a median split of DASS (Lovibond & Lovibond, 1995) scores. We predicted that participants would demonstrate memory enhancement for foils derived from a recognition test for target words learned in a negative context as compared to a neutral context. In addition, we hypothesized that this memory enhancement would be greater for those with high trait anxiety.

We found a significant three-way Anxiety Group by Encoding Instruction Group by Test 1 Context interaction on Test 2 performance, whereby high trait anxiety participants who had studied words using a shallow encoding instruction demonstrated a higher accuracy rate for ‘negatively-tinged’ foils. Results support both of our hypotheses, with a caveat: Participants displayed higher recognition for target foil words intermixed among those learned in a negative context, though this memory advantage was seen only in participants with high trait anxiety. Findings from the study suggest that initial encoding context can create a downstream memory bias, and as such our results extend the source-constrained retrieval hypothesis to emotional contexts. Our results also suggest that negative encoding contexts produce a particularly salient bias for high anxiety individuals. Memory for neutral stimuli, particularly among high anxiety individuals, may become tainted by the mode of processing engaged when such stimuli were incidentally encountered. In being tainted by the reactivated negative mode of processing, the foil words, or incidental stimuli, became particularly salient and meaningful to the participant, thus becoming more memorable. However, this pattern was observed only for those in the Shallow and not in the Deep Encoding Instruction group. This aspect of the results will be discussed separately below.

Support for our interpretation comes from other studies showing that neutral stimuli incidentally presented, or associated with, a negative or threatening context becomes tainted (Ehlers & Clark, 2000). As such, otherwise neutral stimuli seem to become affiliated with the retrieved threat-related information. As suggested by past related work, any memory enhancement that the individual harboured for the original threat transfers to the neutral stimuli, making these incidental stimuli more memorable as well (Bowen & Kensinger, 2017; Senn & Radomsky, 2012). Notably, in our study, the downstream memory bias for ‘negatively-tinged’ foils was only demonstrated by high trait anxiety participants. One possible explanation for this finding is that the amount of attentional resources directed toward threat-relevant stimuli may differ. For high anxiety individuals, it has been shown that threat-relevant stimuli recruit significant attentional (Bishop et al., 2004, 2007; Cisler & Koster, 2010) and working memory (Stout, Shackman, & Larson, 2013) resources. In being tainted by the negative context, the otherwise neutral stimuli may now occupy more working memory space. This is reflected in our results, whereby a negative context leads to similar memorial boosts, albeit only for the foils encountered while re-evaluating targets for membership in the ‘negative-context’ study list.

Previous research has explored constrained memory search for words that were encoded with various levels of processing (Jacoby et al., 2005a, 2005b; Danckert, MacLeod, & Fernandes, 2011). In these studies, participants demonstrated a recognition bias for foils derived from tests of words that had initially been processed deeply, as opposed to shallowly. In our study, however, we manipulated the level of processing across groups, and failed to find a main effect of depth of processing on Test 2 performance. In fact, there were no differences between the groups until Anxiety Group and Foil Valence were taken into consideration. Unlike many other studies exploring constrained memory search (Alban & Kelley, 2012; Danckert, MacLeod, & Fernandes, 2011; Halamish et al., 2012; Kantner & Lindsay, 2013; Marsh et al., 2009), our study implemented an emotional context manipulation in conjunction with a depth of processing instruction at the time of encoding. The discrepancy between the findings in our study and those of prior works suggests that the inclusion of an emotional context at encoding altered the eventual downstream memory bias, reducing any effect from depth of processing alone. One possible explanation is that there is a maximal amount of benefit memory can receive from a particular encoding strategy. As a consequence of studying words using a deep encoding instruction, the benefit offered by emotional valence could not be observed (i.e. memory performance was already high). In contrast to the deep instruction, a shallow mode of processing offers relatively less benefit to memory. Here the negative contexts may have had more leeway to provide an observable benefit.

Another possible explanation is that processing words using a deep encoding instruction diverts attention away from the emotional context. By definition, a deep encoding instruction requires the participant to recall various aspects involving the target word, drawing on previous memory traces and associations with the word's meaning. Consequently, neutral words activate a wide variety of previously formed emotional episodic traces, and attention is directed toward the target study word and away from the context picture. Conversely, words encoded using a shallow instruction are not accompanied by the reactivation of former episodic traces. Shallow encoding instructions only involve reading the word and understanding the physical features of the lettering used to spell it (i.e., whether there is the vowel 'a' in the word). Knowledge of the given word's meaning is irrelevant and unnecessary for the encoding instruction. As such, no previous memory traces are activated, allowing for the current encoding context to be associated with the target word. The result is a memory advantage for negatively-tainted foils in the shallow condition and no effect of emotion for those who studied words using a deep encoding instruction. In this case, anxious individuals do show a memory advantage for negatively-tinged information and receive a benefit from the negative pictures, relative to the low anxiety group. However, this effect can only be seen when words are studied using a shallow encoding instruction such that an association between the emotional context and the word can be made.

Response Bias

Additionally, we found that participants replicated the liberal response bias pattern for words studied within an emotional context on Test 1 (Dougal & Rotello, 2007; Kapucu, Rotello, Ready, & Seidl, 2008). Interestingly, on Test 2, high trait anxiety participants who studied words using a shallow level of encoding also adopted a more liberal response pattern for the foils derived from the neutral test in comparison to the foils for the negative test. This effect was not shown for the low trait anxiety group or for the group who had studied words using a deep level of encoding. Previous work has not explored response bias patterns with regard to trait anxiety differences. Although there were no differences for these groups during Test 1, our findings suggest that anxiety may lead to alterations in response bias downstream.

No Memory Advantage on Test 1

One aspect of our data which requires further explanation, however, is the absence of the expected memory advantage for negative target words on Test 1. The lack of effect may have occurred because our chosen visual negative contexts produced inconsistent affective responses across participants. That is, in our study, the pictures used as negative contexts consisted of a wide variety of content (e.g. blood, cemeteries, automobile accidents). As suggested by Radomsky and Rachman (1999), a memory advantage for emotional material might only be evident when presented with stimuli that are particularly threatening to that individual. Due to the variety of negative pictures used, a given participant may consider one picture threatening, stimulating a high affective response, whereas another participant might not perceive the same picture as a threat. For example, one participant may be upset by the sight of blood shown in some of the pictures, whereas others may not. We should not expect a memory advantage for a word accompanied by a non-threatening picture, since the taint of a non-threatening picture would effectively be similar to that from a neutral picture. Future studies could examine a possible downstream memory effect when the visual context at study is more consistently related to a specific threat, in subgroups of anxious participants (e.g., spider pictures in spider-phobics).

Memory for Foils Effect

Why then was there a downstream effect on memory for the foils? Guez and Naveh-Benjamin (2013) suggest that the influence of a particular manipulation on memory (in their case divided attention, and here, emotional context) may become more pronounced over longer time frames, as consolidation of the memory takes place. Given the relatively short amount of elapsed time between study and Test 1 in our paradigm, the benefit conferred to targets overlayed onto negative versus neutral contexts may not have yet emerged. That is, memory for the neutral-context targets was high, though if we had delayed Test 1, it is possible that differential forgetting may have occurred, allowing us to see the expected memorial benefit for targets encoded with a negative context. Given our paradigm, it is therefore even more remarkable that we observed the memory for foils effect for the negative Test 1 foils. Clearly our manipulation of context produced some difference in how the ‘negative-context’ versus ‘neutral-context’ targets were subsequently evaluated, and this differential evaluation was applied to the foils contained on each test, resulting in the differential memory for foils.

Results from Experiment 1 support our hypothesis that initial encoding context (whether negative or neutral) can influence later memory for incidental stimuli (the foils). While we did find a difference in memory performance on Test 2, we did not find the anticipated emotional context benefit on Test 1. As described above, one of the possible explanations is that each unique context led to various affective, physiological arousal responses across participants. According to the Yerkes-Dodson law (Yerkes & Dodson, 1908), optimal performance requires a moderate level of physiological arousal. Therefore, participants who are very strongly affected by one image would have their memory performance influenced differently than those who are less emotionally affected. As a means to address this possible alternative explanation, in Experiment 2 we changed the negative visual contexts at encoding to be all of one type. Specifically, we replaced these contexts with spider images and examined the influence of this visual context within our paradigm, in individuals with high versus low fear of spiders. In so doing, we could better control the affective state created by the ‘negative-context’ images in those with a high fear of spiders.

Chapter 3: Threat-Relevant Context Influences Memory for Foils

In Experiment 1, we found that high trait anxiety participants demonstrated a downstream memory advantage for negatively-tainted foil words. One limitation of our study, however, was the inconsistent affective response to the negative context images. For example, while some participants may respond rather strongly to the sight of blood, others may be relatively unaffected, despite the sight of gore and physical injury being a generally negative event. In this case, we may have induced a wide range of physiological arousal responses between participants. As explained above, according to the Yerkes-Dodson law (Yerkes & Dodson, 1908), optimal performance requires a moderate level of physiological arousal. Therefore, images containing blood could have produced an arousal level that was too high to produce optimal performance for some participants. Conversely, participants who are unaffected by the sight of blood would have had an arousal response below the ideal moderate point. To address this potential issue, in Experiment 2, we collected data from a sample group who self-reported a specific fear and used threat-relevant images as contexts.

Spider Phobia and Cogntiive Biases

Extensive empirical evidence has illustrated that spider fearfuls demonstrate various cogntiive biases toward threatening spider cues. One such cogntiive process is implicit memory bias. Automatic processes are an integral contributor to the etiology of spider fear (Merckelbach, de Jong, Muris, & van den Hout, 1996). These automatic processes are often reflected in implicit tests of memory whereby spider fearfuls have been shown to more readily associate negativity with spider images (Teachman & Woody, 2003; Huijding & de Jong, 2005) or with avoidant behaviours (Rinck & Becker, 2007). Critically, these behaviours are exhibited by spider phobics only when presented with stimuli that contain the designated threatening stimulus, spiders. For example, using the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998), Teachman and Woody (2003) showed that spider phobics quickly associated spider images with negative terms, however they did not do so for pictures of snakes.

Spider phobics report their initial fear reactions as irrational and out of their intentional control (Mayer, Merckelbach, & Muris, 2000), suggesting an immediate emotional acknowledgement and awareness of the threatening cue. Anxiety has been shown to elicit attentional biases toward sources of threat (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). When presented with threatening stimuli, spider threat cues have been shown to draw the attention of spider phobic subjects (Mogg & Bradley, 2006; Ohman, Flykt, & Esteves, 2001). This effect has been replicated in eye-tracking studies as well, suggesting that when a threat cue is presented, eye gaze immediately redirects to the spider image (Rinck & Becker, 2006).

Alhough the literature on explicit memory biases among the anxious population is mixed (see Mitte, 2008, for review), there is some evidence to suggest that spider phobics may demonstrate a memory advantage for spider stimuli. In multiple experiments, Wessel and Merkelbach (1998, 1997) found that spider phobics demonstrated a memory advantage to spider images. Empirical evidence supports alterations to several cognitive processes among spider phobics, including attention and both implicit and explicit memory bias, toward spider-related cues. Utilizing these cognitive biases, we aimed to determine whether a memory advantage would be displayed for words studied within a spider-related context (Test 1), and whether this memory advantage, if any, would be conferred on Test 2, on incidental stimuli, the foils that were present on Test 1.

3.1 Experment 2

In Experiment 2, instead of using the wide array of negative images used in Experiment 1, we presented participants with spider images in our ‘negative-visual-context’ encoding condition. Moreover, neutral images were replaced with non-insect, non-spider animal pictures to control for the semantic distinction between the living and non-living categories of stimuli. Extensive work has shown that continued exposure to threatening images reduces anxiety to the threat (Mathews, Mackintosh, Williams, Williams, & Kirkby, 2016; Mathews, Naran, & Kirkby, 2015). The decline in fear response, has even been demonstrated using a single half-hour presentation of fearful spider images (Muller, Kull, Wilhelm, & Michael, 2011). To reduce the potential that participants would habituate to the threatening spider images, one third of the visual-context images at encoding were GIF files. Hence, the participants in this experiment studied words overlayed onto spider images, or spider-GIFs, which were threat-relevant for spider-phobics, or animal images and animal-GIFs, which were neutral for all participants.

One of the limitations of Experiment 1 was our inability to verify whether participants had the intended affective response following each study list, which is problematic for two reasons. First, we could not confirm whether participants found the negative context pictures more negative compared to the neutral pictures. As such, we could not fully confirm whether the negative encoding context condition produced the intended affective response. Participants may have had the same emotional response to the negative and neutral pictures. It may seem odd to think that a picture of blood would be rated as negatively as a picture of a boat. However, since we did not include a manipulation check, we were unable to confirm a difference in emotional response between encoding conditions. Second, we could not determine whether memory performance is due to changes in valence or arousal. Although context pictures were controlled across groups for normative arousal ratings, participants may have had varying physiological arousal responses to the negative compared to the neutral pictures. For example, an image of blood may produce a stronger physiological response than an image of a boat. As previously discussed, arousal has a role to play in memory performance (Yerkes & Dodson, 1908). To account for potential changes in arousal and to verify whether encoding context conditions produced the intended affective response, we included the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) to collect self-reports of valence and arousal at baseline prior to either study list, following the spider study list and following the animal study list.

In line with previous studies, an emotional memory boost may only be displayed when anxious individuals are presented with information that they find particularly threatening. As such, we predicted that participants who reported a high fear of spiders would demonstrate a memory advantage for the words studied within the spider context (Test 1), and that this memory boost would then be conferred on the foil words from the Test 1 subtest for targets overlayed onto spider images (and GIFs), when foil memory was assessed on Test 2.

Moreover, in Experiment 1, we had replicated previous findings that participants adopt a more liberal response bias when presented with emotional, as opposed to neutral, information during Test 1 (Dougal & Rotello, 2007; Kapucu et al., 2008). In Experiment 2, we therefore expected that high spider fearful participants would be more liberal in their memory response pattern (Becker & Rinck, 2004). Thus, in addition to differences in memory performance, we predicted that spider fearful participants would be more liberal in reporting that they had seen words overlayed on spider images/GIFs derived from the spider Test 1 subtest.

3.1.1 Method

Participants

Three participants were excluded from analysis due to memory accuracy scores lower than 0 on Test 1. After exclusions, eighty-four participants completed the study (70 females, *M* age = 20.68, *SD* = 5.18, *Range* = 17-57 years). Participants were enrolled in undergraduate Psychology classes and received course credit for their participation. Prior to signing up for the study, participants completed the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) during initial pre-screen testing. When first joining the SONA subject pool at the University of Waterloo, prospective participants completed a series of questionnaires, including the FSQ. Using these pre-screen mass testing scores, participants who scored in the top and bottom 25% were given permission to sign up for the study. Of the 2569 participants who completed the questionnaire, 1138 (695 in the top 25%, 443 in the bottom 25%) qualified for the study. Those scoring in the top 25% were categorized into the High Fear of Spiders group (*N* = 42, mean FSQ score = 90.62, *SD* = 15.28, mean age = 19.95 years, *SD* age = 4.11, age range = 17 - 44), while participants in the bottom 25% were assigned to the Low Fear of Spiders group (*N* = 42, mean FSQ score = 18.20, *SD* = .40, mean age = 21.40 years, *SD* age = 6.03, age range = 18 - 57). Participants were recruited in accordance with ethical guidelines governing the use of humans in research.

High and low fear of spider group mean scores were calculated separately. Scores from time at test and during pre-screen are shown in Table 4. Although mean scores in both groups were higher at study than during pre-screen measures, the high fear of spiders group still reported a significantly higher mean FSQ score than the low fear of spiders group ($t(82) = 17.47$, $p < .001$).

Table 4

Fear of Spiders Questionnaire Ratings for Participants with High and Low Fear of Spiders during Pre-screen, and at Study (standard deviation in parentheses).

	High Fear of Spiders Group	Low Fear of Spiders Group
Pre-screen Test	90.62(15.28)	18.20(.40)
Study	103.2(13.89)	36.83(20.25)

Materials

Context Pictures. Pictures used as background visual context contained either images of spiders (24 pictures) or non-insect animals (24 pictures). The spider pictures were selected from a database of spider images used in previous studies investigating fear of spiders. The animal pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Pictures were neutral in normative valence (*M* = 5.91, *SD* = .81) and arousal (*M* = 4.53, *SD* = 1.03) as collected by the IAPS. Selected pictures were re-sized to the dimensions of 11.7 cm x 8.8 cm from their original size to fit within the parameters of the computer monitor.

Figure 2. Sample picture stimuli of spider (left) and animal (right) context images.

Context GIFs. Past research has shown that exposure to images can be an effective treatment for spider phobia (Mathews et al., 2016; Mathews et al., 2015; Muller et al., 2011). In Experiment 2, unlike in Experiment 1, a third of the contexts were generated using GIF files to ensure participants did not become desensitized to the spider and animal images throughout the encoding phase. Both spider and animal GIFs were collected through an Internet search of various websites that provided public access to their images. Spider GIFs were selected to contain spiders moving in the centre of the image. Likewise, animal GIFs contained various animals that moved in the centre of the image.

Words. As in Experiment 1, words were collected and compiled into lists for the encoding and test phases of the study. In Experiment 2, however, it was critical that the words were unrelated to animals and did not contain any animal nouns to ensure participant memory did not benefit from semantic relatedness (Baddeley, 1966). Words selected were concrete, non-animal nouns selected from the Affective Norms for English Words database (Bradley & Lang, 1999). Two unique 36-item word lists were created as the study lists. For Test 1, each of the lists was intermixed among a novel set of 36 foil words in separate subtests. An additional, unique set of 72 foils were then used as lure words on Test 2. Word lists were matched on normative valence and arousal ratings across the list paired with spider pictures (valence *M* = 5.74, *SD* = 1.67; arousal *M* = 4.51, *SD* = 2.32) and animal pictures (valence *M* = 5.72, *SD* = 1.67; arousal *M* = 4.50, *SD* = 2.27), and the foil lists paired with spider pictures (valence *M* = 5.77, *SD* = .96; arousal *M* = 4.5, *SD* = .87) and animal pictures (valence *M* = 5.60, *SD* = .86; arousal *M* = 4.36, *SD* = .85). Word lists are shown in Appendix B.

Self-assessment Manikin. The self-assessment manikin (SAM; Bradley & Lang, 1994) was used to measure affective response at baseline and after exposure to the spider and animal pictures. The SAM consists of a series of images, and participants were instructed to select the image that best reflected their current mood valence and arousal levels. Participants were also able to indicate that their mood fell between two of the images.

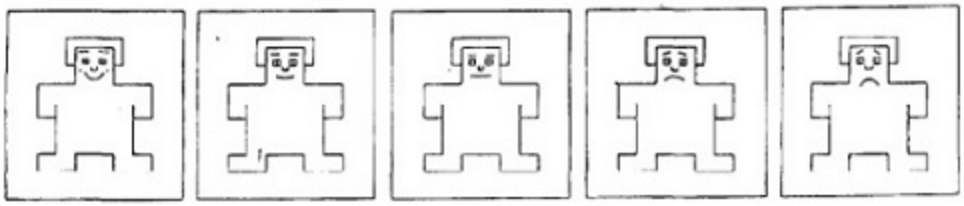

Figure 3a. Self-Assessment Manikin (SAM) Valence scale, showing images depicting extremely positive (left) and extremely negative valence (right) states.

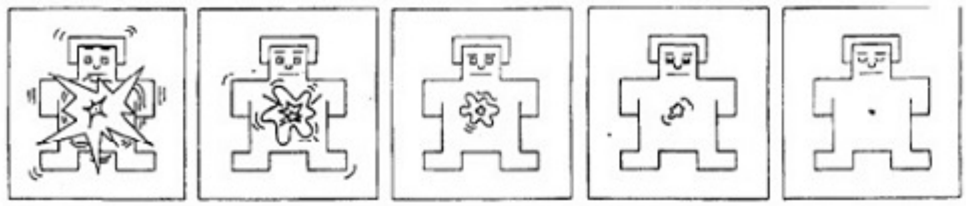

Figure 3b. SAM Arousal scale showing images depicting extremely high physiological arousal (left) to extremely low physiological arousal (right).

Procedure

Participants completed the experiment individually using a desktop computer (19" monitor). Stimulus presentation and response recoding were controlled using E-Prime 2.0 (E-prime v.2.2 software, Psychology Software Tools Inc. Pittsburgh, PA). Participants provided signed consent before providing demographic information, including age, gender, and age that the participant had learned English.

Encoding phase. Participants were presented with a set of 72 words (in 105 point white Sans font with a .14 cm black border) overlayed onto pictures and GIF files (26 cm by 19.5 cm) in sequential trials, and were informed that their memory for the words would later be assessed. The 72 word-picture set was divided into 2 separate sublists, one for those words overlayed onto spider pictures and GIFs and another for words overlayed onto animal pictures and GIF files. Henceforth, these sublists will be referred to as the 'spider study words' and the 'animal study words'. The order in which the sublists were studied was counterbalanced across participants.

For each trial, participants were instructed to study each word and to make a shallow encoding decision about whether the word shown on screen contained the vowel 'a'. Responses were made by pressing the A or D key on a QWERTY keyboard with their dominant hand. To fix amount of study time for each word, the question remained on the screen for 4 seconds regardless of when the participant responded.

Prior to being shown any pictures or words, participants completed the SAM to report baseline valence and arousal levels. After being presented with the spider study words and the animal study words, participants completed the SAM again. In Experiment 1, no measure was in place to determine whether mood changed in the intended direction following the negative and neutral study lists. In this study, we used the SAM to obtain self-report valence and arousal ratings to determine whether the threat-relevant and neutral conditions were producing the intended affective response.

Intentional Recognition Test 1. Following the Encoding Phase, participants completed two subtests of an intentional recognition test, one for each sublist of the study words. Each subtest contained either the spider study words or the animal study words as targets, intermixed among a unique set of foil words. Thus, each subtest contained a total of 72 words (36 studied targets and 36 foils). The subtests containing the spider study words and the animal study words will be referred to as the spider recognition test and the animal recognition test, respectively.

On each recognition test trial, a word (white Courier New font at 26 point) was shown in the centre of the computer monitor. Participants were instructed to determine whether the word was ‘old’ or ‘new’ by pressing the J or L key on a QWERTY keyboard with their dominant hand. Each word remained on the screen until a response was provided, followed immediately by the subsequent target word. Prior to beginning each subtest, participants were told that the target words would be derived from either the spider study words or animal study words. For example, before starting the spider recognition test, participants were told that the ‘old’ words would have been studied in the spider study words sublist from the Encoding Phase.

Incidental Recognition Test 2. As in Experiment 1, following Intentional Recognition Test 1, a surprise recognition test was administered. In this test, the 36 foil word sets (white Courier New font at 26 point) from each of the spider recognition test and the animal recognition test were used as target words. These 72 foil words were intermixed among a brand new set of 72 foils, thus forming a recognition test totaling 144 words. Participants were instructed to determine whether the displayed word was ‘old’ or ‘new’ and to report their response by pressing the J or L key on a QWERTY keyboard with their dominant hand. Each word remained on the screen until a response was provided and was followed immediately by the subsequent word.

Fear of Spiders Questionnaire. Participants completed the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) again during the study to ensure that the fear of spiders groups remained different from one another according to fear of spiders self-reports. The FSQ is an 18-item scale containing statements all regarding a fear of spiders (i.e., "If I came across a spider now, I would get help from someone else to remove it") and participants were instructed to indicate how much they agreed with each statement on a 7-point scale. Each item was displayed on the computer monitor and remained on screen until a response was provided. Once the participant had entered a response, the subsequent statement was immediately displayed. The order of the statements were randomized across participants.

Depression Anxiety Stress Scale. Participants completed the 42-item Depression Anxiety Stress Scale (DASS; Lovibond & Lovibond, 1995). Similar to Experiment 1, participants reported their responses on a 4-point scale from 1-4. Participants were instructed that they had 5 seconds to record their response and that if a response was not provided then the current item would be skipped and the next item would be displayed. The order of the FSQ and DASS was randomized between participants. Anxiety, depression, and stress mean ratings for each spider group are shown in Table 5.

Table 5

Experiment 2: Mean Trait Anxiety, Depression, and Stress Ratings for High and Low Fear of Spiders Groups (standard deviation in parentheses).

	High Fear of Spiders Group	Low Fear of Spiders Group
Anxiety	26.43(7.90)	21.95(6.90)
Depression	25.00(8.99)	21.33(7.51)
Stress	30.29(9.23)	24.62(7.28)

3.1.2 Results

Manipulation Check

To determine whether the study lists had the intended effect on participant mood, we conducted separate ANOVAs for SAM valence and arousal scores.

SAM Valence. Data were analyzed using a repeated measures 2 (Spider Fear Group: low fear of spiders, high fear of spiders) X 3 (Encoding Condition: baseline, post-animal study list, post-spider study list) ANOVA. There was a significant main effect of Encoding Condition (F(2, 164) = 68.71, MSE = 1.37, $\eta^2 = .46$, $p < .001$). There was also a significant between groups main effect comparing the high and low fear of spiders groups (F(1,82) = 14.08, MSE = 1.24, $\eta^2 = .15$, $p < .001$). The Spider Fear Group X Encoding Condition interaction was also significant (F(2, 164) = 13.95, MSE = 1.37, $\eta^2 = .15$, $p < .001$). Simple effects contrasts indicated that high fear of spiders participants reported a significantly more negative valenced mood following the study block which contained the spider visual context images/GIFs compared to baseline reports (F(1,

41) = 81.95, *MSE* = 3.98, $\eta^2 = .67$, $p < .001$) and compared to their reports following the study block which contained animal visual context images/GIFs (*F*(1, 41) = 64.64, *MSE* = 4.06, $\eta^2 = .61$, $p < .001$). This pattern, however, was also demonstrated by the low fear of spiders group, whereby a more negative valenced mood was reported following the spider-context study list compared to baseline (*F*(1, 41) = 20.02, *MSE* = 3.98, $\eta^2 = .33$, $p < .001$) and compared to their reports following the animal-context study list (*F*(1, 41) = 25.43, *MSE* = 4.06, $\eta^2 = .38$, $p < .001$). Post animal study list and baseline reports were not significantly different for either group. To further understand the between-groups differences, we conducted independent sample t-tests to compare valence data between the groups.

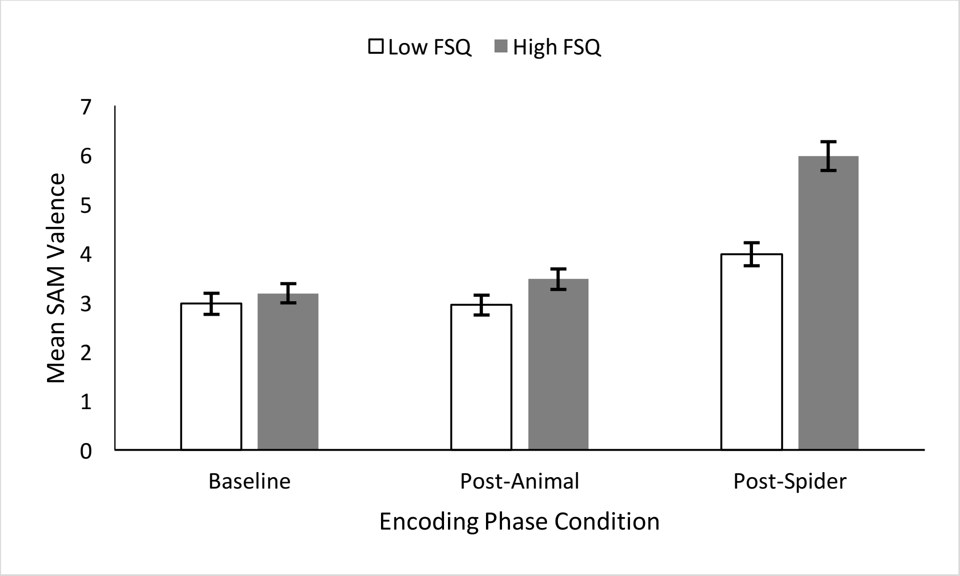

Figure 4. Mean SAM Valence ratings for the low and high Fear of Spiders Questionnaire (FSQ) groups at baseline, following study of the animal list and following study of the spider list.

We conducted independent sample t-tests to determine whether the high and low fear of spiders groups reported different valence levels at the various points throughout the encoding phase. Independent sample t-tests revealed a significant Spider Fear Group difference after studying the spider-context study words ($t(82) = 5.31$, $p < .001$), whereby the high fear of spiders group reported a significantly more negative valence ($M = 5.98$, $SD = 1.91$) than the low fear of spiders group ($M = 3.98$, $SD = 1.52$). Importantly, there were no significant differences between the groups following the animal-context study words (high fear of spiders group: $M = 3.48$, SD 1.35; low fear of spiders group: $M = 2.95$, $SD = 1.29$; $t(82) = 1.82$, $p = .072$), or following baseline (high fear of spiders group: $M = 3.19$, SD 1.25; low fear of spiders group: $M = 2.98$, $SD = 1.39$; $t(82) = .74$, $p = .46$).

SAM Arousal. Data were analyzed using a repeated 2 (Spider Fear Group: low fear of spiders, high fear of spiders) X 3 (Encoding Condition: baseline, post-animal study list, post-spider study list) ANOVA. Mauchly's test indicated that the assumption of sphericity had been violated ($\chi^2(2) = 26.68$, $p < .001$), therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .80$).There was a significant main effect of Encoding Condition ($F(1.61, 131.69) = 29.99$, $MSE = 1.895$ $\eta^2 = .27$, $p < .001$). There was also a significant Spider Fear Groups effect ($F(1,82) = 7.18$, $MSE = 7.31$, $\eta^2 = .08$, $p < .01$). The Spider Fear Group X Encoding Condition interaction was also significant ($F(1.61, 131.69) = 9.46$, $MSE = 1.85$, $\eta^2 = .10$, $p < .001$). For the high fear of spiders group, simple effects contrasts revealed that participants reported a significantly higher arousal after the spider-context study list compared both to baseline ($F(1, 41) = 32.51$, $MSE = 5.29$, $\eta^2 = .44$, $p < .001$) and to their reports following the animal-context study list ($F(1, 41) = 35.58$, $MSE = 4.28$, $\eta^2 = .46$, $p < .001$). This pattern was also found for the low fear of spiders group, albeit the difference was only marginally significant when comparing post-spider study list and post-animal study list reports ($F(1, 41) = 4.22$, $MSE = 4.28$, $\eta^2 = .46$, $p = .05$). Low spider fear group participants reported a significantly higher arousal level following the spider study list than at baseline ($F(1, 41) = 5.33$, $MSE = 5.29$, $\eta^2 = .12$, $p < .05$). To further understand the between groups difference, we conducted independent samples t-tests to compare arousal data between the fear of spiders groups.

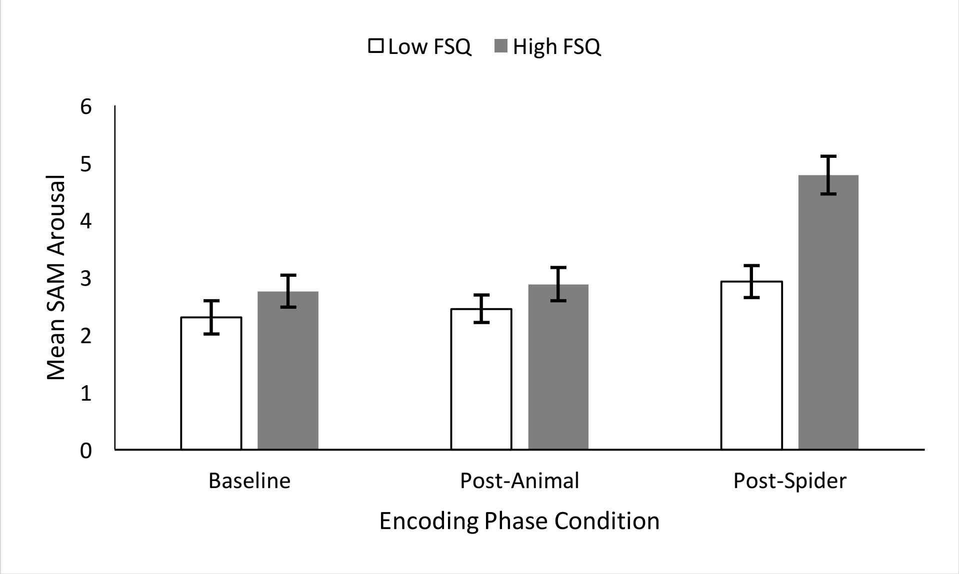

Figure 5. Mean SAM Arousal ratings for the low and high Fear of Spiders Questionnaire (FSQ) groups at baseline, following study of the animal list and following study of the spider list.

Independent t-tests revealed a significant difference between the fear of spiders groups ($t(82) = 4.32$, $p < .001$), whereby the high group reported significantly higher physiological arousal ($M = 4.79$, $SD = 2.10$) than the low fear of spiders group ($M = 2.92$, $SD = 1.83$). Importantly, as with the SAM valence data, there were no significant differences after the animal-context study words (high fear of spiders group: $M = 2.88$, $SD = 1.88$; low fear of spiders group: $M = 2.31$, $SD = 1.56$; $t(82) = 1.14$, $p = .26$) or at baseline (high fear of spiders group: $M = 2.76$, $SD = 1.82$; low fear of spiders group: $M = 2.31$, $SD = 1.88$; $t(82) = .83$, $p = .41$).

Test 1: Intentional Memory for Studied Targets

For the Test 1 analysis, we calculated accuracy rates (hit rate – false alarm rate) for each subtest for each participant. We then conducted 2 (Spider Fear Groups: high fear of spiders group, low fear of spiders group) X 2 (Recognition Test Valence: spider recognition test, animal recognition test) repeated measures ANOVA to determine whether accuracy rate differed between groups for each subtest.

The 2 X 2 ANOVA revealed no significant main effect of Recognition Test Valence ($F(1,82) < .001$, $MSE = .02$, $\eta^2 < .001$, $p = .99$). The main effect of Spider Fear Group also was not significant ($F(1,82) = 2.08$, $MSE = .03$, $\eta^2 = .03$, $p = .15$). The Recognition Test Valence X Spider Fear Group interaction was not significant ($F(1,82) = 1.16$, $MSE = .02$, $\eta^2 = .01$, $p = .28$).

Test 2: Incidental Memory for Foils

As with Test 1, we calculated subtest accuracy rates for participants. We then conducted a 2 (Spider Fear Groups: high fear of spiders group, low fear of spiders group) X 2 (Foil Valence: foils derived from the spider recognition test, foils derived from the animal recognition test) repeated measures ANOVA to compare accuracy rates.

Results of the ANOVA revealed a significant main effect of Foil Valence ($F(1,82) = 4.03$, $MSE = .01$, $\eta^2 = .05$, $p < .05$), whereby recognition of foils from the negative (spider) subtest ($M = .29$, $SD = .16$) was higher than accuracy of foils from the neutral (animal) subtest ($M = .27$, $SD = .17$). The main effect of Spider Fear Group was not significant ($F(1,82) = .31$, $MSE = .05$, $\eta^2 < .01$, $p = .58$). There also was no significant interaction between the Foil Valence and Spider Fear Groups ($F(1,82) = .09$, $MSE = .01$, $\eta^2 < .01$, $p = .77$).

Response Bias

Previous research has suggested that participants adopt a more liberal response bias when attempting to recall negative, in contrast to neutral, information (Becker & Rinck, 2004; Dougal & Rotello, 2007; Kapucu et al., 2008). To investigate response bias in our sample, we calculated criterion *C* for each participant for information tainted by threatening (spider) or neutral (animal) contexts on both Test 1 and Test 2.

Intentional Recognition Test 1. We conducted a 2 (Recognition Test Valence: spider recognition subtest, animal recognition subtest) X 2 (Spider Fear Groups: high fear of spiders group, low fear of spiders group) repeated measures ANOVA for response bias measure *C*. Results of the analysis revealed no main effect of Recognition Test Valence ($F(1,82) = 2.26$, $MSE = .05$, $\eta^2 = .03$, $p = .14$), nor an effect of Spider Fear Group ($F(1,82) = .27$, $MSE = .23$, $\eta^2 < .01$, $p = .61$). The Recognition Test Valence X Spider Fear Group interaction was not significant ($F(1,82) = 1.63$, $MSE = .05$, $\eta^2 = .02$, $p = .21$).

Incidental Recognition Test 2. We conducted a 2 (Foil Valence: foil words derived from the spider recognition subtest, foil words derived from the animal recognition subtest) X 2 (Spider Fear Groups: high fear of spiders group, low fear of spiders group) repeated measures ANOVA for response bias measure *C*. Results of the analysis revealed a main effect of Foil Valence ($F(1,82) = 4.65$, $MSE = .01$, $\eta^2 = .05$, $p < .05$), whereby response bias was more liberal for spider foils ($M = .03$, $SD = .53$) than animal foils ($M = .06$, $SD = .50$). The ANOVA also revealed a main effect of Spider Fear Group ($F(1,82) = 4.95$, $MSE = .49$, $\eta^2 = .06$, $p < .05$), such that the high fear of spiders group had a significantly more conservative response bias than the low fear of spiders group. The Foil Valence X Spider Fear Group interaction was not significant ($F(1,82) < .01$, $MSE = .01$, $\eta^2 < .01$, $p = .98$). Criterion C scores for Test 2 are shown in Table 6.

Table 6

Experiment 2 Test 2: Response Bias Measure Criterion C for Participants with High and Low Fear of Spiders (standard deviation in parentheses).

	High Fear of Spiders Group	Low Fear of Spiders Group
Spider Foils	-.19(.41)	-.14(.37)
Animal Foils	.08(.48)	.11(.43)

3.1.3 Discussion

In Experiment 2, we sought to determine whether contexts that are particularly threatening would induce a downstream memory bias for foil words tainted by those contexts. Previous works suggested that a memory advantage for emotional material would only be displayed if the threat was of particular importance to the individual (Ashbaugh & Radomsky, 2009; Ceschi et al., 2003; Cloitre & Liebowitz, 1991; Radomsky & Rachman, 1999; Radomsky et al., 2001). To this end, we instructed participants to study neutral words overlayed onto spider images and compared memory performance between individuals who self-reported a high versus low fear of spiders. On Test 2, we found a memory advantage for foil words derived from the spider Test 1 subtest. However, contrary to our hypothesis, this memory advantage was displayed by both the high and the low fear of spiders groups.

SAM (Bradley & Lang, 1994) data from our manipulation check indicated that participants reported significantly more negative valence and higher physiological arousal following the spider study list compared to both baseline and the neutral animal study list condition. Importantly, the high fear of spiders group reported a significantly more negative mood following the spider study list in comparison to the low fear of spiders group. There were also no between-group differences at either of the other two time points in the study (baseline and post-animal study list) indicating that our manipulation had the intended emotional effect. However, critically, participants from both groups reported significantly more negative moods following the spider list in contrast to following the animal study list or at baseline. As a result, the spider context images may have offered an emotional boost to words studied within this Test 1 block for both spider fear groups. The memory advantage for the spider-tainted foil words is reflected in our Test 2 results whereby all participants, regardless of spider group categorization, demonstrated higher recognition accuracy for foils derived from the spider subtest.

The results of our study further support a downstream memory advantage for emotionally tainted neutral information. Although the memory advantage for Test 1 was absent, which will be discussed later, participants still demonstrated a downstream memory bias for threat-tinged foil words during Test 2. One possible explanation is the inability to disengage attention from an anxiety-inducing cue. Anxious individuals, both clinical and subclinical groups, have been shown to have difficulty disengaging from a threatening cue (Fox et al., 2002; 2001; Gerdes, Alpers, & Pauli, 2008; Salemink, van den Hout, & Kindt, 2007). Evidence from eye-tracking studies, however, suggests that search for threatening items happens relatively quickly, compared to other stimuli (Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004). Following immediate gazing toward the threat, patients typically avoid the fearful cue (Rinck & Becker, 2006). Although eye gaze is not directed toward the threat, the inability to disengage attention from the cue suggests that threat may still influence various cognitive processes. In turn, the continued attention toward the threat may alter how incidental stimuli in the present environment are perceived. In our study then, the incidental foil words in the Test 1 subtests may have been tainted by lingering or prolonged thoughts concerning the fearful stimuli. The inability to disengage attention from the fearful cue lends an alternate account for the memory advantage for spider foils during Test 2. Why then, however, were we unable to find a difference in memory performance on Test 1?

No Memory Advantage on Test 1

High spider fear participants did not demonstrate a memory advantage for the spider study list during Test 1, contrary to what we anticipated. Previous research demonstrated a memory bias only for information that was particularly threatening (Ashbaugh & Radomsky, 2009; Ceschi et al., 2003; Cloitre & Liebowitz, 1991; Radomsky & Rachman, 1999; Radomsky et al., 2001). They did not, however, test whether there was an attentional or memory advantage for other information found within the context or made related to the threatening target item. The spider images may have proven to be a distraction for participants when going through the study list. Drawing from other research, attention and working memory resources are often directed toward sources of threat (Bishop et al., 2004, 2007; Cisler & Koster, 2010; Stout, Shackman, & Larson, 2013) As a result, memory for the target words in Test 1 may not have benefitted from the affective mood because attention was directed to the spider images, instead of to the target words. In addition, when an anxious cue is present, memory for central features is enhanced, while memory for peripheral information decreases (Wessel & Merkelbach, 1998; 1997). Both attention and memory processes may have been directed toward the fearful cues instead of the intended neutral words.

Conservative Response Bias for High Fear of Spiders Group

Previous research had also indicated that participants would demonstrate a more liberal response bias for emotional material, as opposed to neutral information (Dougal & Rotello, 2007; Kapucu et al., 2008). Test 2 results revealed that low fear spider fear participants did indeed adopt a more liberal response bias. Interestingly, in contrast with previous work (Becker & Rinck, 2004), the high fear of spiders group demonstrated a more conservative response bias. Past studies have investigated response bias when directed toward emotional, versus unemotional, material. However, all words studied and tested throughout our experiment were inherently neutral in valence. Participants may be less prone to report a neutral item as seen before, even if the word was encoded within a threatening context. Another possibility is that downstream memory response bias may manifest differently than response bias patterns for immediate intentional items. We would then only find the liberal response bias in Test 2, and not during Test 1. The conservative response bias displayed by the high spider fear group may be a result of narrowed focus directed toward the spiders, taking attention away from the foils in the spider Test 1 block. In fact, while evidence shows enhanced memory for central, spider stimuli, memory for peripheral details suffers (Wessel & Merkelbach, 1998; 1997). Therefore, the narrowing of focus toward the spider images themselves may have elicited the conservative response bias.

Our results further contribute to the work regarding the ‘source-constrained retrieval’ hypothesis by showing that the memory-for-foils effect can be extended to threat-relevant encoding contexts. Participants in both the high and low fear of spiders groups reported a significantly more negative mood following presentation of the spider study list. As a consequence, foil words that were intermixed among the spider study words received a memory benefit from the emotionally (negative) mode of processing. This benefit was reflected in the comparatively high recognition accuracy during Test 2 for the spider-tainted foil words compared to the neutral, animal-tainted foil words. Although no memory differences were found in Test 1, our results demonstrate that initial encoding contexts can lead to downstream memory biases.

Chapter 4: General Discussion

The goal of this thesis was to investigate whether emotional encoding contexts could in turn influence how we perceive and remember incidental stimuli present in the environment, when we search for those emotionally-tainted targets later on. In a compelling line of work, Jacoby and colleagues (2005a; 2005b) introduced the source-constrained retrieval hypothesis, suggesting we can constrict our retrieval search patterns for information encoded using a particular processing type. As a consequence, incidental information we encounter while retrieving target information itself becomes tainted by that mode of processing. To this point, it was unclear whether incidental information would be similarly tainted by a re-activated emotional mode of processing. As such, in this thesis, we investigated whether the memory benefit offered by emotional pictures (Bishop et al., 2004; Bradley et al., 1992; Danion et al., 1995; Cahill & McGaugh, 1996; Kensinger & Corkin, 2003a, 2003b; Phelps & Sharot, 2008) would be conferred on incidental foil words.

In Chapter 2, we investigated this research question by presenting participants with words overlayed over an image that was either negative or neutral in valence. Using an adapted memory-for-foils paradigm (Jacoby et al., 2005a; 2005b), we found that participants with high trait anxiety displayed a memory advantage for incidental information (foils) tainted by a negative mode of processing. The results of Experiment 1 extend the findings from previous research examing the source-constrained retrieval hypothesis to an emotional mode of processing. Importantly, only high anxiety participants demonstrated the downstream memory advantage for foils. Low trait anxiety participants did not display any differences in memory between the foils encountered among negatively versus neutrally encoded target words; this result suggests that individual differences in trait anxiety play a role in how information is retrieved.

One notable limitation of our first experiment is that we had no way of verifying whether participants had different affective responses to the negative context images. This is problematic as affect and arousal levels can influence memory performance (Yerkes & Dodson, 1908), and likely the ability to constrain search to a particular emotional mode of processing. To address this issue, in Chapter 3, we described an experiment where we instructed spider phobic participants to study words overlayed on pictures of spiders. We also conducted a manipulation check to verify whether participants responded to the emotional conditions as intended. In this study, we found that participants demonstrated a memory advantage for the incidental information (foils) tainted with the threat-relevant (spider) mode of processing. However, contrary to expectations, the memory advatange was demonstrated by all participants, regardless of self-reported spider fear. Importantly, and possibly offering an explanation for the low spider group memory advantage, data from our manipulation check indicated that the low spider group reported more negative mood ratings following the threatening spider study list. Hence, both groups may have been emotionally affected by the threat encoding condition, resulting in the downstream memory advantage for foils encountered within the recognition test for targets encoded with spider contexts.

No Memory Advantage on Test 1

For both studies, we were unable to find the anticipated Test 1 memory advantage for negative or threatening information (Ashbaugh & Radomsky, 2009; Ceschi et al., 2003; Cloitre & Liebowitz, 1991; Cody & Teachman, 2010; Coles et al., 2007; Phelps & Sharot, 2008; Radomsky & Rachman, 1999; Radomsky et al., 2001). A possible explanation is that previous research found a memory advantage specifically for fearful or negative information. The tested information in our study was neutral words that were placed within a negative context, as opposed to the negative context pictures. When present, anxious or fearful cues have been shown to draw attention away from peripheral details (Bishop et al., 2004; Bishop et al., 2007; Cisler & Koster, 2010), which make central details more memorable, but at the cost of the peripheral information (Wessel & Merkelbach, 1998;1997). As a result, memory for the neutral words did not receive a memory benefit from paired negative or threatening images. The question then is why did we see a memory advantage for the negatively-tinged and threat-tinged foil words?

Memory Advantage for Negatively-tainted Foils

As shown in previous studies, information can become associated with a threat-relevant source (Senn & Radomsky, 2012). Research on recapitulation suggests that neural regions, including the amygdala and the left inferior frontal gyrus, that were originally active when encoding negative information, are reactivated during retrieval (Bowen & Kensinger, 2017; Rugg et al., 2008; Vogelsang et al., 2016). As a result, these regions that are known to enhance memory performance, such as the amygdala, may also be active when encoding incidental foil words during the recognition test (Test 1). Some work even suggests that regions integral to the memory process, such as the amygdala and the hippocampus, return to a more active state when an individual attempts to recall neutral information that has become associated with a negative context, as opposed to a neutral or unemotional context (Dunsmoor, Murty, Davachi, & Phelps, 2015; Ford, Morris, & Kensinger, 2014; Smith, Henson, Dolan, & Rugg, 2004). Therefore, during Test 2, following incidental encoding of the foil words during the recognition test for negative targets (Test 1), the now negatively-tinged foils were better remembered than the neutrally-tinged foil words.

Disengagement of Attention

The attention literature may offer an alternative account for why we see a memory advantage for negatively-tinged foils (Test 2), but not target words that were encoded in negative contexts (Test 1). Individuals who encounter anxiety invoking stimuli have been shown to have difficulty disengaging from the fearful cue (Fox et al., 2002; 2001; Gerdes et al., 2008; Salemink et al., 2007). After being presented with fearful items (negative or spider context pictures), attention may have been fixated on those stimuli even after the pictures were no longer displayed. Consequently, although the manipulation did not influence memory performance during Test 1, the lingering attention on the anxiety provoking visual contexts conferred a benefit to memory later on, during Test 2.

Motivation may also play a role in the ability to attend to a threatening stimulus. In a recent study, Nelson and colleagues (2015) found that motivation was associated with an individual's tendency to direct attention towards, or to avoid, a threatening stimulus. As our study did not include a measure of motivation to attend to or avoid the negative context pictures, we cannot determine whether motivation was a factor in directing attention amongst our sample group. It is important for future research to include a measurement of motivation to distinguish those with a tendency to approach threats, from those who tend to avoid them.

Response Bias Patterns

Replicating the results of previous work, Test 1 response bias patterns in Experiment 1 were significantly more liberal during the recognition subtest for target words overlayed onto negative contexts (Becker & Rinck, 2004; Dougal & Rotello, 2007; Kapucu et al., 2008). However, response bias patterns varied drastically between the two experiments detailed in this thesis. During Experiment 1, high trait anxiety participants who had studied words using a shallow encoding instruction adopted a more liberal response pattern for foils derived from the negative recognition test block. In contrast, during Experiment 2, high spider fear participants displayed a significantly more conservative response bias for the words derived from the spider subtest. The answer as to why there was a difference between the studies may lie in the specificity of the threat source. As a speculatory explanation, the tendency to treat all sources as negative when presented with many sources of threat (Experiment 1) may induce a more liberal response bias. In contrast, when focusing on one particular, specific source of threat, such as the spiders in Experiment 2, it may be more prudent to constrain one's search patterns. However, as research in downstream response bias is limited, more work must be conducted before final conclusions can be made.

Limitations and other Directions

To investigate the influence of anxiety on memory, there are two experimental approaches one could take. The first, as in this thesis, is to investigate individual differences in the sample group itself. In Chapters 2 and 3, we conducted experiments that considered individual differences based on neuropsychological scale measurements. In Experiment 1, our anxiety groups were categorized according to a median split based on participants' scores on the DASS (Lovibond & Lovibond, 1995). However, using a median split to develop our groups may not have been ideal as the median can vary based on our sample group. To address this issue, in Experiment 2, the high and low spider fear groups were selected from those who scored in the top 25% and bottom 25% on the FSQ (Szymanski & O'Donohue, 1995). In this way, we were able to collect data from those with an extremely high fear relative to a control group with extremely low fear of spiders.

There is, however, an alternative to the individual differences approach. Specifically, one could create an experimental manipulation to induce a state of anxiety. In Experiment 2, both the high and low fear of spiders groups demonstrated a memory advantage for the spider foils. As explained previously, the high and low fear of spiders groups reported a more negative mood state following presentation of the spiders. Although they had indicated no fear of spiders, they still reacted with a more emotional response toward them, relative to baseline and following the neutral animal study list. In this case, our threatening condition seems to have been successful in inducing an anxious state in both our high and low fear of spiders groups.

It is worth noting in this thesis that an additional study was previously conducted in which we attempted to manipulate emotional state, and then observe the effect that this had on memory within the memory for foils paradigm. In Experiment 3, we used negative or neutral film clips to induce anxiety. For the sake of brevity, I present the data from this experiment for illustrative purposes, but note that the experiment did not lead to significant effects on memory. As shown in Figure 6, we did not see any differences in memory performance on Test 1 or Test 2 regardless of reported anxiety level. Here the paradigm was identical to that in Experiment 1, although there were no negative or neutral context images. Instead, participants either saw the negative (2 minute clip of death scene from the movie Lion King) or neutral film clip (2 minute documentary of deer in the woods), prior to studying a set of visually-presented words during encoding. The remainder of the procedure was the same as in Experiments 1 and 2. As can be seen from Figure 6, this attempt to induce anxiety failed to have the intended effect on either Test 1 or Test 2. However, this general approach of manipulating emotional state rather than splitting participants into groups based on individual difference measures is a viable alternative approach. It is possible that a stronger manipulation of emotional state might have been successful in influencing memory, and future research can explore this possibility.

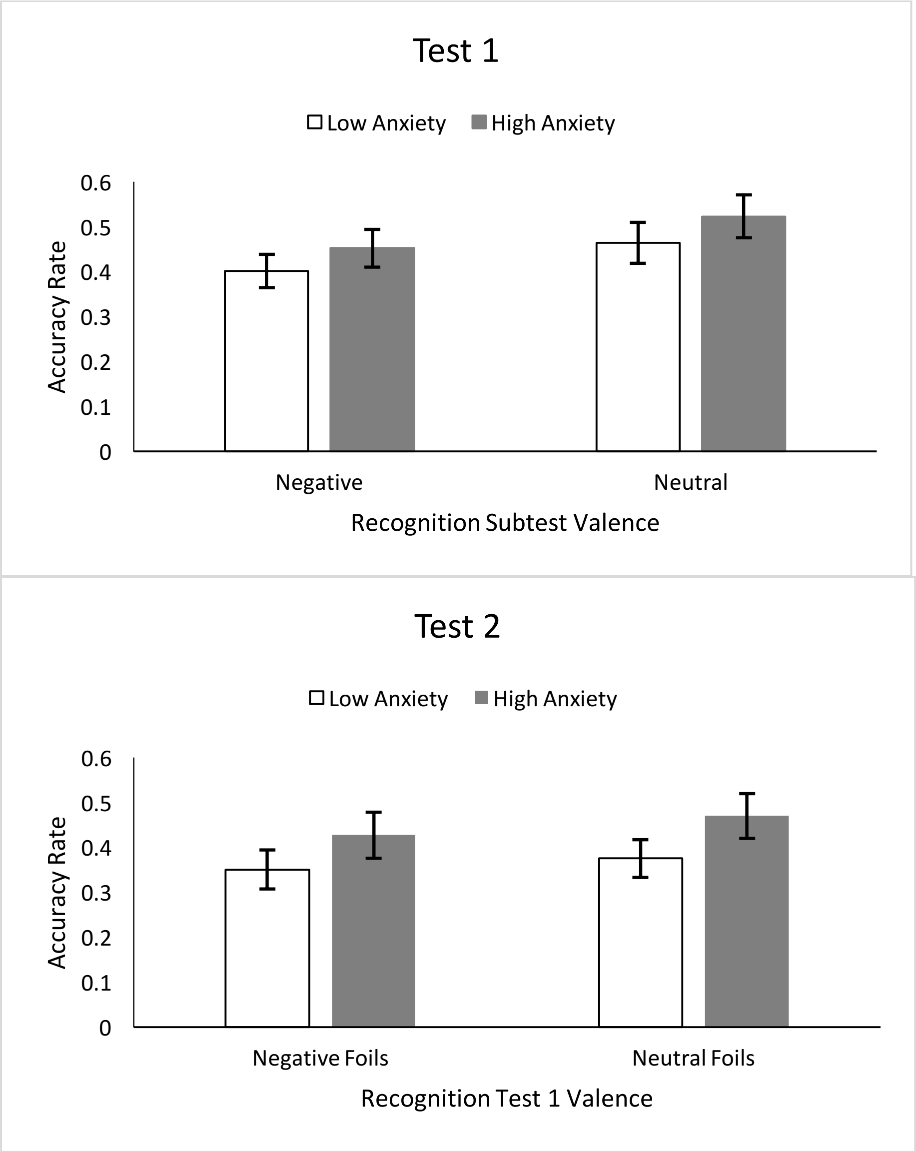

Figure 6. Experiment 3: Accuracy Rate on Test 1 (top) and Test 2 (bottom) for high and low anxiety groups.

Another limitation of Experiment 2 to consider is the use of self-report questionnaires to identify our spider fear groups. According to our manipulation check, both the high and low fear of spiders groups indicated an increase in arousal following the spider study list. This is of particular concern for the low fear of spiders group, since they should have had no emotional reponse to the spiders. One possibility is that self-reporting fear may be difficult for participants to do accurately, particularly when prompted outside the context of the feared situation. In line with the discussion on anxiety manipulations, future research could expose participants to the fearful stimulus, and use physiological and self-report measures during exposure to identify fear groups.

Individual Differences in Anxiety and Anxiety Manipulations

Thus, our findings using anxiety inductions to this point have been rather inconsistent. If we consider, though, that the response bias patterns differ between our spider fear groups, the picture becomes a bit clearer. It is true that both high and low spider fear groups demonstrated a memory advantage for the foils, but the high spider fear group also adopted a considerably more conservative response pattern than the low fear group. If the response patterns had remained equal, we might have seen the predicted memory performance by spider fear group interaction. Thus, it is important to consider both individual differences in trait anxiety as well as anxiety manipulations when determining the influence that anxiety has over memory.

Future Directions

It is important for future research to determine the exact process by which tainted information is influenced by initial encoding contexts. Previous research on recapitulation suggests that when retrieving information encoded using a particular mode of processing (i.e., an emotional mode of processing), areas such as the amygdala and the inferior frontal gyrus, involved at initial encoding become reactivated (Bowen & Kensinger, 2017; Buckner et al., 2001; Rugg et al., 2008; Vogelsang et al., 2016). We were unable to find the predicted behavioural differences in memory performance during Test 1. It is possible that the neural regions involved in emotional processing were not active at the necessary level to produce behavioural effects on memory performance. Another possibility is that we may only see differences in memory performance if the studied and tested items are themselves emotional. In this case, participants would study threatening words and not neutral target words overlayed on threat-relevant visual contexts, as in this thesis.

Whether or not the presence of a fearful cue, or a 'constrained retrieval search' of items tainted by negative emotion, will influence perception of other items present while in that mode of processing is an important question to answer. For example, if a spider phobic were to see a spider in their kitchen, would other items contained within that room become 'contaminated' (hold a negative tag) moving forward? As shown by Senn and Radomsky (2012) otherwise neutral information, such as a kitchen, can be influenced by a negative cue, such as a spider. Consequently, a kitchen could indeed become tainted, hindering the individual's everyday routine.

In addition, it is also important to pinpoint and understand the role of anxiety on memory. Our findings demonstrate that anxiety does play some role in incidental recognition memory. In Experiment 1, only the high anxiety group demonstrated the memory advantage for negatively-tainted foils. While we did not find a between-groups difference in recognition memory performance in Experiment 2, the high spider fear group did adopt a far more conservative response pattern. Notably, these between anxiety group differences across experiments vary quite drastically. It is important for future research in this area to clarify the influence of anxiety on memory and to determine the influence of individual differences in anxiety on memory.

4.1 Conclusion

Emotional events from the past can taint our perception of the present, making current circumstances more memorable. When we constrain our memory search to information or events encountered within a negative context, or learned using a negative mode of processing, some memory benefit held by those thoughts may be conferred on incidental stimuli within our current environment. Of note, this downstream memory bias was not displayed by individuals who reported low anxiety. Results of Experiment 1 suggest that high trait anxiety may alter how threatening information is processed and later remembered. In Experiment 2, all participants reported a more negative mood following presentation of the threat-relevant study list, and this may account for our finding of a memory advantage for foils encountered while in that threat-related mode of processing. Results further support the source-constrained retrieval hypothesis and extend the phenomenon to an emotional mode of processing.

References

Alban, M., & Kelley, C. (2012). Variations in constrained retrieval. *Memory & Cognition, 40*(5), 681-692.

Ashbaugh, A., & Radomsky, A. (2009). Interpretations of and memory for bodily sensations during public speaking. *Journal of Behavior Therapy and Experimental Psychiatry, 40*(3), 399-411.

Baddeley, A. (1966). The influence of acoustic and semantic similarity on long-term memory for word sequences. *Quarterly Journal of Experimental Psychology, 18*(4), 302-309. doi: 10.1080/14640746608400047

Becker, E., & Rinck, M. (2004). Sensitivity and response bias in fear of spiders. *Cognition and Emotion, 18*(7), 961-976. doi:10.1080/02699930341000329

Bishop, S., Dalgleish, T., & Yule, W. (2004). Memory for emotional stories in high and low depressed children. *Memory, 12*(2), 214-230.

Bishop, S., Duncan, J., Brett, M., & Lawrence, A. (2004). Prefrontal cortical function and anxiety: Controlling attention to threat-related stimuli. *Nature Neuroscience, 7*(2), 184-188.

Bishop, S., Jenkins, R., & Lawrence, A. (2007). Neural processing of fearful faces: Effects of anxiety are gated by perceptual capacity limitations. *Cerebral Cortex, 17*(7), 1595-1603.

Bowen, H., & Kensinger, E. (2017). Recapitulation of emotional source context during memory retrieval. *Cortex, 91*, 142-156. doi:10.1016/j.cortex.2016.11.004

Bower, G. (1981). Mood and memory. *American Psychologist, 36*(2), 129-148. doi: 10.1037/0003-066X.36.2.129

Bradley, M., & Lang, P. (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings. In t. c. psychophysiology, *Technical report C-1* (pp. 1-45). University of Florida.

Bradley, M., Greenwald, M., Petry, M., & Lang, P. (1992). Remembering pictures: Pleasure and arousal in memory. *Journal of Experimental Psychology: Learning, Memory and Cognition, 18*(2), 379-390.

Buckner, R.L., Wheeler, M.E., & Sheridan, M.A. (2001). Encoding Processes during Retrieval Tasks. *Journal of Cognitive Neuroscience, 13*(3), 406-415. doi: 10.1162/08989290151137430

Cahill, L., & McGaugh, J. (1996). Modulation of memory storage. *Current Opinion in Neurobiology, 6*(2), 237-242.

Ceschi, G., Van der Linden, M., Dunker, D., Perroud, A., & Bredart, S. (2003). Further exploration memory bias in compulsive washers. *Behaviour Research and Therapy, 41*(6), 737-748.

Cisler, J.M., & Koster, E.H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical Psychology Review, 30*(2), 203-216. doi: 10.1016/j.cpr.2009.11.003

Cloitre, M., & Liebowitz, M. (1991). Memory bias in panic disorder: An investigation of the cognitive avoidance hypothesis. *Cognitive Therapy and Research, 15*(5), 371-386.

Cody, M., & Teachman, B. (2010). Post-event processing and memory bias for performance feedback in social anxiety. *Journal of Anxiety Disorders, 24*(5), 468-479.

Coles, M., & Heimberg, R. (2002). Memory biases in the anxiety disorders: Current status. *Clinical Psychology Review, 22*(4), 587-627.

Coles, M., Turk, C., & Heimberg, R. (2007). Memory Bias for Threat in Generalized Anxiety Disorder: The Potential Importance of Stimulus Relevance. *Cogntiive Behaviour Therapy, 36*(2), 65-73.

Danckert, S.L., MacLeod, C.M., & Fernandes, M.A. (2011). Source-constrainted retrieval influences the encoding of new information. *Memory & Cognition, 39*(8), 1374-1386.

Danion, J., Kauffmann-Muller, F., Grange, D., Zimmermann, M., & Greth, P. (1995). Affective valence of words, explicit and implicit memory in clinical depression. *Journal of Affective Disorders, 34*(3), 227-234.

Dougal, S., & Rotello, C. (2007). “Remembering” emotional words is based on response bias, not recollection. *Psychonomic Bulletin & Review, 14*(3), 423-429.

Dunsmoor, J., Murty, V., Davachi, L., & Phelps, E. (2015). Emotional learning selectively and retroactively strengthens memories for related events. *Nature, 520*(7547), 345-348. doi:10.1038/nature14106

Ehlers, A., & Clark, D. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy, 38*(4), 319-345.

Erk, S., Kiefer, M., Grother, J., Wunderlich, A., Spitzer, M., & Walter, H. (2003). Emotional context modulates subsequent memory effect. *NeuroImage, 18*(2), 439-447.

Ford, J., Morris, J., & Kensinger, E. (2014). Effects of emotion and emotional valence on the neural correlates of episodic memory search and elaboration. *Journal of Cognitive Neuroscience, 26*(4), 825-839. doi:10.1162/jocn_a_00529

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition & Emotion, 16*(3), 355-379. doi:10.1080/02699930143000527

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General, 130*(4), 681-700. doi:10.1037/0096-3445.130.4.681

Gerdes, A., Alpers, G., & Pauli, P. (2008). When spiders appear suddenly: Spider-phobic patients are distracted by task-irrelevant spiders. *Behaviour Research and Therapy, 46*(2), 174-187. doi:10.1016/j.brat.2007.10.010

Greenwald, A., McGhee, D., & Schwartz, J. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology, 74*(6), 1464-1480. doi:10.1037/0022-3514.74.6.1464

Halamish, V., Goldsmith, M., & Jacoby, L. (2012). Source-constrained recall: Front-end and back-end control of retrieval quality. *Journal of Experimental Psychology: Learning, Memory and Cognition, 38*(1), 1-15.

Huijding, J., & de Jong, P. (2005). A pictorial version of the extrinsic affective simon task: Sensitivity to generally affective and phobia-relevant stimuli in high and low spider fearful individuals. *Experimental Psychology, 52*(4), 289-295. doi:10.1027/1618-3169.52.4.289

Jacoby, L., Shimizu, Y., Daniels, K., & Rhodes, M. (2005a). Modes of cognitive control in recognition and source memory: Depth of retrieval. *Psychonomics Bulletin & Review, 12*(5), 852-857.

Jacoby, L., Shimizu, Y., Velanova, K., & Rhodes, M. (2005b). Age differences in depth of retrieval: Memory for foils. *Journal of Memory and Language, 52*(4), 493-504.

Jiang, M., & Vartanian, L. (2012). Attention and memory biases toward body-related images among restrained eaters. *Body Image, 9*, 503-509.

Kantner, J., & Linsay, D. (2012). Top-down constraint on recognition memory. *Memory & Cognition, 41*(3), 465-479.

Kapucu, A., Rotello, C., Ready, R., & Seidl, K. (2008). Response bias in "remembering" emotional stimuli: A new perspective on age differences. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*(3), 703-711.

Kensinger, E., & Corkin, S. (2003a). Effect of negative emotional content on working memory and long-term memory. *Emotion, 3*(4), 378.

Kensinger, E., & Corkin, S. (2003b). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory & Cognition, 31*(8), 1169-1180.

Kolers, P. (1973). Remembering operations. *Memory & Cognition, 1*(3), 347-355.

Kolers, P., & Roediger, H. (1984). Procedures of mind. *Journal of Verbal Learning and Verbal Behavior, 23*(4), 425-449.

Lang, P., Bradley, M., & Cuthbert, B. (2008). International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual. *Technical Report A-8*.

Lovibond, S., & Lovibond, P. (1995). Manual for the Depression Anxiety Stress Scales. *Psychology Foundation, 2nd. Ed.*

MacLeod, C.M., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15-20.

Marsh, R., Meeks, J., Cook, G., Clark-Foos, A., Hicks, J., & Brewer, G. (2009). Retrieval constraints on the front end create differences in recollection on a subsequent test. *Journal of Memory and Language, 61*(3), 470-479.

Mathews, A., & Mackintosh, B. (1998). A cognitive model of selective processing in anxiety. *Cogntiive Therapy and Research, 22*(6), 539-560.

Mathews, A., Mackintosh, C., Williams, S., Williams, M., & Kirkby, K. (2016). Habituation of self-reported anxiety and cortical hyper-vigilance during image-based exposure to spiders. *Journal of Behavior Therapy and Experimental Psychiatry, 54*, 150-157. doi:10.1016/j.jbtep.2016.07.012

Mathews, A., Naran, N., & Kirkby, K. (2015). Symbolic online exposure for spider fear: Habituation of fear, disgust and physiological arousal and predictors of symptom improvement. *Journal of Behavior Therapy and Experimental Psychiatry, 47*, 129-137. doi:10.1016/j.jbtep.2014.12.003

Mayer, B., Merckelbach, H., & Muris, P. (2000). Self-reported automaticity and irrationality in spider phobia. *Psychological Reports, 87*(2), 395-405. doi:10.2466/pr0.2000.87.2.395

Merckelbach, H., de Jong, P., Muris, P., & van den Hout, M. (1996). The etiology of specific phobias: A review. *Clinical Psychology Review, 16*(4), 337-361. doi:10.1016/0272-7358(96)00014-1

Miltner, W., Krieschel, S., Hecht, H., Trippe, R., & Weiss, T. (2004). Eye movements and behavioral repsonses to threatening and nonthreatening stimuli during visual search in phobic and nonphobic subjects. *Emotion, 4*(4), 323-339. doi:10.1037/1528-3542.4.4.323

Mitte, K. (2008). Memory bias for threatening information in anxiety and anxiety disorders: A meta-analytic review. *Psychological Bulletin, 134*(6), 886-911. doi:10.1037/a0013343

Mogg, K., & Bradley, B. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy, 36*(9), 809-848. doi:10.1016/S0005-7967(98)00063-1

Mogg, K., & Bradley, B. (2006). Time course of attentional bias for fear-relevant pictures in spider-fearful individuals. *Behvaiour Research and Therapy, 44*(9), 1241-1250. doi:10.1016/j.brat.2006.05.003

Morris, C., Bransford, J., & Franks, J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Behavior, 16*(5), 519-533.

Muller, C., Kull, S., Wilhelm, F., & Michael, T. (2011). One-session computer-based exposure treatment for spider-fearful individuals - Efficacy of a minimal self-help intervention in a randomised controlled trial. *Journal of Behavior Therapy and Experimental Psychiatry, 42*(2), 179-184. doi:10.1016/j.jbtep.2010.12.001

Nelson, A.L., Purdon, C., Quigley, L., Carriere, J., & Smilek, D. (2015). Distinguishing the roles of trait and state anxiety on the nature of anxiety-related attentional biases to threat using a free viewing eye movement paradigm. *Cognition and Emotion, 29*(3), 504-526. doi: 10.1080/02699931.2014.922460

Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*(3), 466-478. doi:10.1037/0096-3445.130.3.466

Phelps, E., & Sharot, T. (2008). How (and why) emotion enhances the subjective sense of recollection. *Current Directions in Psychological Science, 17*(2), 147-152. doi:10.111/j.1467-8721.2008.00565.x

Radomsky, A., & Rachman, S. (1999). Memory bias in obsessive-compulsive dirsorder (OCD). *Behaviour Research and Therapy, 37*(7), 605-618.

Radomsky, A., Rachman, S., & Hammond, D. (2001). Memory bias, confidence and responsibility in compulsive checking. *Behaviour Research and Therapy, 39*(7), 813-822.

Rinck, M., & Becker, E. (2006). Spider fearful individuals attend to threat, then quickly avoid it: Evidence from eye movements. *Journal of Abnormal Psychology, 115*(2), 231-238. doi:10.1037/0021-843X.115.2.231

Rinck, M., & Becker, E. (2007). Approach and avoidance in fear of spiders. *Journal of Behavior Therapy and Experimental Psychiatry, 38*(2), 105-120. doi:10.1016/j.jbtep.2006.10.001

Roediger, H., Gallo, D., & Geraci, L. (2002). Processing approaches to cognition: The impetus from the levels-of-processing framework. *Memory, 10*(5-6), 319-332.

Rugg, M.D., Johnson, J.D., Park, H., & Uncapher, M.R. (2008) Encoding-retrieval overlap in human episodic memory: A functional neuroimaging perspective. *Progress in Brain Research, 169*, 339-352. doi: 10.1016/S0079-6123(07)00021-0.

Salemink, E., van den Hout, M., & Kindt, M. (2007). Selective attention and threat: Quick orienting versus slow disengagement and two version of the dot probe task. *Behaviour Research and Therapy, 45*(3), 607-615. doi:10.1016/j.brat.2006.04.004

Schneider, W., Eschman, A., & Zuccolotto, A. (2001). *E-Prime user's guide.* Pittsburgh: Psychology Software Tools, Inc.

Senn, J., & Radomsky, A. (2012). Well that changes everything! The genesis of memory bias for threat with implications for delayed onset in anxiety disorders. *Journal of Behavior Therapy and Experimental Psychiatry, 43*(4), 1019-1025.

Shimizu, Y., & Jacoby, L. (2005). Similarity-guided depth of retrieval: Constraining at the front end. *Canadian Journal of Experimental Psychology, 59*(1), 17-21.

Smith, A.P.R., Henson, R.N.A., Dolan, R.J., & Rugg, M.D. (2004). fMRI correlates of the episodic retrieval of emotional contexts. *Neuroimage, 22*(2), 868-878. doi:doi.org/10.1016/j.neuroimage.2004.01.049

Stout, D., Shackman, A., & Larson, C. (2013). Failure to filter: Anxious individuals show inefficient gating of threat from working memory. *Frontiers in Human Neuroscience, 7*. doi:10.3389/fnhum.2013.00058

Szymanski, J., & O'Donohue, W. (1995). Fear of Spiders Questionnaire. *Journal of Behavioural Therapy and Experimental Psychiatry, 26*(1), 31-34. doi:10.1016/0005-7916(94)00072-T

Teachman, B., & Woody, S. (2003). Automatic processing in spider phobia: Implicit fear associations over the course of treatment. *Journal of Abnormal Psychology, 112*(1), 100-109. doi:10.1037/0021-843X.112.1.100

Vogelsang, D., Bonnici, H., Bergstrom, Z., Ranganath, C., & Simons, J. (2016). Goal-directed mechanisms that constrain retrieval predict subsequent memory for new "foil" information. *Neuropsychologia, 89*, 356-363. doi:doi.org/10.1016/j.neuropsychologia.2016.07.016

Wessel, I., & Merckelbach, H. (1997). The impact of anxiety on memory for details in spider phobics. *Applied Cognitive Psychology, 11*(3), 223-231.

Wessel, I., & Merckelbach, H. (1998). Memory for threat-relevant and threat-irrelevant cues in spider phobics. *Cognition and Emotion, 12*(1), 93-104.

Yerkes, R., & Dodson, J. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18*(5), 459-482. doi:10.1002/cne.920180503

Appendix A: Experiment 1 Word Lists

Negative Study Words	Neutral Study Words	Negative Test 1 Foil Words	Neutral Test 1 Foil Words
Adult	Army	Assassin	Banner
Art	Bar	Avenue	Barrel
Bathtub	Bees	Body	Bench
Beast	Book	Butterfly	Bird
Boy	Brother	Cabinet	Bottle
Bullet	Car	Casino	Candy
Child	Clock	Cliff	Circle
Chocolate	Cockroach	Crown	Clothing
Cottage	Dentist	Diver	Cow
Dancer	Doll	Door	Detail
Dog	Dove	Fabric	Elevator
Elbow	Face	Flag	Family
Fire	Fork	Frog	Farm
Fish	Friend	Fur	Foot
Glass	Gymnast	Hairdryer	Grass
Golfer	Hairpin	Hay	Hamburger
Hat	Hospital	Hotel	Hawk
Infant	Insect	Jelly	Honey
Ink	Journal	Kids	Iron
Kitten	Lamb	Lamp	Jug
Lake	Letter	Lightbulb	Lawn
Lump	Material	Market	Lion
Maniac	Mosquito	Mother	Machine
Mountain	Office	Muffin	Medicine
Nurse	Owl	Paint	Needle
Paper	Penthouse	Pencil	Part
Person	Pest	Pet	Patient
Poster	Puppy	Radio	Pie
Priest	Rat	Reptile	Python
Rabbit	Rock	Sailboat	River
Scholar	Scorpion	Statue	Shark
Ship	Stool	Taxi	Skyscraper
Spider	Swimmer	Teacher	Stove
Tank	Truck	Trumpet	Tower
Vest	Watch	Wagon	Violin
Wasp	Wife	Woman	Whistle

Test 2 Foil Words

Astronaut
Bandage
Basket
Bathroom
Board
Bowl
Boxer
Building
Cake
Cat
Cellar
Chair
City
Coin
Cord
Criminal
Curtains
Doctor
Dress
Egg
Engine
Father
Field
Finger
Flower
Garbage
Garden
Girl
Gun
Hammer
Hand
Highway
Horse
House
Hydrant
Item
Kettle
Key
King
Lantern
Lightning
Locker
Mail
Man
Metal
Milk
Mushroom
Nun
Pamphlet
Pancakes
Pasta
People
Pig
Pizza
Plane
Queen
Restaurant
Roach
Salad
Seat
Snake
Sphere
Street
Table
Thief
Tool
Umbrella
Vehicle
Volcano
Window
Writer
Yacht

Appendix B: Experiment 2 Word Lists

Spider Study Words	Animal Study Words	Spider Test 1 Foil Words	Animal Test 1 Foil Words
adult	army	assassin	banner
art	bar	avenue	barrel
bathtub	basket	body	bench
bowl	book	cabinet	bottle
boy	brother	casino	candy
bullet	butter	cliff	circle
cane	car	cord	clothing
chair	clock	crown	detail
chocolate	clouds	diver	elevator
cottage	coin	fabric	face
dancer	dentist	flag	family
egg	dinner	fur	farm
elbow	dirt	hairdryer	finger
fire	doll	hay	foot
glass	door	jelly	fungus
golfer	face	kids	grass
hat	fork	lamp	hamburger
hotel	friend	lightbulb	hawk
ink	gymnast	mantel	honey
iron	hairpin	market	jewel
lake	hospital	milk	jug
lantern	journal	mother	lawn
mountain	letter	muffin	machine
nurse	material	paint	medicine
ocean	office	pencil	museum
paper	patent	radio	needle
person	penthouse	sailboat	part
poster	pest	statue	pasta
priest	rock	street	patient
salad	stool	taxi	pie
scholar	swimmer	teacher	river
ship	truck	tree	skyscraper
stove	vehicle	trumpet	spring
table	watch	utensil	tower
tank	wife	wagon	umbrella
vest	windmill	woman	whistle

Test 2 Foil Words

ace
alien
alley
ankle
astronaut
bathroom
beach
bed
board
boxer
building
cake
cellar
chin
city
coast
column
criminal
curtains
diploma
doctor
dress
earth
engine
errand
father
field
flower
foam
garbage
garden
girl
gun
hammer
hand
highway
house
hydrant
item
ketchup
kettle
key
king
knot
lightning
locker
mail
man
metal
mushroom
news
nun
pamphlet
pancakes
people
pig
pillow
pizza
plane
queen
razor
restaurant
runner
seat
sphere
tennis
thief
tool
volcano
window
writer
yacht