THE ROLE OF WORKING MEMORY IN SPATIAL SELECTIVE ATTENTION FOR EMOTIONAL FACIAL EXPRESSIONS IN SOCIAL ANXIETY

by

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(Under the Direction of Nader Amir)

ABSTRACT

Individuals with social anxiety show attentional bias for threat-related information (Asmundson & Stein, 1994; Bradley, Mogg, Falla, & Hamilton, 1998; MacLeod, Mathews, & Tata, 1986). Studies have used the probe detection task to index attentional bias. However, the cognitive processes that may cause such a bias remain unclear. There is emerging evidence that the contents of working memory may influence selective attention to stimuli in one's environment (Awh, Anllo-Vento, & Hillyard, 2000; Desimone, 1996; Downing, 2000). Prior to social or performance situations socially anxious people often report experiencing negative cognitions and imagery related to these situations. Consequently, the contents of working memory may bias attention toward negative aspects of the event (e.g., physiological arousal, ambiguous facial expressions, etc.). The present study examines this hypothesis by introducing a working memory task into a probe detection task.

INDEX WORDS: Information processing, Social anxiety, Working memory

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B.S., Ohio University, 1999

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2003

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August 2003

ACKNOWLEDGEMENTS

I would like to thank Heide Klumpp, Amy Selvig, Courtney Beard, Robert Brady, Jennifer Hewett, and Nader Amir for their constructive criticism, help in data collection, and general contributions that have created an enjoyable work environment. Steve Beach and Kimberly Shipman were very helpful in the planning stages of this project and have certainly improved its quality through their suggestions. A special thanks is extended to Nader Amir for sharing his enthusiasm for research, creativity, and expertise in computer programming, experimental design, and statistical analysis. You have set a fine example for me to follow.

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CHAPTER 1

INTRODUCTION

Social Phobia is defined as marked and persistent fear of one or more social or performance situations in which an individual is exposed to unfamiliar people or to possible scrutiny by others (DSM-IV American Psychological Association, 1994). Socially anxious individuals commonly experience physical symptoms such as blushing, increased heart rate, sweating, dry mouth, and nausea in social or performance situations. In addition, individuals with social phobia experience negative cognitions in social situations. These include thoughts such as "Everyone can see how nervous I am," "I look stupid," or "I'm boring." Individuals with social phobia attempt to reduce these uncomfortable physical and cognitive symptoms by avoiding social interactions whenever possible. They also engage in behavioral avoidance: avoiding eye contact, speaking in sheepish tone, slouching, and refraining from eating.

Researchers have proposed several potential mechanisms for this expression of anxiety. Neurobiological models of social anxiety focus on examining patient responses to various drugs with known mechanisms of action. For example, compared to non-anxious controls, individuals with generalized social phobia have elevated cortisol levels in response to fenfluramine, a stimulant known to inhibit serotonin reuptake (e.g., Tancer, Mailman, Stein, Mason, Carson, & Golden, 1995). These results suggest that individuals with social anxiety may be hypersensitive to autonomic arousal, a condition commonly found in individuals with panic disorder (Craske & Barlow, 1993).

Furthermore, many medications used for treating panic disorder (e.g., fluoxetine, alprazolam, phenelzine) are also effective in the treatment of social phobia suggesting pathophysiological overlap between the disorders (Black, Uhde, & Tancer, 1992; Gelernter, Uhde, Cimboic, Arnkoff, Vittone, Tancer, Bartko, 1991).

While the evidence from neurobiological studies may inform pharmacological treatments of social anxiety, it does not support a specific biological model of social anxiety. For example, fluoxetine, alprazolam, and phenelzine represent three classes of drugs (selective serotonin reuptake inhibitors, benzodiazepines, and mono-amine oxidase inhibitors) with different mechanisms of action, all of which are used to treat social anxiety as described above. Furthermore, selective serotonin reuptake inhibitors (SSRIs) are an effective treatment of social phobia but also a wide variety of disorders including depression, eating disorders, and panic disorder (Devlin & Walsh, 1995; Nemeroff, 1994; Oehrberg, Christiansen, & Behnke, 1995). Thus, only general information regarding biological mechanisms responsible for social anxiety can be gleaned from these studies.

Conditioning models of social anxiety suggest that individuals develop anxiety through repeated pairing of conditioned and unconditioned stimuli (Barlow, 2002; Bouton, Mineka, & Barlow, 2001). For example, an emotional experience, such as being teased by a classmate during lunch, may result in an appropriate anxiety response (unconditioned response). This response becomes inappropriate if it is later associated with eating in public in general (conditioned response). Early models were based largely on the classical conditioning theory (Wolpe, 1958), but these models could not account for the tendency of some stimuli to become conditioned more easily than others (even in the absence of a traumatic experience) or for the lack of extinction when phobic individuals were exposed to their feared stimuli (Marks, 1969; Rachman, 1991).

Preparedness theories integrate conditioning models with biological theory (Öhman, 1986). Accordingly, social anxiety is conceptualized as an innate vulnerability for developing conditioned fear responses to social threat because of the importance of social dominance hierarchies in human evolution (Öhman & Mineka, 2001). Early evidence for preparedness theories of anxiety came from research on rhesus monkeys. When monkeys viewed experimentally manipulated video tapes of other monkeys displaying fear responses to novel objects such as a toy snake or flowers, they only developed fear responses to snakes (Cook & Mineka, 1990). Bouton et al. (2001) provide a recent review of the evidence in favor of "prepared" conditioning models of anxiety that addresses the shortcomings of earlier models (i.e., the absence of a traumatic event). These authors suggested that "false alarms" (e.g., inappropriate autonomic arousal) may become associated with benign internal or external cues resulting in learned anxiety. The cues then serve as signals of upcoming false alarms leading an individual to become vigilant of threat in their environment and/or exhibit avoidance behaviors (Bouton et al., 2001). The conditioning models described above have been applied to the study of panic disorder. However, they may lack a satisfactory explanation for the lack of extinction when physiological cues (CS) are not followed by panic attacks (McNally, 1994).

More specific models of social anxiety focus on a combination of cognitive and behavioral factors. For example, Clark and Wells' (1995) cognitive model of social anxiety suggests that anxious individuals become self-focused in social situations and misinterpret their experiences. According to this model, socially anxious individuals attend to their physiological arousal and monitor their comments and behaviors to the exclusion of external social cues. Thus, their performance in social situations is hindered because they may not perceive social interactions accurately, and they may miss cues indicative of acceptance by the group. Furthermore, these individuals may incorrectly evaluate their performance in social situations based on their level of arousal. For example, feeling sweaty or nauseous in a group may lead a socially anxious individual to believe he or she appeared silly to the members of the group. This may result in a stronger anxiety response in future interactions and greater avoidance because the individual will expect the experience to be a failure at the first sign of physiological arousal.

According to the cognitive model, processes involving the focus of attention, interpretation, and memory are implicated in the maintenance and perhaps etiology of social anxiety (Clark & Wells, 1995). Treatment outcome research provides evidence supporting the role of self-focused attention in social anxiety. For example, Wells and Papageorgious (1998) found that the efficacy of standard exposure therapy was improved by instructing individuals to focus on external environmental cues during exposures. In addition, Hofmann (2000) showed that changes in negative self-focused thoughts co-varied significantly with changes in social anxiety. Finally, the amount of time anxious individuals spend focusing on themselves has been positively correlated with the degree of social anxiety (Hope, Heimberg, & Klein, 1990).

The above research is limited because of its reliance on self-report measures of anxiety and attention. Consequently, researchers have used paradigms from experimental cognitive psychology to examine information-processing biases involved in anxiety (McNally, 2000). Information processing includes various mechanisms of attention, interpretation, and memory that are measured via behavioral correlates (e.g., response latency, accuracy). While self-focused attention in social situations has been highlighted as a central aspect of the model described above, information-processing researchers have found that anxious individuals direct their attention to external sources of threat (Hope, Rapee, Heimberg, & Dombeck, 1990; MacLeod, Mathews, & Tata, 1986; Mathews & MacLeod, 1985; Mattia, Heimberg, & Hope, 1993; Watts, McKenna, Sharrock, & Tresize, 1986).

To examine attentional bias to threat, researchers have used dual-task paradigms. In these paradigms, participants are required to perform a task in the presence of either competing stimuli or a competing task. Decrements in performance (e.g., slower response latencies) are referred to as interference effects because the presence of a competing stimulus or task interferes with performance on the relevant task. This is because the competing task may gain access to attentional resources hampering the processing of the relevant task (Peterson & Posner, 1990). For example, in the emotional Stroop task (Stroop, 1935) participants see lists of words printed in various colors of ink and are asked to name the ink color in which each word is written as quickly as possible while resisting the tendency to read the word (for a recent review see Williams, Mathews, & MacLeod, 1996). Longer response latencies to correctly name the color of threat-relevant words compared to response latencies to name the color of neutral words is thought to reflect preferential allocation of attention to the threatening word meanings. Individuals with social anxiety are slower to color-name social threat words compared to physical threat words. Thus, they may be more vigilant for threat cues (Amir, McNally, Riemann, Burns, Lorenz, & Mullins, 1996; Mattia, Heimberg, & Hope, 1993). However, the interpretation of these results is unclear because the location of threat and the color are confounded in this task. Therefore, it is impossible to know whether the source of dual-task interference is greater allocation of attention to threat or difficulty in post-attentional processes such as response selection (Luck, 1998).

Researchers have also used paradigms that do not confound the two processes mentioned above (e.g., MacLeod, Mathews, and Tata, 1986). For example, in the dot probe paradigm participants are presented with pairs of words on a computer screen, one in the upper portion and one in the lower portion. One word is neutral (e.g., table), and the other word has a threatening meaning (e.g., stupid). Participants are asked to read the upper word and ignore the lower word. On critical trials, either the upper or the lower word is replaced with a probe (•), and participants are asked to signal its presence by pressing a button. This design yields four types of critical trials: Upper probe replacing upper threat (UPUT), upper probe replacing lower threat (UPLT), lower probe replacing lower threat (LPLT), and lower probe replacing upper threat (LPUT). MacLeod et al. (1986) found that generally anxious individuals with primarily social concerns displayed shorter response latencies for probes replacing social threat words compared to generally anxious individuals with primarily physical concerns and non-anxious controls (NACs). In addition, generally anxious individuals with physical concerns displayed shorter response latencies for probes replacing physical threat words compared to socially anxious and non-anxious individuals.

MacLeod and Mathews (1988) developed an equation for calculating a attentional bias score using the response latencies associated with the four types of critical trials listed above. According to MacLeod and Mathews (1988), the average of two quantities, each representing the difference between mean response latencies for probes replacing neutral and probes replacing threat-related stimuli, reflects preferential attention to threat.

$$\frac{(\mathrm{UPLT} - \mathrm{UPUT}) + (\mathrm{LPUT} - \mathrm{LPLT})}{2}$$

If attention is directed toward threat, the mean response latencies for probes replacing threat words would be faster than mean response latencies for probes replacing neutral words (i.e. UPUT and LPLT would be smaller values than UPLT and LPUT). Thus, the calculation of the bias score would yield a positive number, indicating attentional vigilance for threat. Conversely, if attention is directed away from threat, the mean response latencies for detecting probes replacing neutral words would be faster than mean response latencies for probes replacing threat words (i.e. UPLT and LPUT would be smaller values than UPUT and LPLT), and the bias score were negative, indicating attentional avoidance of threat. If neither attention vigilance nor avoidance is present, the bias score would be zero. Similar bias scores can be calculated for different types of threat (e.g., social and physical).

Using this formula, MacLeod and Mathews (1988) found that high trait anxious medical students under high state anxiety (i.e., just before an exam) had significantly larger bias scores for exam-related threat words than low trait anxious medical students. Specifically, anxious participants had a positive bias score for exam-related words whereas controls had a negative bias score. This finding suggests that anxious participants shifted their attention toward exam-related threat words (attentional vigilance), and controls shifted their attention away from threat (attentional avoidance).

Asmundson and Stein (1994) extended this finding to individuals with social phobia. Participants saw social and physical threat words paired with neutral words and were instructed to read the top word and then, indicate if a dot appeared after the words. These researchers found that individuals with social phobia responded faster to probes, regardless of the probe position, when a social threat word appeared in the top position of the display. The authors concluded that reading the social threat words had led to general hypervigilance in socially anxious individuals, thus decreasing probe detection latencies on critical trials.

To increase the ecological validity of the probe detection task, Mogg and colleagues (Bradley, Mogg, & Millar, 2000; Bradley, Mogg, Falla, & Hamliton, 1998) used pictures of emotional faces to examine attentional bias. In one study, Bradley et al. (1998) used emotional faces and pairs of dots (:), (··) to examine attentional bias in individuals with high and low trait anxiety. By using these pairs of dots, participants were forced to attend to the probe in order to determine its orientation. The authors calculated bias scores based on mean detection latencies using the equation suggested by MacLeod and Mathews (1988). The results of this study supported the notion of attentional vigilance for threatening expressions in trait anxious individuals, but not for emotional faces in general (i.e., happy facial expressions). In addition, individuals low in trait anxiety displayed attentional avoidance of threatening faces but vigilance for happy faces. Table 1 provides a summary of the results of several probe detection studies. Two studies that examined attentional bias for threat in social anxiety failed to find a bias for threat, and one study found avoidance of this material (Mansell, Ehlers, Clark, & Chen, 1999; Mansell, Ehlers, Clark, & Chen, 2002).

Posner (1988) suggests that visual spatial attention involves facilitation and inhibition of cued locations. That is, the presentation of a cue increases alertness as well as directs attention to the spatial location of the cue. Therefore, the processing of stimuli in this location is facilitated. As attention is directed to the location of the cue, a second mechanism initiates. This second mechanism inhibits processing of stimuli in all other locations. Posner (1988) referred to this second mechanism as the "cost" of attending. The mechanism of facilitation suggests anxious individuals may have larger bias scores than NACs because their attention is directed toward threat, allowing them to quickly detect probes following threat stimuli (i.e., UPUT, LPLT are small). Alternatively, the mechanism of cost of attending, or disengagement, suggests anxious participants may have larger bias scores than NACs because they experience difficulty disengaging their attention from threat on trials where probes follow neutral stimuli (UPLT, LPUT are large). In either case, the MacLeod and Mathews (1988) equation will produce a positive bias score despite the obvious difference between these two mechanisms.

Amir and Elias (2002) conducted two studies examining the mechanisms of facilitation and disengagement in socially anxious individuals. These researchers included neutral-neutral word pairs in this study. This allowed them to calculate two bias scores, reflecting facilitation of probe detection when probes replaced threat stimuli and difficulty disengaging from threat when probes replaced neutral stimuli. Facilitation was defined as the mean probe detection latency for trials in which probes replace threat (UPUT and LPLT) subtracted from the mean probe detection latency for baseline trials consisting of neutral-neutral word pairs (UPUN, LPLN).

$$\text{Facilitation} = \frac{(\text{UPUN} - \text{UPUT}) + (\text{LPLN} - \text{LPLT})}{2}$$

Disengagement was defined as the mean probe detection latency for baseline trials (UPLN, LPUN) subtracted from trials in which probes replace neutral words rather than a competing threat word (UPLT and LPUT).

$$\text{Disengagement} = \frac{(\text{UPLT} - \text{UPLN}) + (\text{LPUT} - \text{LPUN})}{2}$$

Amir and Elias' (2002) results were consistent with previous probe detection research when using the MacLeod and Mathews (1988) bias score equation. That is, socially anxious individuals in this study had larger bias scores than NACs for social threat words, suggesting anxious individuals possessed attentional vigilance for threat. However, when these authors examined response latency for facilitation and disengagement bias scores, they found that facilitation bias scores did not differ between socially anxious individuals and controls for social threat words. These results suggest that anxious individuals do not preferentially direct visual attention to threatening information. However, disengagement bias scores for social threat words were significantly larger for socially anxious individuals compared to NACs.

While there is some evidence that anxious individuals show difficulty disengaging attention from threat, the cognitive factors that may influence such a bias remain unclear. This is because information processing research in anxiety has traditionally focused on examining various cognitive processes in isolation. However, it is likely that cognitive operations require an interaction of two or more basic processes. For example, researchers have found that the contents of working memory can influence selective attention to cues in one's environment (Awh, Anllo-Vento, & Hillyard, 2000; Desimone, 1996; Downing, 2000). Definitions of working memory can vary depending on one's model of memory or the task at hand (Baddeley, 1986). In the current proposal, visual working memory is defined as the active maintenance of a stimulus in memory after it has been removed from immediate perception.

Several studies have examined the role of working memory on selective attention. For example, Awh et al. (2000) recorded event-related potentials (ERPs) in human participants asked to memorize locations on a computer monitor. They found enhanced brain activation when stimuli were presented in the memorized locations compared to non-memorized locations. These activations were similar to those observed during an explicit selective attention task using identical stimuli. This suggests that attention may have been biased to these spatial locations as a result of holding them in working memory.

Downing (2000) examined the influence of visual working memory on selective attention in a probe detection task. Participants were presented with a memory target (i.e., a face) for 1 second. They were instructed to remember the target. Following a 1.5 second delay, two faces appeared side by side. One face always matched the target face and the other was a novel face. After a 40 ms delay, both pictures disappeared and a probe (i.e., a bracket) replaced either the right or left face. Participants were required to indicate the orientation of the bracket (up or down) as quickly as possible by pressing keys on a keyboard, and the computer recorded response latencies for each trial. Finally, a single test face was presented at the end of each trial, and participants were asked if the test face matched the memory target. The test face matched the original face on 50% of the trials. Response latencies for detecting probes that replaced memory-matched faces were significantly faster than response latencies for detecting probes that replaced non-matched faces. These results suggest that working memory modified the allocation of attention during the probe detection task. That is, attention was preferentially directed toward the matching member of the subsequent pair. Downing conducted three additional experiments that systematically ruled out object type, priming, and intra-trial rehearsal as possible confounds of these results.

In summary, researchers have shown that the contents of working memory can affect the allocation of visual attention even if the memory load is unrelated to the specific search goal. Thus, attending to negative cognitions and physiological arousal may affect selective attention to threat in social anxiety via working memory. In the current study, I examined the influence of working memory on attention in socially anxious individuals, by replicating Downing (2000) using emotional facial expressions. Two additional types of trials were included in order to examine 1) the effects of a non-emotional, task-irrelevant working memory load on attentional bias and 2) the effects of working memory on two mechanisms of attention, facilitation and disengagement.

The basic methodology of the current study follows that of Downing (2000) with three differences. First, Downing used only neutral facial expressions, and the memory target always reappeared later in the same trial as one of the faces in the probe detection portion. In the current study, neutral and angry facial expressions were included, and the emotional expression of the memory target, rather than the exact person, was represented by one of the faces in the probe detection portion. Second, on some trials, neutral-neutral face pairs were used to obtain a baseline measure of attention. Baseline trials allowed the examination of facilitation and disengagement bias scores. Third, some memory targets were non-emotional pictures of inanimate objects (e.g., furniture, tools). This condition was included in order to examine the effect of a general working memory load on attentional bias.

I tested the following hypotheses related to the influence of working memory on selective attention in socially anxious and non-anxious individuals using the MacLeod and Mathews bias score. First, socially anxious individuals would allocate attention to angry expressions on trials requiring working memory for inanimate objects while non-anxious controls would not. This would replicate the findings of earlier probe detection studies examining attentional bias in trait anxiety. Second, socially anxious individuals would lose their attentional bias to angry expressions when presented with neutral faces as memory targets. Third, non-anxious individuals would show attentional bias to angry expressions when presented with angry faces as memory targets.

CHAPTER 2

METHOD

Participants

Participants in this study were 15 socially anxious individuals (60% female) and 20 non-anxious controls (55% female) from the University of Georgia. These participants were selected from approximately 500 undergraduates who participated in a screening. All participants received partial course credit for participating in the study. Consent was obtained at the time of the screening process and again before the laboratory experiment.

Group membership was determined based on a cutoff score of 19 on the Social Phobia Inventory (SPIN). This cutoff has been effective in distinguishing socially phobic individuals from a mixed sample of non-treatment seeking healthy individuals and treatment seeking psychiatric patients (Connor, Davidson, Churchill, Sherwood, Foa, & Weisler, 2000). Non-anxious controls scored 15 or below on the SPIN.[1]

Participants completed the Beck Depression Inventory (BDI; Beck & Steer, 1987), the State-Trait Anxiety Inventory - Trait Scale (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986; Peterson & Reiss, 1992), the brief Fear of Negative Evaluation scale (BFNE; Leary, 1983), and the Social Phobia Inventory (SPIN; Connor, Davidson, Churchill, Sherwood, Foa, & Weisler, 2000). Socially anxious individuals were more depressed, more trait anxious, more anxiety sensitive, more fearful of negative evaluation, and more fearful and avoidant of social interactions than non-anxious controls. Demographic information and means with standard deviations for the above scales are presented in Table 2.

The BDI (Beck & Steer, 1987) is a 21-item scale that assesses depressive symptoms over the previous week. The BDI is a reliable measure (r ranges from .48 to .86) that has been shown to have high internal consistency (α = .86, Beck, Steer, & Garbin, 1988). The STAI-T (Spielberger et al., 1983) is comprised of 20-items that measure trait anxiety. This measure had been shown to be reliable over a 20-day period (r = .86, males; r = .76, females; Spielberger et al., 1983). The ASI (Reiss, et al., 1986) is a 16-item index that measures fear of symptoms associated with sympathetic arousal present in panic disorder. This questionnaire has been shown to be internally consistent (α ranges from .82 to .91; Peterson & Reiss, 1992) and reliable over a 3-year period (r = .71; Maller & Reiss, 1992). The BFNE (Leary, 1983) is a 12-item self-report measure designed to assess symptoms of social phobia associated with the fear of negative evaluation. The BFNE has been shown to have adequate test-retest reliability and good internal consistency (Leary, 1983). The SPIN (Connor et al., 2000) is a 17-item self-report measure designed to assess fear, avoidance behaviors, and physiological symptoms of social anxiety over a variety of contexts. The SPIN has been shown to have good test-retest reliability (r = .89) and good internal consistency (α = .94) over a two-week interval.

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[1] In one case, a score on the brief Fear of Negative Evaluations scale (BFNE) was used to verify group

Procedure

In this study, I examined the influence of working memory on the allocation of attention by combining aspects of each into a dual task. A working memory load was introduced via a recognition task involving different types of visual stimuli. Participants held these visual stimuli in working memory, and their attention was measured via response latency on a probe detection task. These components are described below.

Working Memory Component

A working memory load was introduced via a recognition task. The computer displayed brief instructions for the experiment, and participants completed approximately four practice trials before beginning the actual experiment. After pressing a start button, a fixation cross (+) appeared in the center of the monitor for 500 ms followed by a memory target presented for 1000 ms. Participants were asked to remember the target until the end of the trial. Following a probe detection task (described below), participants performed a recognition task on a test stimulus by indicating whether or not it matched the target.

Three types of recognition trials were created from three memory target types (i.e., inanimate objects, neutral faces, and angry faces). Photographs of inanimate objects (e.g., furniture, appliances; Lang, 1995) were used to create recognition trials that introduced a non-emotional working memory load. Neutral faces were used to create recognition trials that introduced a working memory load for faces, and angry faces were used to create recognition trials that introduced an emotional, task-relevant working memory load (Ekman & Friesen, 1976).

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membership due to missing data (Leary, 1983).

Matching test stimuli were identical to the memory target. Non-matching test stimuli shared the same emotional valence as the memory target (i.e., non-emotional, neutral, or angry), but the individual or object in the photograph was different. Participants indicated a matching or non-matching test stimulus by moving the cursor to the appropriate button on the computer screen. Response latency in milliseconds and accuracy in % correct were recorded for the recognition task. Thirty-six pictures (12 inanimate objects, 12 angry faces, and 12 neutral faces) were used to create a set of 18 memory pairs (6 inanimate objects, 6 angry faces, and 6 neutral faces). A pair consisted of two different pictures of similar emotional valence. Memory pairs were counterbalanced across participants such that half the pictures were used as targets in one version of the experiment and the other half in another version. The faces were gray-scale photographs of emotional facial expressions developed by Ekman and Friesen (1976), and the non-emotional, inanimate objects were photographs from a set developed by Lang (1995).

Attentional Component

Allocation of attention was measured via a probe detection task that occurred during the retention interval of the recognition task. The probe detection task began with the presentation of a second fixation cross for 1500 ms. After the fixation cross disappeared, participants saw a pair of faces presented simultaneously (separated vertically by 6cm) for 500 ms. After the face pair disappeared, participants were asked to decide whether the probe that replaced one of the two faces was an “E” or an “F.” Participants were told that the face pairs were simply distracters to make the memory task more difficult. After detecting the probe, participants completed each trial by making the recognition judgment described above.

Three types of probe detection trials were created. Two trial types were created by pairing one angry and one neutral expression of the same individual. A third trial type was created by pairing two neutral expressions of the same individual (i.e., neutral-neutral). The face pairs were created from 8 gray-scale photographs (4 individuals, each in angry and neutral expressions) from the set developed by Matsumoto and Ekman (1988). Forty-eight trials were created for the probe detection task (4 individuals X 3 trial types (angry-neutral, neutral-angry, and neutral-neutral) X 2 probe types (E , F) X 2 probe positions (top, bottom)).

Combining the Tasks

Memory targets and probe detection stimuli were non-overlapping sets. Downing (2000) repeated the identical memory target during the probe detection portion of his experiments. However, if working memory is implicated in attentional bias in social anxiety, it is important to show that conceptual (i.e., meaning based variables, e.g., negative affect), rather than perceptual (i.e., physical characteristics, e.g., hairstyle), information is encoded from faces held in working memory. Thus, anxious individuals should exhibit biased attention toward similar expressions in an array even if the person is different.

The recognition trial types were combined with the probe detection trial types for a total of 288 experimental trials. Of these trials, 96 trials included non-emotional objects as the memory target preceding the probe detection task, with 50% of trials ending in a matching object (48 probe detection trials X 2 memory conditions). Another

96 trials included angry faces as the memory target, and the remaining 96 trials included neutral faces as the memory target preceding a probe detection task.

All stimuli were 6cm X 6cm gray-scale photographs presented in the center of the monitor. The participants were seated 30 cm from the screen. The experimental session was preceded with a practice block of 4 trials. The faces used for practice trials were not used during the experimental trials. All participants were tested individually. Participants were asked to respond as quickly as possible to probes without sacrificing accuracy.

CHAPTER 3

RESULTS

Response latencies of less than 285 ms or greater than 2500 ms were eliminated from the data. This removed 1% of the trials. In addition, responses latencies more than $\pm$2.5 standard deviations away from an individual's mean response latency were eliminated (2.7% of trials). Finally, all inaccurate trials were removed. Trials were deemed inaccurate if 1) the incorrect probe letter was chosen or 2) the incorrect memory judgment was made. This resulted in removal of 4.4% of the trials. Approximately 7% of trials were dropped in total. Mean response latencies for various trials were used to calculate three bias scores for each memory load condition. Raw data are presented in Table 3. Table 4 presents the raw data for baseline trials only.

Bias score comparisons for face versus object memory load

To examine the general effects of a task-irrelevant working memory load on attentional bias, face type was collapsed and the results of each bias score were entered into a 2(Memory Load Type: Objects, Faces) X 2(Group: High Social Anxiety, Low Social Anxiety) repeated measures ANOVA.

MacLeod and Mathews bias scores: These analyses revealed a significant main effect for Memory Load Type [$F(1, 33) = 18.47$, $p < .01$]. The main effect of Group [$F(1, 33) = .72$, $p = .40$] and the interaction of Memory Load Type and Group [$F(1, 33) = 2.96$, $p = .10$] were non-significant. Inspection of means indicated significantly larger bias scores for object memory loads than facial expressions regardless of group. These data are presented in Figure 1. MacLeod and Mathews bias scores were then decomposed into separate facilitation and disengagement bias scores to examine the effect of task-irrelevant working memory load on these mechanisms of attention.

Facilitation bias scores: These analyses revealed a significant main effect for Memory Load Type [$F(1, 33) = 7.60$, $p < .01$]. The main effect of Group [$F(1, 33) = .09$, $p = .77$] and the interaction of Memory Load Type and Group [$F(1, 33) = 1.53$, $p = .22$] were non-significant. Inspection of means indicated significantly larger bias scores for object memory loads than facial expressions regardless of group. These data are presented in Figure 2.

Disengagement bias scores: These analyses revealed no significant main effects for Memory Load Type [$F(1, 33) = .71$, $p = .40$] or Group [$F(1, 33) = .39$, $p = .54$]. The interaction of Memory Load Type and Group [$F(1, 33) = .04$, $p = .84$] was also non-significant. These data are presented in Figure 3.

Bias score comparisons for neutral versus angry memory load

To examine the effects of an emotional working memory load on attentional bias, bias scores were entered into a 2(Memory Load Expression: Neutral Faces, Angry Faces) X 2(Group: High Social Anxiety, Low Social Anxiety) repeated measures ANOVA.

MacLeod and Mathews bias scores: These analyses revealed no significant main effects of Memory Load [$F(1, 33) = .001$, $p = .97$] and Group [$F(1, 33) = .13$, $p = .72$]. The interaction of Group and Memory Load [$F(1, 33) = .07$, $p = .79$] was also non-significant. These data are presented in Figure 4. MacLeod and Mathews bias scores were then decomposed into separate facilitation and disengagement bias scores to examine the effect of emotional working memory load on these mechanisms of attention.

Facilitation bias scores: These analyses revealed no significant main effects of Memory Load [$F(1, 33) = 1.78$, $p = .19$] and Group [$F(1, 33) = .79$, $p = .38$], but the interaction of Memory Load and Group was significant [$F(1, 33) = 4.20$, $p < .05$]. A simple effects analysis was conducted to examine the interaction further. These data are presented in Figure 5. Simple effects of group revealed that non-anxious controls displayed significantly larger facilitation bias scores under neutral memory load than socially anxious individuals [$t(33) = 2.48$, $p < .02$]. However, groups did not differ on facilitation scores under angry memory loads [$t(33) = .87$, $p = .39$]. Simple effects of memory load revealed significantly larger bias scores under angry memory load compared to neutral memory load for socially anxious individuals [$t(14) = 2.31$, $p < .04$] and no effect of memory load in non-anxious controls [$t(19) = .54$, $p = .60$].

Disengagement bias scores: These analyses revealed no significant main effects of Memory Load [$F(1, 33) = 2.15$, $p = .15$] and Group [$F(1, 33) = .16$, $p = .69$]. However, the interaction of Memory Load and Group was marginally significant [$F(1, 33) = 3.70$, $p = .06$]. A simple effects analysis was conducted to examine the interaction further as it is of theoretical import. These data are presented in Figure 6. Simple effects of memory load revealed a marginally significant effect for larger disengagement scores in socially anxious individuals under neutral memory loads compared to angry memory loads [$t(14) = 1.98$, $p = .07$]. There was no significant difference for memory load in non-anxious controls [$t(19) = .39$, $p = .70$]. Simple effects analysis of group revealed no significant differences between groups under neutral memory load [$t(33) = 1.67$, $p = .10$] or angry memory load [$t(33) = 1.08$, $p = .29$].

CHAPTER 4

DISCUSSION

The results of the current study are broadly consistent with previous information processing research in anxiety (e.g., MacLeod, Mathews, & Tata, 1986) and support two of the three hypotheses discussed in the introduction. It was hypothesized that anxious individuals, and not NACs, would allocate attention to angry faces while holding non-emotional objects in working memory. Under object memory loads, socially anxious individuals displayed positive bias scores, suggesting attentional bias toward threatening information. Therefore, the addition of a working memory task itself did not appear to disrupt the cognitive processes involved in processing threatening information in socially anxious participants.

The paradigm employed in the current study was based on a paradigm used by Downing (2000) in which an unselected sample of non-anxious individuals showed attentional bias for objects in their visual field that matched images held in working memory. In a departure from Downing's methodology, the current paradigm did not present identical faces during the attentional task but rather faces that matched the emotional valence of the memory load. Consequently, it was hypothesized that individuals in the current study would show a bias for faces that matched the emotional expression of targets held in memory. Specifically, it was predicted that neutral memory loads would eliminate attentional bias for threat in SAs by shifting attention toward neutral faces, and angry memory loads would create attentional bias for threat in NACs by shifting attention toward angry faces. Contrary to hypothesis, comparisons of MacLeod and Mathews bias scores for neutral versus angry facial memory loads failed to reveal any differences. This would suggest that holding faces in working memory leads to a general reduction of attentional bias for threat regardless of group membership.

The inclusion of neutral-neutral trials in the current study allowed the calculation of individual indices of facilitation and disengagement, two mechanisms involved in spatial selective attention. A comparison of these bias scores for face versus object memory loads revealed that significant differences found in MacLeod and Mathews (1988) bias scores were due to the differences in facilitation rather than disengagement. In addition, examination of these component scores revealed significant differences due to group membership and memory load, which went undetected using the MacLeod and Mathews bias score calculation. Facilitation bias scores reflect the difference in mean response latencies for trials in which both faces are neutral and trials in which probes replaced the angry facial expressions of a neutral-angry face pair. Therefore, positive scores indicate a bias for threatening information. Consistent with this hypothesis, results showed that anxious individuals showed significantly smaller facilitation scores under neutral memory loads compared to non-anxious individuals. Furthermore, the socially anxious group showed significantly facilitation bias smaller scores under neutral memory loads than angry memory loads. These results suggest a reversal of the facilitation bias typically observed in anxious individuals, when a neutral memory load is induced. Thus, socially anxious individuals may be able to disrupt their bias for threat by using memory strategies.

Disengagement bias scores reflect the difference in mean response latencies for trials in which probes replace the neutral facial expressions of neutral-angry face pairs and trials in which both faces are neutral. Researchers have shown that anxious individuals are characterized by difficulty disengaging attention from threat (Amir & Elias, 2003; Fox, Russo, Bowles, & Dutton, 2001, Yiend & Mathews, 2001). If this is the case, angry memory loads may bias attention toward angry faces and disrupt the ability to disengage attention from angry faces in non-anxious controls. Contrary to this explanation, controls showed no difference on disengagement under neutral versus angry memory loads. Surprisingly, anxious individuals displayed significantly larger disengagement scores when under neutral memory loads compared to angry memory loads. These results suggest that angry facial memory loads may help anxious individuals disengage from angry faces, while neutral memory loads may have no effect on disengagement difficulty.

Overall, these results extend the findings of Downing (2000) by showing that semantic information can also influence the directing of attention. However, the implications of the specific findings are mixed. The results regarding facilitation bias scores were consistent with my hypothesis and showed that anxious individuals may experience reduced attention to threat when holding neutral information in working memory. This result is generally consistent with theoretical rationales for implementing cognitive restructuring in the treatment of social anxiety. By focusing one's current thoughts on more neutral cognitions, anxious individuals may attend to more relevant information during social or performance situations and experience reduced anxiety as a result.

The results of disengagement bias scores were contrary to hypothesis and therefore, may have several possible interpretations. Under neutral memory loads, anxious individuals experienced difficulty disengaging attention from threat, suggesting disengagement bias cannot be overcome by simply holding neutral information in memory. However, under angry memory loads, anxious individuals experienced enhanced ability to disengage threat. One plausible explanation is that angry memory loads lower the threshold for detecting subsequent sources of threat, allowing anxious individuals to avoid threat more effectively and resulting in negative disengagement scores.

The current study has limitations. Researchers have shown that non-anxious individuals can be trained to attend to threat or non-threat stimuli using a probe detection paradigm in which the probe replaces either threat or neutral stimuli with a higher probability than the other (Mathews & MacLeod, 2002). However, non-anxious controls in the current study failed to show significant changes in their attentional processes under either neutral or angry memory loads. The discrepancy between these results may be due to methodological differences. Mathews and MacLeod trained attention directly by making probe position contingent on the position of threat or neutral stimuli. That is, in their study there was a built-in incentive to attending to either threat or neutral stimuli (i.e., efficient probe detection). In contrast, the current study may have "trained" attention within a trial via working memory without creating a contingency between memory load and probe position. Therefore, the resilience of attentional processes in non-anxious individuals to threat stimuli held in memory might be an indication of health or a failure of the paradigm to modify the directing of attention consistently across groups.

I did not measure the impact of changes in attentional bias on emotional vulnerability. MacLeod, Rutherford, Campbell, Ebsworthy, & Holker (2002) showed that training individuals' attention toward negative versus neutral information modified their reactions to a subsequent stress test. Specifically, individuals trained toward negative information reported elevated anxiety and depression after a stress test compared to individuals trained to attend to neutral information. The current paradigm may be modified to create a similar training that would reduce attentional facilitation for threat under neutral memory load and enhance attentional disengagement of threat under angry memory load. Individuals trained to have less facilitation bias for threat would be expected to report fewer symptoms of anxiety after a stress test. However, individuals trained to disengage threat more easily may show either reduction or no change in anxiety after a stress test. That is, angry memory loads may promote habituation to threat and improved processing (reduced emotional vulnerability) or avoidance of threat and incomplete processing (no change in emotional vulnerability). Therefore, self-report data collected before and after a stress test may provide some indication of the actual mechanism responsible for enhanced disengagement of threat in this paradigm.

In summary, the relationship between attention and memory has been described as unidirectional, where attentional processes prioritize incoming information and dictate what is eventually stored in memory (i.e., bottom-up processing). New evidence from cognitive researchers has shown memory can affect attention (i.e., top-down processing) (e.g., Downing, 2000). Threatening information may gain obligatory access to attentional pathways so that appropriate responses can be mobilized. Differences in attentional bias for threat stimuli observed between anxious individuals and non-anxious controls may be the result of lower thresholds for what is perceived as threatening by anxious individuals. Thresholds are most likely determined by an interaction of processes occurring at the level of attention and higher-order cognitive processes (e.g., working memory). Working memory may provide one mechanism through which attentional thresholds can be modulated to detect environmental stimuli (e.g., probes) more efficiently. Specifically, the current results may suggest that neutral memory loads improve performance on trials in which probes replace threat stimuli and threatening memory loads improve performance on trials in which probes replace neutral stimuli.

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Table 1. <u>A partial summary of studies examining probe detection in anxious populations</u>

Study	Population	Materials	Findings
MacLeod et al. (1986)	GAD	words	Bias for social and physical threat
MacLeod & Mathews (1988)	Medical Students	words	Interaction of state & trait anxiety; Bias for exam-related words
Broadbent & Broadbent (1988)	High, low state And trait non-clinical	words	Interaction of state & trait; Bias for threat; No bias for animal names
Asmundson et al. (1992)	Panic Disorder vs. controls	words	Bias for physical vs. social; Upper area

Asmundson & Stein (1994)	Generalized Social Anxiety, vs. controls	words	Bias for social vs. physical; Upper area
Bradley et al. (1998)	High, Low trait anxiety	faces	Bias for threatening faces at 500ms; No avoidance at 1250ms
Mogg & Bradley (1999)	High, Low trait anxiety	faces	Bias for threatening faces at 500ms
Mansell et al. (1999)	High, Low trait with state manipulation	faces	Bias away from emotional faces (+ & -) in state manipulation
Bradley et al. (2000)	High, Med, Low	faces	High and Medium anxiety group showed bias for threat; state anxiety

Mogg, et al. (2000)	Generalized Anxiety Disorder, Depressed	faces	Participants who exhibited a bias toward threat faces had earlier eye movements
Mansell et al. (2002)	Social Anxiety	words	High Socially anxious participants showed no bias to or away from threat words

Table 2. Demographic and psychometric data

	Socially anxious M (SD)	Control M (SD)	t	p
Age	19.9 (3.6)	19.1 (.9)	.92	ns
Education (years)	13.2 (1.5)	13.6 (1.2)	.79	ns
BDI	12.0 (6.9)	6.7 (3.8)	3.01	.005
STAI-T	46.4 (14.7)	35.1 (6.7)	3.20	.003
ASI	21.2 (8.7)	14.3 (7.0)	2.40	.02
BFNE	42.0 (13.1)	23.1 (3.4)	4.00	.001
SPIN	27.8 (13.8)	8.0 (4.2)	6.60	.000

Note: BDI = Beck Depression Inventory, STAI-T = State-Trait Anxiety Inventory-Trait Form, ASI = Anxiety Sensitivity Index, BFNE = Fear of Negative Evaluation, SPIN = Social Phobia Inventory.

Table 3. Mean response latencies (ms) and standard deviations for groups by trial type

	Socially Anxious	Control
Memory Load Type		
Inanimate Object Load		
Angry face position		
Top		
Probe position		
Top	865 (205)	731 (130)
Bottom	884 (232)	744 (129)
Bottom		
Probe position		
Top	885 (213)	740 (147)
Bottom	830 (201)	729 (143)
Neutral Face Load		
Angry face position		
Top		
Probe position		
Top	880 (181)	733 (174)
Bottom	854 (195)	711 (128)

Table 3 continued

Bottom		
Probe position		
Top	861 (192)	712 (143)
Bottom	868 (200)	706 (128)
Angry Face Load		
Angry face position		
Top		
Probe position		
Top	889 (214)	744 (151)
Bottom	842 (227)	705 (138)
Bottom		
Probe position		
Top	858 (203)	730 (131)
Bottom	838 (162)	713 (122)

Table 4. Mean response latencies (ms) and standard deviations for baseline trials (neutral-neutral face pairs)

Memory Load Type	Socially Anxious	Control
Inanimate Object Load	876 (206)	743 (147)
Neutral Face Load	841 (175)	722 (140)
Angry Face Load	873 (195)	722 (141)

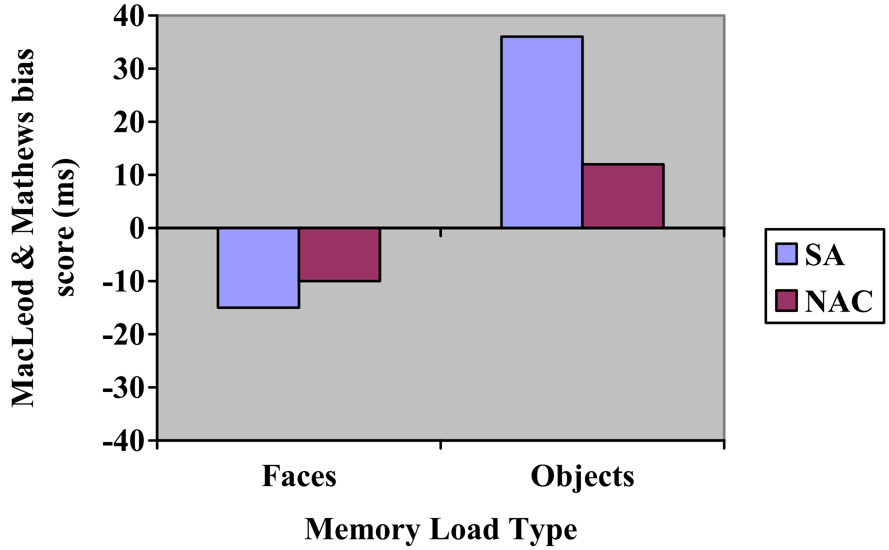

Figure 1. MacLeod and Mathews (1988) bias scores for object and face working memory loads in socially anxious individuals (SA) and non-anxious controls (NAC).

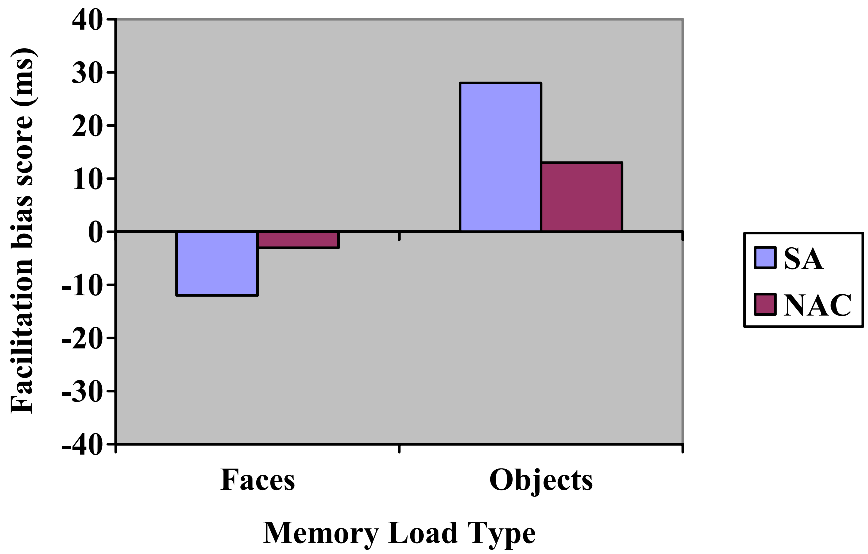

Figure 2. Facilitation bias scores for object and face working memory loads in socially anxious individuals (SA) and non-anxious controls (NAC).

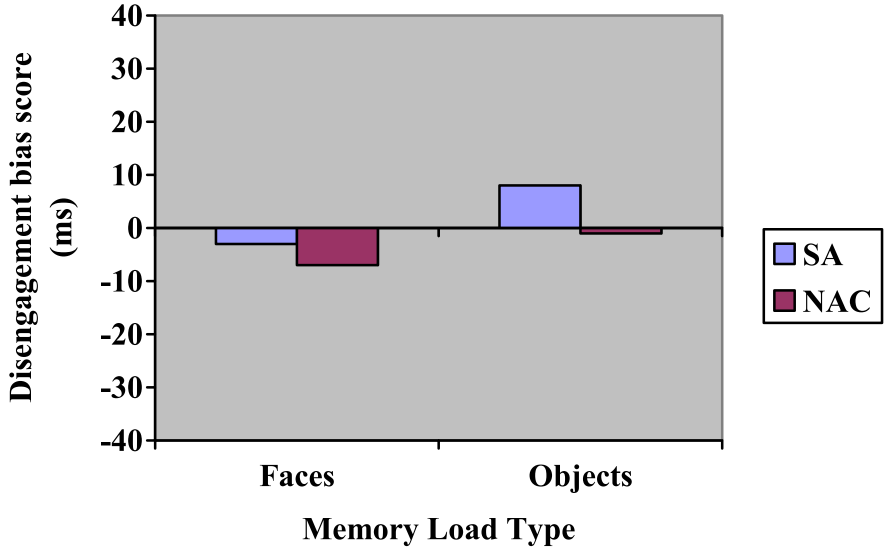

Figure 3. Disengagement bias scores for object and face working memory loads in socially anxious individuals (SA) and non-anxious controls (NAC).

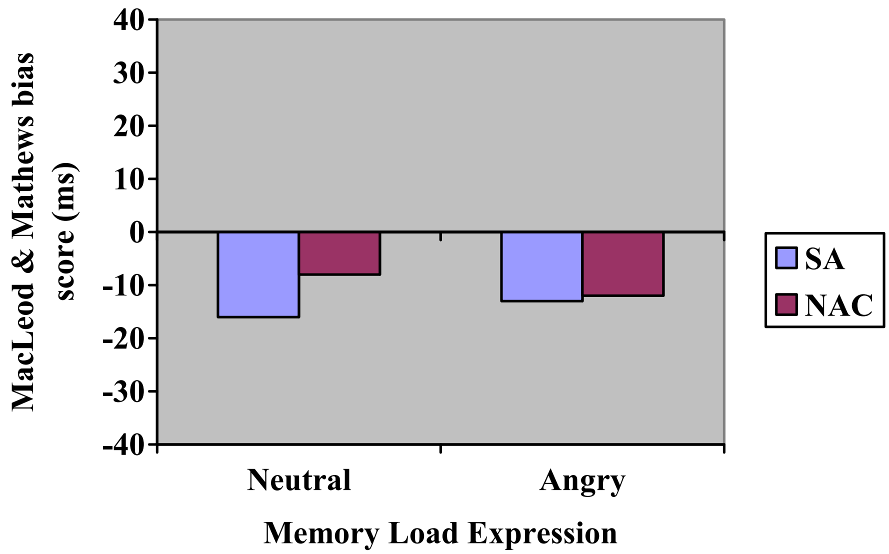

Figure 4. MacLeod and Mathews (1988) bias scores for neutral versus angry face working memory loads in socially anxious individuals (SA) and non-anxious controls (NAC).

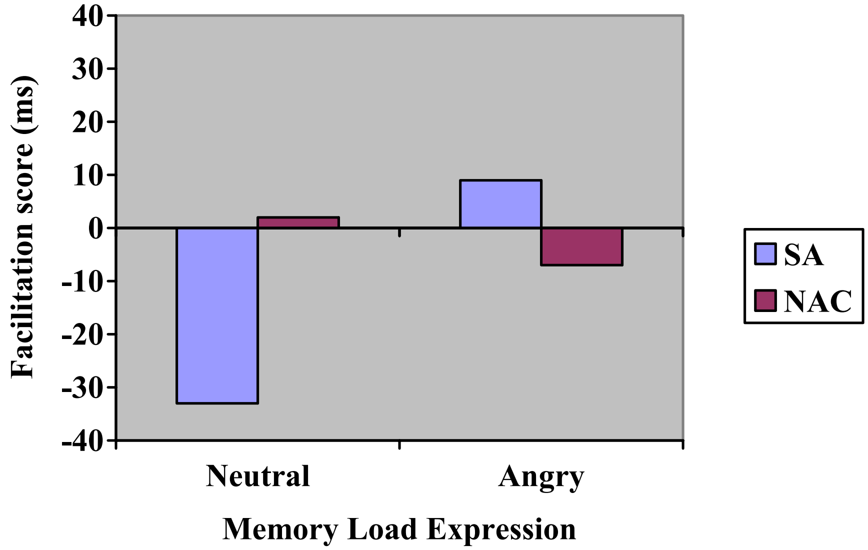

Figure 5. Facilitation bias scores for neutral and angry working memory loads in socially anxious individuals (SA) and non-anxious controls (NAC).

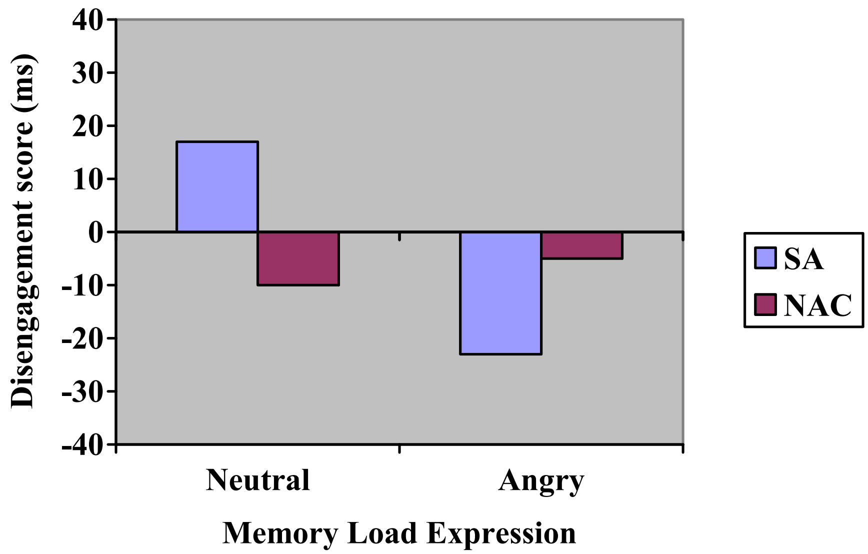

Figure 6. Disengagement bias scores for neutral and angry working memory loads in socially anxious individuals (SA) and non-anxious controls (NAC).