Memory for Physiological Feedback in Social Anxiety Disorder:

The Role of Fear of Bodily Sensations

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ABSTRACT

This study examined whether individuals with social anxiety disorder (SAD) have a memory bias for bodily sensations associated with anxiety. Using a physiology false feedback paradigm, 33 individuals with SAD and 34 non-anxious control participants (NAC) completed a performance task while monitoring stimuli they were told provided feedback on whether their physiological response was changing or stable. Reaction time to detect the feedback during the performance task was assessed, as was memory for the feedback via free recall and recognition tasks. SAD participants were found to have a slower reaction time to change compared to stable words, whereas no difference in reaction time for change and stable was found for NAC participants, In contrast, on measures of free recall and recognition for their feedback no differences were found between SAD and NAC individuals. Overall, participants exhibited enhanced memory for stimuli indicative of changing physiological arousal. Furthermore, among SAD participants only, fear of bodily sensations was associated with enhanced memory for stimuli associated with physiological responses. Results suggest that it may be necessary to measure not only fear of social situations, but also the focus of those fears, such as bodily sensations, when examining memory biases in social anxiety.

KEYWORDS: social anxiety; social anxiety disorder; social phobia; memory bias; fear of bodily sensations; beliefs

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1. Introduction

Cognitive models hypothesize that individuals with social anxiety disorder (SAD) will exhibit enhanced memory for social threat information (Clark & Wells, 1995; Rapee & Heimberg, 1997). However, most studies using social threat word stimuli have been unsuccessful in detecting memory biases in SAD (Cloitre, Cancienne, Heimberg, Holt, & Liebowitz, 1995; Foa, McNally, & Murdock, 1989; Rapee, McCallum, Melville, Ravenscroft, & Rodney, 1994). The few studies that have found evidence of a memory bias in social anxiety have done so for negative public self-referent information (O'Banion & Arkowitz, 1977), particularly under conditions of social evaluation (Breck & Smith, 1983; Smith, Ingram, & Brehm, 1983). Some studies have used more ecologically valid stimuli, such as critical or angry faces (Coles & Heimberg, 2005; Foa, Gilboa-Schectman, Amir, & Freshman, 2000; Lundh & Öst, 1996a; Lundh & Öst, 1996b; Pérèz-López & Woody, 2001). Though some of these studies have found evidence of a memory bias among individuals with social anxiety (Foa et al. 2000; Lundh & Öst, 1996a), several others have failed to find such evidence (Coles & Heimberg, 2005; Lundh & Öst, 1996b; Pérèz-López & Woody, 2001).

Other researchers have assessed memory for social interactions using both vignettes and real interactions (Brendle & Wenzel, 2004; Daly, Vangelisti, & Lawrence, 1989; Kimble & Zehr, 1982; Mellings & Alden, 2000; Stopa & Clark, 1993; Wenzel, Finstrom, Jordan, & Brendle, 2005). Brendle and Wenzel (2004) failed to demonstrate that social anxiety was associated with enhanced recall of negative evaluative information presented in vignettes depicting prototypical social situations and subsequently replicated this finding using video-taped social situations

(Wenzel et al., 2005). Some studies have demonstrated that individuals with high levels of social anxiety remember fewer details of a social interaction compared to non-anxious controls (Daly et al., 1989; Kimble & Zehr, 1982; Mellings & Alden, 2000; Stopa & Clark, 1993).

The prediction that social anxiety is associated with enhanced memory for social threat information has generally not been supported. Studies with positive findings have used self-referent stimuli (Breck & Smith, 1983; O'Banion & Arkowitz, 1977; Smith et al., 1983), whereas most negative findings have used general social threat stimuli (Cloitre et al., 1995; Foa et al., 1989; Rapee et al., 1994). Null findings for memory bias in social anxiety for external social threat combined with research finding evidence for memory bias for self-referent information suggest that memory biases in social anxiety may be for information about the self in social situations.

This idea is consistent with another major aspect of cognitive-behavioral models of social anxiety; the tendency for socially anxious individuals, in social situations to direct attention towards the self, particularly thoughts and beliefs about the self, as well as toward bodily sensations of arousal (Clark & Wells, 1995; Rapee & Heimberg, 1997). Individuals with SAD report greater levels of public self-consciousness, the tendency to direct attention towards observable aspects of the self (Fenigstein, Scheier, & Buss, 1975), compared to non-anxious participants (Hope & Heimberg, 1988; Jostes, Pook, & Florin, 1999; Lundh & Öst, 1996c; Saboonchi, Lundh, & Öst, 1999). When self-focused attention is experimentally induced, individuals with SAD exhibit enhanced concern over the impression they will leave (Alden, Teschuk, & Tee, 1992) and report increased anxiety (Woody, 1996; Woody & Rodriguez, 2000). Even among individuals without SAD, experimentally induced self-focused attention results in increased concern over rejection (Fenigstein, 1979), suggesting that self-focused attention may play a causal role in the maintenance of social anxiety.

Consistent with evidence suggesting that social anxiety is associated with enhanced attention towards aspects of the self, two recent studies have found that individuals high in social anxiety exhibit attentional biases towards cues of internal arousal versus cues of external social threat (Mansell, Clark, & Ehlers, 2003; Pineles & Mineka, 2005). Mansell and colleagues (2003) found that under conditions of anticipated social threat, speech anxious individuals exhibited an internal bias, which indicated faster response to cues of internal arousal rather than an external probe, compared to non-anxious individuals. These findings were replicated by Pineles and Mineka (2005) using visual signals representing arousal rather than tactile signals.

The presence of enhanced attention towards internal cues of arousal in social anxiety may explain why researchers have generally been unsuccessful in detecting memory biases for external social threats. It may be that it is the self-focused information for which people with social anxiety have an enhanced memory. This is consistent with research demonstrating enhanced memory for self-referent information (Breck & Smith, 1983; O'Banion & Arkowitz, 1977; Smith et al., 1983).

The current study examined whether individuals with SAD exhibit a memory bias for internal physiological sensations. Participants were asked to complete a video-taped word pronunciation performance task, as they monitored their physiology. They were told that if the word appears on one side of the computer screen, it indicates that their physiology is changing, whereas if it appears on the opposite side of the screen it indicates that their physiology is stable. After completing the task, participants were subsequently asked to recall and recognize the words they had seen. We predicted that SAD participants would remember more stimuli associated with changing physiology compared to non-anxious participants.

2. Method

The study design was approved by the ethics committee at Concordia University, Montreal, Quebec and was carried out in accordance with the Declaration of Helsinki.

2.1 *Participants*

Participants included individuals diagnosed with SAD (n = 40) and undergraduate students from Concordia University, Montreal, Quebec (n = 42), who served as a non-anxious control group (NAC). Participants were recruited via advertisements in local newspapers for SAD participants, and via notices posted around the university campus as well as announcements made in classes for NAC participants. To attempt to match the two groups on age, students over the age of 30 were particularly encouraged to participate during recruitment. Exclusion criteria included current reports of psychosis, or a current diagnosis of bipolar or panic disorder. All participants provided informed consent for study procedures at the beginning of the study. As deception was involved in the study, at the end of the study participants were informed of the true nature of the study and given the opportunity to withdraw consent to have their data included in analyses. No participant withdrew consent. Participants received either cash remuneration, partial credit towards their classes or had their name entered in a draw for cash prizes in exchange for participating.

Participants were excluded if they indicated that they did not at all believe their physiology was being monitored (SAD n = 1; NAC n = 1) or they did not learn how to correctly monitor their physiology (SAD n = 6; NAC n = 7; see section 2.2.7 below for more information). After excluding these participants, there were 33 individuals in the SAD group and 34 individuals in the NAC group. The average age of SAD participants was 34.70 (*SD* = 11.89) and 64% were female. The average age of NAC participants was 29.53 (*SD* = 11.59) and 62% were female. There were no significant differences in age, t (65) = -1.80, p = .08, d = 0.45,or gender, χ^2 (1) = .025, p = .87, between the groups. There was also no significant difference between the groups with regard to highest level of education attained, U = 468.00, p = .30. Among SAD participants the distribution of highest level of education attained was as follows: 3% elementary school, 24% high school, 21% pre-university college[1], 51% university. Among NAC participants the distribution of highest level of education attained was as follows: 21% high school, 51% pre-university college, 27% university. Data concerning highest level of education attained was missing for one NAC participant.

Diagnoses were assessed with the Anxiety Disorders Interview Schedule – IV (ADIS-IV; T. A. Brown, DiNardo, & Barlow, 1994). Individuals in the NAC group did not meet criteria for any DSM-IV disorder. In the SAD group, the mean ADIS-IV severity score for SAD was 4.70 (Range 4-6; *SD* = .81). For all but three participants in the SAD group, SAD was the primary diagnosis. Primary diagnoses for the remaining participants were depression, generalized anxiety disorder (GAD), and post-traumatic stress disorder (PTSD). Participants reported an average of 7.48 (*SD* = 2.05) feared situations with a range from 3 – 11 feared situations. Thus most SAD participants in this study met criteria for the generalized subtype. Among SAD participants 21.2% received one additional diagnosis, 30.3% received two additional diagnoses, and 3% received three additional diagnoses. Six met criteria for GAD, 7 for obsessive-compulsive disorder, 3 for PTSD, 6 for depression, 1 for substance dependence without physiological dependence and 1 for substance dependence without physiological dependence in

[1] In Quebec students are required to complete a pre-university college which is the equivalent of the final two years of high school in other parts of Canada and the United States.

sustained partial remission. Participants meeting criteria for substance dependence agreed not to use the substance(s) on the evening before or day of the experiment.

Participants were included if they were currently taking medications, though they were required to be stabilized on the same dosage for at least one month prior to participating in the study. Among the SAD participants, 27.3% reported currently taking a psychotropic medication. Medications included selective serotonin reuptake inhibitors (n = 4), tricyclic antidepressants (n = 1), other types of antidepressants (n = 2), and benzodiazepines (n = 2). Among the NAC group, 2 participants also reported taking psychotropic medication. One was prescribed an anti-psychotic drug and the other a benzodiazepine.[2]

2.2 *Measures*

2.2.1. *Anxiety Disorders Interview Schedule-IV (ADIS-IV; T.A. Brown, et al., 1994).*

The ADIS-IV is a semi-structured interview that assesses for the presence of anxiety and mood disorders using DSM-IV (American Psychiatric Association, 2000) criteria. For each diagnostic category a dimensional rating from 0 (*none*) to 8 (*very severely disturbing/disabling*) is given at the end of each subsection. Scores greater than 4 indicate that the problem causes significant distress or interference and that all DSM-IV criteria are met to warrant a diagnosis. The ADIS-IV has demonstrated good to excellent inter-rater reliability for all categories except for Dysthymia (T.A. Brown, DiNardo, Lehman, & Campbell, 2001). The interview was administered by doctoral level students trained to administer the ADIS-IV.

2.2.2. *Social Phobia Scale (SPS) and Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998).*

[2] Results pertaining to the predictions of the study did not change when analyses were rerun excluding the two SAD participants meeting diagnostic criteria for substance dependence without physiological dependence and the two NAC participants who reporting taking psychotropic medication.

The SPS and SIAS are 20-item self-report questionnaires assessing the fear of being observed by others and social interaction anxiety, respectively. Scores greater than 24 on the SPS or greater than 34 on the SIAS are suggestive of SAD (Heimberg, Mueller, Holt, Hope, & Liebowitz, 1992). Both scales have exhibited excellent internal consistency, ($\alpha s > .85$) (Heimberg et al., 1992; Mattick & Clarke, 1998; Osman, Gutierrez, Barrios, Kopper, & Chiros, 1998), test-retest reliability (Mattick & Clarke, 1998), and convergent and divergent validity in clinical and non-clinical samples (Heimberg et al., 1992; Mattick & Clarke, 1998). Additionally, the SPS and the SIAS have been shown to effectively discriminate those with SAD from those without SAD (E. J. Brown et al., 1997; Mattick & Clarke, 1998; Peters, 2000).

2.2.3 *Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996).*

The BDI-II is a 21-item self-report measure assessing cognitive, affective, and somatic symptoms of depression. The scale has exhibited acceptable internal consistency ($\alpha s > .89$) (Beck et al., 1996; Carmody, 2005; Dozois, Dobson, & Ahnberg, 1998; Osman et al., 1997; Wiebe & Penley, 2005), test-retest reliability (Beck et al., 1996; Wiebe & Penley, 2005), as well as acceptable convergent and divergent validity (Beck et al., 1996; Osman et al., 1997) in clinical and non-clinical samples.

2.2.4 *Body Sensations Questionnaire (BSQ; Chambless, Caputo, Bright, & Gallagher, 1984).*

The BSQ is a 17-item self-report questionnaire assessing concern and preoccupation with autonomic arousal. A total score is calculated by averaging the 17 individual items, thus scores can range from 1 to 5. The scale has exhibited acceptable internal consistency ($\alpha = .87$) and 1-month test-retest reliability among a sample of individuals with agoraphobia (Chambless et al., 1984). The scale has also exhibited acceptable convergent and divergent validity (Chambless et al., 1984). Research also suggests that this scale is appropriate for use among individuals with other anxiety disorders beyond agoraphobia (Zgourides, Warren, & Englert, 1989). The BSQ was used as a measure of fear of bodily sensations rather than the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986) because items simply assess fears of bodily sensations whereas the ASI also includes wording within the items related to beliefs about the meaning of some sensations (e.g., "When I notice my heart is beating rapidly, I worry that I might have a heart attack") that are likely to be more relevant to panic disorder than SAD.

2.2.5 *Subjective Units of Distress Scale (SUDS).*

Participants were asked to rate how happy, angry, anxious, and depressed they were feeling at the present moment using a 100 mm visual analog scale (VAS) from 0 (*I do not feel at all X*) to 100 (*I feel extremely X*) for each emotion at baseline, just prior to, and just after the word pronunciation task. Only ratings of anxiety were analyzed; the other emotion ratings were used as filler items.

2.2.6 *Performance ratings.*

Participants were asked to rate how accurate, clear, expressive and likeable they anticipated appearing from 0 (*not at all*) to 100 (*completely*) just prior to the word pronunciation task. They were asked to make self-evaluations of these variables using the same rating scale just after completing the word pronunciation task.

2.2.7 *Manipulation check.*

At the end of the study participants were asked to rate, using a 100mm VAS, the degree to which they believed the computer was measuring their physiology from 0 (*completely believed*) to 100 (*did not believe at all*). Participants who did not at all believe the computer was measuring their performance, by circling 100 on the VAS, were excluded. They were also asked using a 100mm VAS the degree to which they believed that their physiology was a good indicator of their performance from 0 (*physiology reflected my performance*) to 100 (*physiology was unrelated to my performance*). To ensure that participants correctly learned how to monitor their physiology based upon the location of the words on the computer screen during the word pronunciation task, participants were asked whether words on the left indicated their physiology was stable, changing, or unrelated to their performance. Participants who answered incorrectly were excluded.

2.3 *Word Stimuli*

A total of 60 nouns were selected from the Toronto Word List (Friendly, Franklin, Hoffman, & Rubin, 1982) for use during the word pronunciation and the recognition tasks. The Toronto Word List contains 1080 nouns that are rated for frequency, imagery, and concreteness in the English language. Words with the 20 highest and 20 lowest rankings of frequency, imagery, and concreteness were eliminated from the word list. Words that were shorter than 5 letters were also eliminated. Additionally, all nouns from the Toronto Word List were screened by nine individuals from the Fear and Anxiety Disorders Lab at Concordia University, who are familiar with stimuli that may appear threatening to someone with an anxiety disorder, particularly SAD. Any word identified as potentially threatening (e.g., “speech”, “party” and “needle”) was eliminated from the word list. From the remaining words, 60 were randomly selected; 30 words were used for the word pronunciation task and 30 words were used as lures during the recognition test. All words were matched for word frequency, imagery and concreteness. Examples of words used include “figure”, “basket”, “silver”, and “province”.

2.4 *Procedure*

Participants were told that the study examines whether performance on a word pronunciation task improves if one knows how his/her physiology is responding. Participants were told word pronunciation is an important part of giving a good speech and that changes in physiology increase the likelihood of word mispronunciation. After being informed of the study purpose, baseline SUDS were taken and participants were administered the ADIS-IV.

2.4.1 *Task Training Phase*

After completing the interview, participants were seated in front of a computer. All experimental tasks (with the exception of questionnaire completion) were completed on the computer using SuperLab Pro V 2.0.4 (Cedrus Corporation, 2003) software.

During the training phase, the operation of the computer was demonstrated to participants. Participants were asked to focus on a + that appeared in the centre of the screen. The + appeared for 1000 ms, and was subsequently replaced by a colored triangle that appeared either on the left (3.5 inches [8.89 cm] from the top and 1.60 inches [4.11 cm] from the left) or on the right (3.5 inches [8.89 cm] from the top and 6.34 inches [16.10 cm] from the left) side of a 16 inch (40.64 cm) screen. Participants were asked to press “F” on the keyboard whenever the triangle appeared on the left and “J” on the keyboard whenever it appeared on the right, and then to name the color of the triangle. These keys were chosen because they are distinguished by raised marks, corresponding to the placement of the left and right index finger when touch typing. After completing 6 training trails, during which half the triangles appeared on the left and half appeared on the right, the experimenter verified that participants understood the computer task before continuing on to the next phase of the study.

2.4.2 *Physiology Monitoring Training*

Following the task training phase, participants were connected to physiology monitoring equipment. TD-142G vinyl disposable electrodes were attached to the inner elbow of each arm and a Velcro electrode cuff was attached to the left ring finger of participants. Participants were told that the electrodes attached to the arm measured heart rate fluctuation and the electrode attached to the finger measured sweating. A Panasonic video camera was mounted directly on top of the computer monitor facing the participant and a computer microphone was placed just to the left of the monitor. Participants were told that the camera would measure "jerky awkward movements," and that the microphone would measure fluctuations in voice quality. A webcam was mounted on top of the computer monitor and participants were told that it was an infra-red camera that would measure how much heat was coming off their body, "a good measure of how much [they were] blushing."

Participants were told that the equipment would monitor their physiology and that they would receive feedback as to whether their physiology was changing or not changing. At no point in time during the experiment was the physiology of participants ever measured. Participants were told that when the stimuli appears on one side of the screen (e.g., left) it indicates that their physiology is changing and when it appears on the other side of the screen (e.g., right) it indicates that it is stable. The location of stimuli associated with changing and stable physiology was counterbalanced across participants.

Participants then completed a practice exercise to help them better remember how to monitor their physiology. The practice exercise was the same as the training task, except that participants were also asked to say out loud whether their physiology was changing or stable based on feedback from the computer. To increase the believability of the physiology manipulation, the practice exercise was completed under two conditions; while sitting quietly when 5 out of 6 of the triangles appeared in the location associated with stable physiology, and after having jogged on the spot for 30 seconds when 5 of out 6 of the triangles appeared in the location associated with changing physiology.

2.4.3 *Word Pronunciation Task*

Just prior to completing the word pronunciation task, participants were reminded of the supposed purpose of the experiment. To increase the level of threat provoked by the word pronunciation task, participants were also told that their performance was being videotaped and would be shown to a psychologist and a linguist at a later date who would evaluate their performance. In reality, though the task was video-taped, the recordings were erased after each testing session. Just prior to beginning the task, participants provided SUDS ratings and answered anticipatory performance rating questions.

During the word pronunciation task, participants saw 30 words in total, half of which were randomly assigned to appear on the left, with remaining words appearing on the right. As soon as they detected the word, participants were asked to indicate if the word appeared on the left or the right by pressing “F” or “J” respectively, and then to say the word to the camera. Reaction time (RT) between the word appearing on the screen and participants pressing the key was measured. No more than two words in a row appeared on the same side consecutively.

After completing the word pronunciation task, participants once again provided SUDS ratings and completed the self-evaluation performance questions. Participants were then given a 3 minute distraction task consisting of a series of simple math problems to ensure that study words were not held in working memory.

2.4.4 *Memory Assessment*

Participants were told that they would be completing two more word pronunciation tasks and although their performance was still being evaluated and their physiology would continue to be monitored, they would no longer receive feedback on how their physiology was responding.

2.4.4.1 *Free recall.*

Participants were asked to recall and say out-loud to the video camera as many of the words they saw during the first task as possible. Participants were then given 3 minutes to recall as many words as possible. At the end of 3 minutes, participants were asked to rate how confident they were that they were correct from 0 (*not at all confident*) to 100 (*completely confident*) for each word they said.

2.4.4.2 *Recognition.*

Participants were then shown 60 consecutive words on the computer appearing in the center of the screen. Half of the words were from the word pronunciation task, while remaining words had not been seen during the experiment. No more than three words in a row were targets or lures and no more than two consecutive words were targets that had appeared on the left or the right. Participants were asked to indicate by pressing a key on the keyboard if the word was new ("N" key), old and appeared on the left ("F" key), or old and appeared on the right ("J" key). They were then asked to say the word to the camera.

Once the recognition task was completed participants were disconnected from the equipment and completed questionnaire packages which included the questionnaires listed above. Finally, participants answered the manipulation check questions and were debriefed concerning the true nature of the study.

2.5 *Statistical Analyses*

The percentage of correctly recalled words associated with changing and stable physiology were calculated, as were the percentages of hits and false alarms during the recognition task. Hit rates were calculated as the percentage of items correctly recognized (e.g., described as old) regardless of whether they correctly remembered the location of the word (e.g., whether it appeared on the left or right). False alarms were calculated as the percentage of new items participants said appeared on the left or right. Because hit and false alarm rates do not adequately distinguish memory accuracy from response bias, signal detection theory was used. *d'*, a measure of sensitivity, reflects the degree of overlap between distribution of signal (e.g., responses to old items) and noise (e.g., the responses to new items) measured in standard deviation units (MacMillan & Creelman, 2005; Stanislaw & Todorov, 1999). Criterion *c* was used as a measure of response bias. It reflects the distance, measured in standard deviations, between the neutral point (where the signal and noise distributions intersect) and the response criterion set by the participant. Positive values of *c* reflect a tendency to say an item was new (e.g., they had not seen it before) and negative values reflect the tendency to say an item was old (e.g., they had seen it before). Criterion *c* was chosen as a measure of response bias because it is less affected by changes in *d'* compared to other measures of response bias (MacMillan & Crellman, 2005; Stanisklow & Todorov, 1999). *d'* and *c* were calculated using the formulas described by Sorkin (1999). Because *d'* and *c* cannot be calculated when hit or false alarm rates are equal to 0 or 1, log linear adjustments, which have been shown to yield less biased results than other adjustment methods (Miller, 1996), were used to calculate hit and false alarm rates.

3. Results

3.1 *Psychopathology*

Independent *t*-tests revealed that SAD participants scored significantly higher on the SPS, $t\ (62) = -9.94$, $p < .001$, $d = 2.52$, the SIAS, $t\ (61) = -9.27$, $p < .001$, $d = 2.37$, the BDI-II, $t\ (64) = -4.71$, $p < .001$, $d = 1.18$, and the BSQ, $t\ (64) = -3.99$, $p < .001$, $d = 1.00$. Participants' scores are presented in Table 1.

3.2 *Manipulation Check*

There was no significant difference between SAD and NAC participants in the degree to which they believed the computer was measuring their physiology, t (65) = 1.03, p = .31, d = .26. In general both SAD (M = 27.58, SD = 24.77) and NAC (M = 34.74, SD = 31.57) participants moderately believed that the computer was measuring their physiology.

There was also no significant difference between SAD and NAC participants in the degree to which they thought that their physiology might be a good indicator of their performance, t (65) = 1.17, p = .25, d = .29. In general both SAD (M = 23.58, SD = 19.69) and NAC (M = 29.26, SD = 20.06) participants moderately believed that their physiology would be a good indicator of their performance.

3.3 *Anxiety and Perceived Performance during Word Pronunciation Task*

To examine the effect of the word pronunciation task on anxiety and beliefs about performance we examined anxiety SUDS and performance measures prior to and after the task. For anxiety, a group (SAD vs. NAC) x time (baseline vs. pre-task vs. post-task) ANOVA revealed that SAD participants (M = 55.01, SD = 24.71) reported significantly more state anxiety than NAC participants (M = 34.22, SD = 23.50), F (1, 64) = 23.19, $p < .001$, $\eta_p^2 = .27$. The main effect of time was also significant, F (2, 128) = 10.94, $p < .001$, $\eta_p^2 = .15$. Pairwise comparisons show that anxiety was significantly greater at pre-task (M = 48.61, SD = 26.58) than at baseline (M = 41.62, SD = 28.19) or post-task (M = 36.56, SD = 26.17). The group x time interaction was not significant, F (2, 128) = .17, p = .85, $\eta_p^2 = .003$.

For performance perception, a group (SAD vs. NAC) x time (anticipated vs. perceived) MANOVA with ratings of accuracy, clarity, expressiveness, and likeability as the dependent variables revealed a main effect for group, F (4, 62) = 7.45, $p < .001$, $\eta_p^2 = .33$, and time, F (4, 62) = 5.07, $p < .001$, $\eta_p^2 = .25$, but no group x time interaction, F (4, 62) = 1.15, p = .34, η_p^2 =

.07. Univariate ANOVAs demonstrated that compared to perceived ratings, anticipatory ratings were significantly lower for accuracy, F (1, 65) = 13.36, $p < .001$, $\eta_p^2 = .17$, and significantly higher for how likeable participants thought they were, F (1, 65) = 6.76, $p < .05$, $\eta_p^2 = .09$. There was a trend for participants to also give lower ratings for how clear, F (1, 65) = 3.26, $p = .08$, $\eta_p^2 = .05$, and higher ratings for how expressive, F (1, 65) = 3.40, $p = .07$, $\eta_p^2 = .05$ they were, when anticipating their performance prior to the task compared to their perception of their performance after the task. That is, on some performance measures participants under-anticipated their performance whereas on other measures they over-anticipated their performance. SAD participants rated themselves as significantly less accurate, F (1, 65) = 9.26, $p < .01$, $\eta_p^2 = .13$, clear, F (1, 65) = 16.45, $p < .001$, $\eta_p^2 = .20$, expressive, F (1, 65) = 9.06, $p < .01$, $\eta_p^2 = .12$, and likable, F (1, 65) = 21.62, $p < .001$, $\eta_p^2 = .25$, overall compared to NAC participants. Results are presented in Table 2.

3.4 *Reaction Time during the Word Pronunciation Task*

A group (SAD vs. NAC) x variable (change vs. stable words) ANOVA revealed that SAD participants responded significantly slower than NAC participants during the word pronunciation task, F (1, 64) = 8.35, $p < .01$, $\eta_p^2 = .12$. There was no main effect for variable, F (1, 64) = .70, $p = .41$, $\eta_p^2 = .01$, however there was a significant group x variable interaction, F (91, 64) = 5.74, $p < .05$, $\eta_p^2 = .08$. Pairwise comparisons demonstrate that participants in the SAD group responded significantly more slowly to words associated with changing physiology (M = 1330.42ms, SD = 506.80ms) compared to words associated with stable physiology (M = 1237.69ms, SD = 473.03ms), F (1, 64) = 5.08, $p < .05$, $\eta_p^2 = .07$, whereas there was no significant difference in the NAC group with regard to reaction time for words associated with changing (M = 935.94ms, SD = 442.52ms) or stable (M = 980.59ms, SD = 467.48ms), physiology, F (1, 64) = 1.25, p = .27, η_p^2 = .02.

3.5 *Memory*

3.5.1 *Free Recall*

All memory-related results are presented in Table 3. For the percentage of items recalled, a group x variable ANOVA revealed no significant main effects for group, F (1, 65) = .17, p = .68, η_p^2 = .003, variable, F (1, 65) = .34, p = .56, η_p^2 = .01, nor a significant group x variable interaction, F (1, 65) = .006, p = .94, $\eta_p^2 < .0001$. Of items that were correctly recalled, a group x variable ANOVA found that participants reported significantly greater confidence in their memory for words associated with changing compared to stable physiology, F (1, 34) = 5.34, $p < .05$, η_p^2 = .14. There were no significant differences in confidence ratings between groups, F (1, 34) = .76, p = .39, η_p^2 = .02, nor was there a significant group x variable interaction, F (1, 34) = .61, p = .44, η_p^2 = .02.

3.5.2 *Recognition*

For the percentage of hits, a group x variable ANOVA revealed no significant main effects for group, F (1, 65) = .002, p = .97, $\eta_p^2 < .0001$, variable, F (1, 65) = 1.78, p = .19, η_p^2 = .03, nor a significant group x variable interaction, F (1, 65) = 2.10, p = .15, η_p^2 = .03.

For false alarm rates, the group x variable ANOVA revealed no significant main effects for group, F (1, 65) = .13, p = .34, η_p^2 = .01, or variable, F (1, 65) = 2.67, p = .11, η_p^2 = .04, nor a significant group x variable interaction, F (1, 65) = .19, p = .66, η_p^2 = .003.

To determine if there were any differences in overall memory accuracy during recognition we also examined *d'*. The group x variable ANOVA revealed a significant main effect for variable, F (1, 65) = 5.05, $p < .05$, η_p^2 = .07. Participants were more accurate at detecting words associated with changing compared to stable physiology. The main effect of group was not significant, *F* (1, 65) = .51, *p* = .48, η_p^2 = .008, nor was the group x variable interaction, *F* (1, 65) = 2.16, *p* = .15, η_p^2 = .03.

For response bias, a group x variable ANOVA revealed no significant, main effects for group, *F* (1, 65) = .35, *p* = .56, η_p^2 = .005, or variable, *F* (1, 65) = .15, *p* = .70, η_p^2 = .002, nor a significant group x variable interaction, *F* (1, 65) = .75, *p* = .39 , η_p^2 = .01.

3.6 *Correlations Between Information Processing. Depression and Anxiety*

To examine the relationships between information processing with symptoms of depression, social anxiety, and fear of bodily sensations, correlations between the BDI, SPS, SIAS, and the BSQ with RT during the word task, and percentage of items recognized were calculated. They are presented in Table 4 for each group. There were no significant correlations between these symptom variables and RT during the task in the NAC and SAD groups separately. Among SAD participants, scores on the BSQ were significantly and positively correlated with percentage of recognized changing and stable items. In the NAC group there were no significant correlations between recognition and any symptom measure.

To examine if the correlation between the BSQ and the percentage of recognized changing and stable items was significantly larger among SAD than NAC participants *r* s were transformed to Fisher's Z to test for the significance of differences between independent *r*s (Glass & Hopkins, 1984). The correlations for SAD participants were significant larger than the correlations for NAC participants for both the correlation between the BSQ and the percentage of hits for stimuli associated with changing physiology, z = 9.03, p < .001, and stimuli associated with stable physiology, z = 10.60, p < .001.

4. Discussion

This study examined whether individuals with SAD exhibit a memory bias for cues they believed indicated changing physiological arousal. Contrary to expectations we did not find that individuals with SAD remembered more words associated with changing physiology compared to a non-anxious control group. We did, however, find that participants, regardless of social anxiety status, were more accurate in recognizing words associated with changing than stable physiology and were more confident in their recall of words associated with changing than stable physiology. That is all participants appeared to show enhanced memory for information that their physiology was changing.

These results suggest that a memory bias for increasing arousal is not specific to social anxiety. Other studies have also found that all participants, regardless of social anxiety level, show enhanced memory for social threat words (Rapee et al., 1994) or affectively valenced words (Cloitre et al., 1995). One possible explanation for these findings is that processes implicated in social anxiety, such as self-focused attention, are activated in most individuals when anxiety increases in social situations. Consistent with this hypothesis, research has found that overall, individuals, regardless of the level of social anxiety, increase self-focused attention under evaluative conditions (Mellings & Alden, 2000). What may distinguish individuals with SAD from individuals without SAD is the degree and frequency of anxiety experienced. To detect memory biases in SAD, it may be necessary to use a control group reporting minimal levels of social anxiety or to test memory using performance tasks that provoke very minimal anxiety in control participants.

An alternative hypothesis is that individual differences in the type(s) of feared stimuli among SAD participants may determine if memory biases for bodily sensations exist. We found that among SAD participants only, there was a positive correlation between a measure of fear of bodily sensations and the percentage of items associated with changing and stable physiology recognized. The relationship between recognition and fear of body sensations was not apparent among non-anxious participants. That is, SAD participants who tended to report greater fear of bodily sensations also remembered more stimuli associated with their bodily response.

We also found higher correlations between the SPS and the BSQ than the SIAS and the BSQ, particularly among SAD participants. This is consistent with other research suggesting that fear of public speaking, but not fear of social interactions, is associated with fear of bodily sensations and panic-like symptoms (Hofmann, Ehlers, & Roth, 1995; Norton, Cox, Hewitt, & McLeod, 1997).

To account for the difficulty in demonstrating memory biases in anxiety, Williams and colleagues' (1997) model of emotion and information processing suggests that anxiety is associated with early pre-attentive information processing biases apparent in attentional tasks followed by avoidance at the voluntary stage of information processing where explicit memory biases are likely to occur. This model, however, is inconsistent with clinical observations that suggest individuals with anxiety often dwell upon fearful situations and models of social anxiety in particular that implicate post-event processing as one of the maintaining factors (Clark & Wells, 1995). Our results, though correlational, point to another possibility consistent with a different approach based on personal significance (see Radomsky & Rachman, 2004). It may be that at later stages of processing individuals selectively elaborate aspects of a social situation they believe are most relevant to their anxiety experiences. Individuals with SAD who fear bodily sensations would be more likely to remember the arousal they experienced during a social situation but may not be more likely to remember information about bored audience members, whereas the opposite may be true for individuals with SAD who report fear of judgment from others but less fear of their bodily sensations. Consistent with this alternative hypothesis regarding anxiety and memory, the few studies that have demonstrated enhanced memory for threat in social anxiety have used personally relevant stimuli (Breck & Smith, 1983; Daly et al., 1989; Mellings & Alden, 2000; O'Banion, & Arkowitz, 1977, Smith, et al., 1983). It is also consistent with research suggesting that memorial biases are likely only to be detected when interpretation biases are examined concurrently (Hertel, Brozovich, Joormann, & Gotlib, 2008). Future research assessing memory using more idiographic approaches is warranted. Furthermore research in which the interpretation of social experiences, such as the meaning of bodily sensations during a social performance, is manipulated should be conducted to examine how such interpretations influence memory.

One other interesting finding emerged from this study and warrants discussion. During the encoding task we found that participants with SAD had longer RTs than non-anxious participants for words associated with changing but not stable physiology. It may be that slower response times for stimuli associated with changing physiology observed among SAD participants resemble the slower response of anxious compared to non-anxious participants to the 'emotional Stroop' paradigm (e.g., Lundh & Öst, 1996c). Results could reflect factors that have also been suggested to affect the emotional Stroop response including cognitive avoidance and inhibition of response due to the emotional reaction elicited by information that one's physiology is changing (Bögels & Mansell, 2004). Previous research has demonstrated that individuals with social anxiety preferentially attend to internal cues of arousal rather than external cues of social threat (Mansell et al., 2003; Pineles & Mineka, 2005). Current results suggest that selective attention may be further refined and directed towards specifically changes in physiological response. As this study was designed as a memory study rather than an attention study, participants were not asked to respond as soon as they detect the location of the word, interpretation of these results needs to be made with caution. Future research examining selective attention for different types of internal cues in social anxiety warrants examination.

Methodologically, this study was one of the few studies to assess memory during a social task rather than in anticipation of a task. More particularly, this was one of the first studies to assess memory for personal internal information using an objective method. The alternative performance task (e.g., the word pronunciation task) in this study was successful in provoking anxiety and resulted in similar changes in anxiety and perceived performance among SAD and NAC participants as standard performance tasks (e.g., Ashbaugh, McCabe, Antony, Schmidt, & Swinson, 2005; Mellings & Alden, 2000). This new methodology may allow researchers to examine memory and other information processes during anxiety provoking events rather than in anticipation of them as is frequently done (e.g., Mansell et al., 2003). However, rates of recall among participants were low ranging from 8.04% to 9.23%. These low rates of recall may have prevented us from detecting group or stimulus differences in recall. A task that encourages deeper encoding, such as having participants create sentences with the words, may have increased rates of recall.

In addition to this methodological challenge, a few other limitations should be noted. First, to maintain the believability, ecological validity of the task, and encourage deeper processing of the stimuli of interest, participants were told that changes in physiology results in a greater likelihood to mispronounce words. This may have led participants to pay particular attention to stimuli indicative of physiological change and may account for differences in recognition of stimuli associated with change versus stable physiology, but would not necessarily account for the correlations between recognition of stimuli associated with change and stable physiology and fear of bodily sensations observed among SAD participants. Additionally, though most participants likely interepted “changing physiology” to reflect increasing physiological response, some may have interpretted it to mean decreasing physiological response as well, which could potentially affect how they process the meaning of such changes. These individual differences may have increased variability in results. Replication addressing these limitations is warranted.

Additionally, the SAD group reported higher levels of depression than the NAC group. However, correlations between reaction time, recognition and scores on the BDI-II were non-significant for both the NAC and SAD groups, suggesting that depression may not have played a significant role in determining results. Secondly, our NAC group was comprised of undergraduate students. Though we attempted to reduce potential differences between the two groups by actively recruiting students over the age of 30, a community control group may have been a better comparison group. Future researchers may wish to replicate findings from this study with depression as a further exclusionary criterion and use a community control group to further examine memory for physiological arousal in social anxiety. Finally, control for familywise error rates for the correlational analysis was not possible without substantially reducing the power of the study, though we did attempt to reduce the possibility of making a Type I error by limiting the number of correlations between BSQ and memory to percentage recognized only.

The results of this study suggest that enhanced memory for bodily sensations of arousal may be apparent in some individuals with SAD, specifically those who report elevated fears of those sensations. For these individuals, reappraisal of beliefs about bodily sensations, interoceptive exposure, and attention retraining to reduce self-focus (Wells & Papageorgiou,

1998) may be particularly beneficial during cognitive-behavioral treatment. More broadly, these findings suggest the importance of taking an idiographic approach toward feared stimuli in both the research and cognitive-behavioral treatment of SAD.

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Table 1

Mean (SD) Scores on Symptom Measures for Social Anxiety Disorder (SAD) and Non-anxious Control (NAC) Participants

Measure	SAD	NAC
	(*n* =33)	(*n* = 34)
SPS[a*]	37.35	9.36
	(13.68)	(8.39)
SIAS[b*]	46.65	17.22
	(13.50)	(11.65)
BDI-II[c*]	16.82	6.42
	(11.04)	(6.24)
BSQ[d*]	2.46	1.77
	(.72)	(.68)

[*] $p < .001$;

[a] Social Phobia Scale(Mattick & Clarke, 1998)

[b] Social Interaction Anxiety Scale (Mattick & Clarke, 1998)

[c] Beck Depression Inventory-II (Beck et al., 1996)

[d] Body Sensations Questionnaire (Chambless et al., 1984)

Table 2

Mean (SD) Anticipated and Perceived Performance for Social Anxiety Disorder (SAD) and Non-anxious Control (NAC) Participants

	SAD		NAC	
Performance Variable	Anticipated	Perceived	Anticipated	Perceived
Accurate†*	74.55	78.24	81.15	90.41
	(15.78)	(18.55)	(11.61)	(11.20)
Clear*	71.06	71.76	81.74	87.06
	(16.00)	(18.98)	(10.81)	(12.05)
Expressive*	58.33	52.00	73.06	67.62
	(23.11)	(25.28)	(17.05)	(24.21)
Likeable†*	52.36	51.33	77.53	72.94
	(24.61)	(22.88)	(16.78)	(21.10)

* The main effect of group was significant at $p < .05$.

† The main effect of time was significant at $p < .05$.

Table 3

Mean (SD) Recall and Recognition Scores for Words Associated with Changing and Stable Physiology for Social Anxiety Disorder (SAD) and Non-anxious Control (NAC) Participants

Memory Variable	Change		Stable	
	SAD	NAC	SAD	NAC
% Recalled	9.23 (6.86)	8.82 (8.16)	8.67 (6.77)	8.04 (7.48)
Recall Confidence	93.65^{x} (11.64)	95.33^{x} (12.88)	82.51^{y} (25.44)	89.83^{y} (20.13)
% Recognition Hits	72.12 (15.37)	74.12 (18.70)	71.92 (13.92)	69.22 (15.22)
% Recognition False Alarms	10.51 (8.04)	8.24 (6.88)	11.92 (10.71)	10.69 (9.56)
Recognition *d'*	1.88^{x} (.67)	2.08^{x} (.62)	1.82^{y} (.63)	1.82^{y} (.38)
Recognition *c*	.34 (.31)	.35 (.38)	.32 (.33)	.41 (.39)

Note. Values in the same row with differing superscripts are significantly different from each other at $p < .05$.

Table 4

Correlations Between Symptom and Encoding and Memory Measures for Social Anxiety Disorder (SAD) and Non-anxious Control (NAC) Participants

Variable	SPS[a]	SIAS[b]	BDI[c]	BSQ[d]
		SAD (*n* = 33)		
SPS	--	.66**	.18	.52**
SIAS	--	--	.18	.29
BDI	--	--	--	.26
RT Change	.21	-.08	.18	.09
RT Stable	.27	-.05	.29	.28
% Hits Change	.13	.12	.22	.45**
% Hits Stable	.23	.07	.22	.43*
		NAC (*n* = 34)		
SPS	--	.79**	.29	.58**
SIAS	--	--	.38*	.60**
BDI	--	--	--	.33
RT Change	-.28	-.08	.04	-.27
RT Stable	-.21	-.09	.02	-.25
% Hits Change	-.13	-.24	-.14	-.01
% Hits Stable	.07	-.03	-.11	-.12

* $p < .05$

** $p < .01$

[a] Social Phobia Scale (Mattick & Clarke, 1998)

[b] Social Interaction Anxiety Scale (Mattick & Clarke, 1998)

[c] Beck Depression Inventory-II (Beck et al., 1996)

[d] Body Sensations Questionnaire (Chambless et al., 1984)