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Attentional Biases, Emotional Arousal, and Post-Event Processing in Social Anxiety: An Eye-Tracking Study

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Research across the past two decades has identified attentional biases (AB) to threat as a cognitive vulnerability factor for social anxiety symptoms. However, much remains unknown regarding the nature of the association between AB and other key physiological and cognitive maintenance factors proposed by the cognitive-behavioral model of social anxiety. The current study investigated the relationship between AB to threat and emotional, physiological and cognitive responding to a social stressor in an undergraduate sample (*N* = 55) using eye-tracking methodology. Findings revealed a significant positive association between AB-disgust and subjective emotional reactivity (SER). Furthermore, AB-disgust had a significant indirect effect on post-event processing (PEP) via SER. Results also demonstrated that SER and subjective emotional recovery significantly predicted PEP. Hypothesized links between AB-disgust and the remaining variables considered, including subjective emotional recovery, physiological reactivity and recovery, and PEP, were not supported. Results extend previous research by demonstrating that the preconscious process AB to threat, directly impacts emotional responding to a social situation, and indirectly influences downstream cognitive processes. Research and clinical implications are discussed.

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Chapter 1: Introduction

Social anxiety disorder (SAD) is a debilitating condition characterized by marked and persistent fear of negative evaluation, particularly in social or performance situations in which embarrassment may occur (APA, 1994). This fear is often accompanied by physical symptoms such as pounding heart, sweating, blushing, muscle tension, and upset stomach. The consequences of SAD may be extreme for some individuals. Compared to healthy individuals, those with SAD report increased rates of suicidal ideation, greater use of medical facilities, along with impaired occupational and academic performance (Davidson, 1994). Many errands of daily life also require social interactions, such as ordering food at a restaurant, talking on the phone, or attending a concert. These tasks, considered trivial by many, are challenging for over 15 million Americans who are affected by SAD (ADAA, 2013).

Individuals with SAD anticipate embarrassment and criticism in most social situations. This fear of negative evaluation is associated with a subsequent desire for preparedness regarding potential social threats. One element of preparedness is the detection of threat. Clinical and anecdotal reports suggest that individuals with SAD are more likely to notice frowning or bored faces in a crowd compared to those who do not have SAD (Veljaca & Rapee, 1998). The tendency to preferentially attend to stimuli congruent with one's mood or self-perception is called an attention bias (AB). Although being prepared for a threat may sometimes be adaptive, the threat detection system (including AB) of individuals with SAD is thought to be oversensitive (Craske et al., 2009), which may act as a maintenance factor by reinforcing symptoms.

Over the past decade, tremendous strides have been made in understanding AB associated with SAD. Much of the research to date has focused on investigating and identifying AB in relation to early versus late stages of information processing (e.g., Buckner et al., 2010; Schofield et al., 2012; Wieser et al., 2009). A second line of research has focused on the effects of masked primes (e.g., Helfinstein et al., 2008) or impending social threat (e.g., Garner et al., 2006; Sposari & Rapee, 2007) on AB, while a third set of investigations has examined the effects of attention retraining on emotional reactivity to social stressors (e.g., Klumpp & Amir, 2010). This literature notwithstanding, much remains unknown regarding the relationship between AB and other facets associated with information processing in SAD. One area in particular that deserves greater study is how AB could influence downstream emotional and cognitive processing following social stressors. This information would shed further light on mechanisms that elicit and maintain social anxiety symptoms, and may also be helpful in guiding intervention research. To address this gap in the extant research, the purpose of the current study is to examine the association between AB and (1) physiological and emotional reactivity to a stressor, (2) physiological and emotional recovery from a stressor, and (3) post-event processing.

Etiological and Maintaining Factors Associated with SAD

Etiological models of SAD posit that a combination of genetic and environmental factors account for the development of SAD. Family studies have demonstrated elevated levels of social anxiety in the family members of individuals diagnosed with SAD (Fyer et al., 1993; Fyer et al., 1995), and twin studies have found that approximately 10% of the variance in social anxiety may be attributed to genetic factors (Hettema et al., 2005). A range of environmental factors have additionally been found to influence the development and maintenance of SAD. The first is a child's interactions with his/her parents. Specifically, there appears to be an association between greater levels of social anxiety in the child and a parenting style characterized by greater control and emotional distance (Arrindell et al., 1989). A second environmental factor is aversive or stressful social experiences. One study found that 58% of individuals with social anxiety remember an extremely humiliating social experience from their childhood (Ost & Hugdahl, 1981). In addition, negative life events such as parental divorce, parental psychopathology, family conflicts, and sexual abuse have been shown to increase the likelihood of developing SAD (Chartier et al., 2001; Kessler et al., 1997; Magee, 1999; Stein et al., 1996; Stemberger et al., 1995).

The cognitive-behavioral model of SAD (Clark & Wells, 1995; Rapee & Heimberg, 1997) incorporates these biological and environmental factors, and furthermore highlights the role of cognitive, behavioral and emotional processes that are more specific to SAD (see Figure 1). Relevant to our understanding of

AB in SAD, the model posits that individuals with social anxiety preferentially allocate their attention to potential sources of threat upon entering a social situation. This allocation of attention, along with underlying dysfunctional beliefs and assumptions, leads to the perception of social threat. More specifically, individuals with SAD form a mental image of themselves as seen by the audience and compare this image with the standards that they believe the audience holds (Rapee & Heimberg, 1997). Any incongruence detected between the two leads the individual with SAD to anticipate and fear negative evaluation. With increasing apprehension, the individual experiences the cognitive (e.g., automatic thoughts; further preferential allocation of attentional resources to internal and external stimuli), physical (e.g., heart racing), and behavioral (e.g., safety behaviors such as playing with phone) symptoms which in turn reinforce and maintain social anxiety. These processes can take place in the moment during a social interaction, though they may also play an active role in maintaining symptoms *after* the situation has resolved. For example, individuals with SAD have been found to reflect on, and ruminate about the negative aspects of the situation (i.e., post-event processing). This model has been specifically put forth to capture the etiology and maintenance of SAD. However, in line with recent taxometric findings that indicate that SAD is captured by a dimensional latent distribution (Ruscio, 2010), the model also captures non-clinical and sub-clinical social anxiety symptoms.

Attention Biases in SAD

From a theoretical perspective, attention allocation influences the way that information is received and processed, and thus has implications for how one responds cognitively and physiologically to anxiety-provoking situations (Beck & Clark, 1997). Prior to reviewing the extant literature on AB in relation to social anxiety symptoms and SAD, it should be noted that AB has been conceptualized in several different ways. Specifically, there appear to be three primary definitions. First, AB has been described as increased vigilance towards threat, measured by faster reaction time or initial orientation to threat stimuli. A second definition is that AB reflects increased avoidance from threat, as measured by slower reaction time to threat, and initial orientation to non-threat stimuli. Finally, other studies have described AB as difficulties disengaging from threat measured by a longer reaction time to detect a probe placed opposite of the threatening stimuli. Despite differences in these definitions, all three are captured by the cognitive behavioral model of social anxiety described above and reflect preferential processing of threat. In the review below, as well as in the current study, all types of preferential processing of threat will be conceptualized as an AB.

A number of different experimental paradigms have been used to test the association of social anxiety with AB to social threat stimuli. Despite methodological differences, the majority of results have pointed to the presence and salience of AB in social anxiety (Bar-Haim et al., 2007). The emotional Stroop test is one of the earliest methods used to assess AB, and requires individuals to name the ink color of a word presented on a screen. Response latencies in naming the color of social threat words (e.g. *criticize*) compared to neutral words (e.g. *chair*) are hypothesized to indicate an AB to threat. A majority of the studies that used the emotional Stroop test supported the hypothesis that individuals with SAD are faster to respond to words of social threat (Heinrichs & Hofmann, 2001) compared to neutral words. In addition, some studies have shown that individuals with SAD have particular difficulty ignoring the meaning of words related to negative evaluation (e.g., *criticize*) and to observable symptoms of social anxiety (e.g. *sweating*) in Stroop tests when they are asked to name the color of such words (Bogels & Mansell, 2004). Despite these findings in support of AB, the emotional Stroop test is not without its limitations, the primary one being that it relies on reaction time as a proxy for an AB. Some researchers have argued that the delay in responding to social threat stimuli in Stroop tests may be due to other factors such as response bias (Williams et al., 1996). Further, this test does not allow for getting a precise measure of the location of attention during the task. Thus, it is not clear whether response latencies on this task indicate inhibition difficulties in attention allocation.

Researchers have also utilized visual search tasks to assess AB. Individuals are asked to scan a group of faces and detect the positive or negative one. The results of such studies have suggested that individuals with SAD exhibit vigilance to threat. Gilboa-Schechtman et al. (1999) asked participants with SAD and controls to detect the dissimilar face from photographed faces on a matrix as quickly as they could. The SAD group was significantly faster to detect angry faces in a neutral crowd than happy faces, and slower than controls when searching for neutral faces in angry crowds, pointing to the presence of a bias towards non-neutral facial expressions in social anxiety. A different study used a free-viewing paradigm to measure the gaze of individuals with SAD and control subjects with an infrared corneal reflection technique. The study found that the SAD group spent less time overall looking at facial features of sad and neutral faces compared to happy faces (Horley et al., 2004). One may argue that faster detection of threat stimuli coupled with superficial processing of this information may lead to the continued presence of social anxiety symptoms by preventing the individual from truly understanding all of what is happening in a given situation. A primary limitation of this research is that visual search tasks—particularly when used in conjunction with reaction time—also do not provide a pure measure of AB.

A third methodological approach has involved testing the preferential processing of threatening stimuli using a modified dot-probe paradigm. On this task, participants are asked to fixate on a cross in the center of a computer screen, usually for 500-1000 milliseconds. When the cross disappears, they are presented with two words (or faces) in the center of the screen. Subsequently the words disappear, and a probe, such as an asterisk, replaces one of the words. The participant is asked to respond to the probe by pressing a key. Quicker responses to the probes that replace threat words are thought to indicate AB towards threat. This line of research has shown that individuals with social anxiety symptoms respond faster to probes replacing threat stimuli masked with jumbled facial features as opposed to neutral stimuli (Mogg & Bradley, 2002); this was inconsistent with the results of emotional Stroop studies discussed above. Interestingly, Amir et al. (2003) found that individuals high in social anxiety were slower to detect the target when the target appeared on the opposite side of the screen following a social threat word, indicating that this group had difficulties moving their attention away from threat. Taken together, these two results demonstrate that early and quick processing of threat and difficulties reorienting attention away from threat are associated with social anxiety symptoms.

Dot-probe studies have also been used to examine whether AB is influenced by the presence or absence of an imminent social threat (e.g., giving a speech). Mansell et al. (1999) asked individuals who were high (HSA) or low on social anxiety (LSA) symptoms to detect the location of a probe that followed a facial expression (positive or negative) or a household object. Half of the participants were told that they would be asked to give an impromptu speech after the task. HSA individuals showed an AB away from all emotional faces (positive and negative) only when they were threatened to give a speech after the task. The LSA group in the speech condition, and the participants in the no speech condition (regardless of their group status), did not demonstrate this bias. The results of this study suggested that the inclusion of a social threat anticipation may lead individuals with social anxiety symptoms to avoid all emotional stimuli prior to actual social evaluation. Similarly, Sposari and Rapee (2007) found that individuals with SAD exhibited a preference towards faces rather than household objects in a no-stress condition; however, they became vigilant of faces when told that they would later give a speech. These dot-probe studies indicated that anticipation of immediate negative evaluation may influence the manifestation of AB.

Dot-probe tasks offer three major advantages over the emotional Stroop tests. First, the simultaneous presentation of threat and neutral stimuli increases internal validity—individuals with SAD are often confronted with simultaneous exposure to different stimuli (both positive and negative) that compete for attention. Secondly, the dot-probe paradigm allows for the assessment of both vigilance to and avoidance from threat. This distinction is important given research described above, showing that vigilance and avoidance may be activated under different circumstances. Thirdly, by relying on faces as stimuli, the dot-probe task increases ecological validity compared to tasks using words. In real life social situations, individuals are more likely to encounter ambiguous or negative faces, rather than direct negative verbal feedback. These advantages notwithstanding, the dot-probe still represents an indirect assessment of AB, as it relies on reaction time, and does not allow for assessing natural gaze over time.

Eye-tracking technology has been one method for directly addressing the shortcoming of these previous methods for assessing AB. An eye tracker assesses the changes in attentional deployment over time and continuously records the exact position of the eye gaze without requiring the participant to provide an explicit response. One study that highlights the salience of the qualitative information provided by the continuous assessment of eye gaze was conducted by Wieser et al. (2009), where individuals with high or low fear of negative evaluation (FNE) were presented with pictures of angry or happy facial expressions paired with neutral expressions. Results revealed that the high FNE group looked at emotional faces more than neutral ones. A closer investigation of the time course of attention demonstrated that the high FNE group attended to the emotional faces longer during the first 1000 milliseconds, and then oriented their attention away from them in the next 500 milliseconds. These findings suggested that attentional deployment may take different forms in early- versus late-stage information-processing. Interestingly, there is some evidence from studies, using similar eye-tracking methodology, that late-stage attentional processes may also reflect difficulties with orienting attention away from threat stimuli. Buckner et al. (2010) presented a non-clinical sample of participants with faces displaying disgust or happiness matched with socially irrelevant objects and found evidence for biased attention towards social threat cues (i.e. disgust faces) followed by difficulty disengaging from threat. Furthermore, Schofield et al. (2012) found that social anxiety was associated with greater attention to emotional (angry, fearful, and happy) rather than neutral facial expressions. Taken together, these eye-tracking studies point to the importance of assessing AB continuously and tentatively support the presence of attentional vigilance towards threat in social anxiety, followed by either avoidance or difficulty with disengagement.

In conclusion, as the studies reviewed above suggest, there appears to be strong support for an association between AB and social anxiety symptoms. Despite using different methods and conceptualizations for capturing AB, along with investigating both clinical and non-clinical samples, the majority of the different studies suggest that individuals with high social anxiety symptoms have AB for negative stimuli. Important questions remain however, with respect to the exact nature of these ABs, as well as how ABs may influence and/or interact with additional facets of the etiological model of SAD. For example, there is a dearth of research examining how AB may affect cognitive and physiological processes related to emotional responding in individuals with SAD and/or high social anxiety symptoms (see Figure 1).

Emotional Stress Reactivity and Recovery in SAD

Heightened fear responding to threat is a key feature of anxiety disorders and may also play a role as a maintaining factor (Craske et al., 2009). According to Rapee & Heimberg's cognitive-behavioral model of SAD (1997), the focus of one's attention, along with one's interpretation of a situation have implications for the cognitive and physiological processes that follow. As mentioned in the section above, there is some research on the impact of masked threat primes on the manifestation of AB. For example, one study has shown that individuals with greater social anxiety symptoms exhibit an AB to threat after a masked neutral prime, but not after a masked threatening prime (Helfinstein et al., 2008). In addition, there is research pointing to the effect of impending explicit social threat on AB. Garner et al. (2006) demonstrated that when participants anticipated giving a speech, those with greater social anxiety symptoms attended faster to emotional rather than neutral faces but showed reduced maintenance of attention on emotional faces. This vigilance-avoidance pattern did not surface in the absence of speech anticipation.

In contrast to the literature examining the impact that threat may have on AB, the relationship between AB and *subsequent* perceptions of stressful situations remains unclear. Specifically, no studies to date have examined how AB may influence subjective and objective physiological threat responding, such as emotional reactivity and recovery in social anxiety. Investigating this association may provide a better understanding of the maintenance factors in social anxiety. The relationship between AB and general emotional reactivity (i.e., not specific to social anxiety) has been examined in nonclinical populations. Fox et al. (2010) obtained cortisol measurements and self-reported anxiety measures from healthy college students. Students also completed a dot-probe task that assessed AB. Four months later, the same students were invited to a laboratory experiment where they were asked to prepare and present a 5-minute speech on why statistics is important in psychology in front of a small audience and a video camera. Eight months after the baseline, they were asked to give a short speech to an experimenter and a video camera about whether they were well prepared for the upcoming final exams. The researchers found that AB at baseline were the strongest predictor of increased cortisol response to the follow-up lab and real life stressful situations. These results provided preliminary evidence that AB may be causally related to physiological stress responding in healthy populations.

The literature on post-traumatic stress disorder (PTSD), which shares common vulnerability factors with SAD (e.g., anxiety sensitivity), has provided further insight into the relationship between AB and emotional reactivity in clinical populations. Felmingham et al. (2011) found that individuals with PTSD showed more initial fixations to words related to trauma compared to individuals with trauma who have not developed PTSD. Moreover, the former group also evidenced greater skin conductance responses to their fixations to threat, suggesting an association between AB and high autonomic arousal and fear responding. Similarly, another investigation has found greater AB and an exaggerated startle response in PTSD patients compared to healthy controls (Fani et al., 2012). Taken together, these findings point to the association of AB with heightened emotional reactivity, conceptualized from both a subjective and physiological perspective.

In social anxiety, only one study to date has examined the association between AB and emotional reactivity. Results showed that modifying negative AB via attention training towards positive stimuli decreased subjective social anxiety symptoms as well as skin conductance response to a stressor (Heeren et al., 2012). However, this study did not use a continuous measure of AB.

In addition to considering reactivity in response to an emotional stressor, it is also informative to examine how individuals recover from a stressor back to their original physiological state. Findings from the depression literature have repeatedly demonstrated that reactivity and recovery are not necessarily the flip-side of the same coin. For example, Teasdale (1988) has argued that differences in mood recovery from a stressor—rather than reactivity—has been more reliably shown to be different in individuals with mood disorders compared to healthy controls. Surprisingly, the association between AB and recovery from an emotional stressor has received very little attention in the anxiety literature. One study that examined this association in the depression literature showed that AB to sad and fear stimuli moderated the relationship between self-reported mood reactivity and mood recovery following a sad mood induction (Clasen et al., 2012). Impaired mood recovery appears to be one of the primary deficits associated with psychological disorders and may constitute possible cognitive risk factors (e.g., rumination), which would in turn contribute to the maintenance of illness symptoms. Mood and anxiety disorders share many common cognitive vulnerability factors (e.g., AB, negative affect). It therefore is plausible that a similar association between AB and both reactivity to and recovery from stressors is applicable to social anxiety.

Post-Event Processing in SAD

Post-event processing (PEP) refers to repeated thinking about and reevaluation of one's performance following a social situation (Brozovich & Heimberg, 2008). As such, PEP has been conceptualized as a key cognitive vulnerability factor that maintains social anxiety symptoms following social situations. The cognitive-behavioral model of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997) suggests that individuals with SAD selectively remember negative information about themselves and others from social situations (Coles & Heimberg, 2002) and brood over past negative social experiences while anticipating a new social situation.

Previous research has linked PEP with biased memory for social events and avoidance behaviors (Turner et al., 1989). However, there is a clear need to examine the association of PEP with other cognitive risk or maintenance factors of social anxiety symptoms. Given previous studies demonstrating a link between greater biased self-perceptions of one's performance and greater PEP (e.g., Makkar & Grisham, 2011), there may also exist a relationship between one's attentional focus and the extent to which she/he engages in PEP. In fact, a recent study found that focusing on non-task information, such as one's physical symptoms, partially explained the relationship between trait social anxiety and PEP through its effect on self-evaluation of performance (Chen et al., 2013). Individuals who had an inappropriate attentional focus tended to evaluate their performance more poorly, which in return, increased their rumination after the event. These findings provide preliminary evidence for an association between attentional processing and PEP.

PEP reflects downstream information processing after social situations and any relationship that may exist between attention processes and PEP may complement the expected associations between AB and subjective and objective physiological recovery. In other words, PEP is both a cognitive and a behavioral assessment of what individuals do following stressors and may be reflective of the amount of recovery from stress. Elucidating this link would contribute to a more holistic understanding of the interplay between cognitive risk and maintenance factors of social anxiety symptoms.

Current Study

Research across the past two decades has provided support for the role AB to threat may play as a cognitive vulnerability for SAD. Accumulating evidence indicates that, compared with healthy controls, individuals with SAD or those with high social anxiety symptoms are disproportionately quicker to attend to emotional stimuli—particularly negatively valenced stimuli—as compared to neutral stimuli. However, there remains some uncertainty regarding the association between AB and other important cognitive and physiological responses to a social stressor. Elucidating these links may help in furthering our understanding of the cognitive processes that play a role in the etiology and maintenance of social anxiety symptoms, and may also provide information on potential targets for intervention research.

Examining AB in conjunction with physiological and subjective emotional reactivity may provide a first step towards a more complete understanding of AB as a maintenance factor for SAD. As described in the above section, one study with a healthy college population, has suggested a causal link between AB and subjective and physiological reactivity, by demonstrating that AB at baseline were the strongest predictor of increased cortisol response to a lab stressor at a 4 month follow-up, and a real life stressor at an 8 month follow-up session (Fox et al., 2010). From a clinical perspective, recent research on PTSD, which shares multiple common vulnerability factors with SAD, has also detected associations between AB and elevated skin conductance responses to initial threat fixations (Felmingham et al., 2011), along with exaggerated startle response during fear learning and extinction (Fani et al., 2012). The only study that has examined such a relationship in SAD found that attention training towards positive stimuli alleviated not only self-reported social anxiety, but also skin conductance reactivity to a stressor (Heeren et al., 2012), suggesting an association between AB and, physiological, and self-reported emotional reactivity. It may be that in the face of a social situation, AB triggers the autonomic response system, suggesting the possibility of danger. Danger perception may further elicit physiological arousal, reinforcing one's maladaptive cognitions and resulting in excessive levels of perceived and physiological arousal. In line with this theory, the current study examined the association between AB and both physiological and subjective emotional reactivity. In an effort to extend Heeren et al. (2012)'s findings, we employed a continuous and direct assessment of AB (i.e., eye-tracking).

Importantly, no study to date has examined the association between AB in social anxiety and recovery from a social stressor. If such an association does indeed exist, modifying AB in treatment may help individuals recover more quickly from stressors, which in turn may have important implications for emotion regulation. As such, we furthermore examined the association between AB and both subjective and physiological recovery from a stressor. An additional relationship that is interesting to consider is how AB could impact the relationship between reactivity and recovery. One recent study from the depression literature has pointed to the moderating role of AB in the relationship between mood reactivity and mood recovery in response to a sad mood induction (Clasen et al., 2012). Using self-report measures of mood reactivity and recovery, Clasen et al. (2012) demonstrated that mood reactivity predicted mood recovery in individuals with AB towards negative stimuli. Research has shown that mood disorders and SAD share similar cognitive vulnerability factors (e.g., negative affectKlein Hofmeijer-Sevink et al., 2012). Given this common denominator between the two disorders, it is reasonable to expect AB to play a comparable role in the relationship between subjective reactivity and recovery to a social stressor in SAD. The current study aimed to replicate Clasen et al. (2012)'s findings by examining the link between AB, and subjective stress reactivity and recovery.

Finally, the current investigation examined the relationship between AB and individuals' cognitive response (i.e., PEP) to a social stressor, once the immediate threat is no longer present. Past research has shown that individuals with SAD selectively remember more negative information from social events, and evaluate their performance against the standards that they believe the audience holds (Coles & Heimberg, 2002). Thus, it is reasonable to expect that selective attention to threat would influence the extent to which one engages in PEP, by influencing the amount and quality of negative material that the individual remembers from the situation. Furthermore, greater PEP may also be conceptualized as a form of impaired cognitive recovery from social stressors. Given recent research demonstrating that attending to non-task information during a social stressor partially accounts for the relationship between social anxiety symptoms and PEP (Chen et al., 2013), it is plausible that attentional processes that occur outside of conscious awareness (i.e., AB) may also be associated with greater PEP.

To summarize, three important limitations have emerged from the literature: (1) The extant literature has not conclusively identified the nature of the association between AB and other key cognitive and physiological responses to stress in SAD. Particularly, no study to date has examined the link between AB and physiological recovery in SAD; (2) The small number of studies that pointed to a link between AB and physiological reactivity have important methodological shortcomings such as the lack of a continuous and direct assessment of AB; (3) No studies have simultaneously investigated AB in SAD in relation to subjective and physiological reactivity, recovery and PEP. The current study attempted to address these shortcomings.

Aims & Hypotheses

As described in the methods section below, we defined AB as greater overall visit duration on threat based on previous research (Schofield et al., 2012; Wieser et al., 2009). Additionally, and within more of an exploratory vein, we considered secondary operationalizations of AB, including fixation duration and fixation count (i.e., duration and number of times spent fixating on each image) when relevant. Fixation was defined as uninterrupted attention to a stimulus for 100ms (Buckner et al., 2010). Subjective emotional reactivity was measured by self-reported distress immediately following the stress induction. Physiological reactivity to stress was assessed by galvanic skin response immediately after the stress induction. The recovery period was set at 30 minutes based on previous studies (e.g., Carroll et al., 2011; Roy et al., 2001). Subjective emotional recovery was assessed by the time it takes individuals to get back to their baseline self-reported anxiety. Physiological recovery was defined as the time required to return to baseline skin conductance levels. PEP was measured by a modified version of the Thoughts Questionnaire (Edwards et al., 2003).

Aim 1 is to examine the association between AB and emotional reactivity in response to a social stressor.

Hypothesis 1.1. Greater AB to threat will be associated with greater subjective emotional reactivity in response to the anticipation of a social stressor.

Hypothesis 1.2. Greater AB to threat will be associated with higher levels of physiological reactivity in response to the anticipation of a social stressor.

Aim 2 is to examine the association between AB and subjective and physiological recovery from stress.

Hypothesis 2.1. Greater AB to threat will be associated with impaired subjective stress recovery.

Hypothesis 2.2. Greater AB to threat will be associated with impaired physiological stress recovery.

Hypothesis 2.3. AB will moderate the relationship between subjective emotional reactivity and recovery such that the slowest recovery will occur among individuals with greater AB towards threat stimuli who also demonstrate greater emotional reactivity.

Aim 3 is to examine the association between AB and PEP.

Hypothesis 3.1. Greater AB to threat will be associated with greater PEP during the recovery period.

Aim 4 is to examine the relationship between AB, subjective emotional reactivity, subjective emotional recovery, and PEP.

Hypothesis 4.1. Greater emotional reactivity and slower emotional recovery will predict greater PEP.

Hypothesis 4.2. Greater emotional reactivity will mediate the relationship between AB and PEP.

Chapter 2: Method

Participants

Subjects were recruited from the University of Miami (UM) undergraduate participant pool. The sample consisted of students (*N* = 66; 47% female) enrolled in Introductory Psychology classes at UM, who participated in exchange for research familiarization credit. The age range of the sample was 18-22 with a mean of 19.13 (*SD* = 1.02). Sixty eight percent of the sample identified as White, while 6.2% identified as Black, 16.7% as Asian or Pacific Islander, and 9.1% as other. Twenty three percent of all participants reported identifying as Latino. Participants were screened via the Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998) in the beginning of the semester. Students scoring within the clinical range (≥34; Heimberg et al., 1992) were sent e-mails to encourage them to participate; however, the distribution of SIAS scores within the final sample (M = 20.38, SD = 10.9, Range = 0-50) was similar to the means reported for other non-clinical, student samples (e.g., Schofield et al., 2012). Evidence from a taxometric investigation (Ruscio, 2010) and a meta-analysis of AB in clinical and non-clinical populations (Bar-Haim et al., 2007) indicates that negative AB in the non-clinical anxious populations do not differ from those seen in clinical populations. This helps justify our sample selection, in that we would expect similar findings to emerge with a clinical sample.

Procedure

Figure 3 depicts a detailed schematic of the study procedures. Upon arrival to the laboratory, a trained research assistant obtained informed consent from participants and answered any questions they had. The consent form stated that the study had two different aims, including (1) measuring pupil dilation in response to visual stimuli, and (2) examining the relationship between different cognitive, emotional, and behavioral factors. The first aim was stated in order to disguise the true purpose of the experiment (i.e., that eye-tracking was involved) in an effort to avoid any social desirability effects.

Participants first completed a battery of questionnaires on an online data collection website. Next, the research assistant asked the participant to wash his/her hands and remove any jewelry in order to prepare the participant for the application of electrodes that were necessary for the psychophysiological data collection. Following the application of electrodes, participants were taken to a small sound isolated room within the laboratory that measured 6’ 8” (height) x 5’ 10” (width), x 7’ 10” (length) (Model 7296, WhisperRoom Inc., Morristown, TN) and seated sixty inches away from a Samsung 1080p television screen.

A baseline psychophysiological reading was obtained for five minutes prior to the beginning of the attention task. Next, the research assistant completed the eye tracker calibration procedure to ensure valid data collection. Following calibration, participants read the instructions of the attention task on the television screen and completed 6 practice trials. Once the research assistant made sure that the participant understood the procedure, participants completed the attention task, where they were asked to naturally view a series of 108 picture pairs. They were told to keep their eyes on the screen and look at anything they pleased.

Upon completion of the attention task, participants were told that they would be asked to give a 3-minute speech in front of a video camera while the research assistant rated the participant's performance on its quality. The participants were also told that expert psychologists would later rate their performance from the videotape. They were asked to wait for 3 minutes while the research assistant made preparations for the task. During this time, subjects did not know the topic of the speech. This period of anxious anticipation was used as the stressor onset reactivity period. Subjective distress ratings were obtained from participants for a total of nine times throughout the experiment (see Figure 3).

After the speech, participants watched a nature video on parrots in Australia for 30 minutes to assist in their recovery from stress that may have been induced by the speech task. This period also served to provide participants with an opportunity to self-evaluate their speech performance in order to aid in the assessment of PEP. Finally, participants completed a questionnaire assessing their thoughts and feelings about their speech performance.

Materials

Assessment of Attention Bias

Attention Task Stimuli. Photographs of faces displaying emotional (angry, happy, disgusted) and neutral expressions from the Karolinska Directed Emotional Faces Dataset were used in the current study (KDEF; Lundqvist et al., 1998). A previous study that examined the emotional valence and arousal of the KDEF faces yielded 36 happy, 36 angry, and 36 sad straight gaze expressions that were most salient to the study of mood disorders (Sanchez & Vazquez, 2013). In the current study, the sad stimuli were replaced with those displaying disgusted expressions of the same actor, in an effort to make them more salient to social anxiety (Amir et al., 2008). All emotional pictures were then paired with neutral expressions of the same actors (see Appendix B). Stimuli were edited using the procedures suggested by Calvo and Lundqvist (2008). Specifically, facial stimuli were placed in an oval template, leaving hair, neck, ears, and other non-facial parts out of the picture. The picture resolution was set at 1280 by 768 pixels for optimal picture quality.

Attention Task. The attention task used was similar to the one described by Buckner et al. (2010) with the exception of task stimuli. Following completion of 6 practice trials to ensure that participants understood the task, they completed 108 trials, consisting of three 36 picture pairs (angry-neutral, disgusted-neutral, happy-neutral) that were counterbalanced for condition, gender of the actor, and side of presentation (i.e., right or left). Stimuli were presented using EPrime 2.0 Professional software on a 40 inch Samsung 1080p television screen. Each facial stimulus was 6.5 inches wide and 8.5 inches long. Pictures were 15.3 inches apart from each other in the center of the screen.

Participants were asked to naturally view the screen where written instructions were provided. Each trial began with a blank dark grey screen, followed by the presentation of a cross in the center of the screen for 500 milliseconds (ms). The cross was then replaced by a random number from 1 to 9 which remained at the center of the screen for 1000 ms. Participants were asked to say this number out loud to ensure that their attention was in the middle of the screen. When the number disappeared, a pair of pictures appeared on the screen for 3000 ms, consistent with Sanchez et al. (2013). Participants naturally viewed the picture until the appearance of another cross in the middle of the screen. The attention task took around 10 minutes to complete. See Figure 2 for a sample trial.

Eye Tracking. A Tobii X120 Eye Tracker was used to track eye movements during the attention task. This system tracks the reflections of infrared lights from the front of the cornea to the back of the lens (Crane & Steele, 1985) and provides gaze coordinates at a rate of 60 Hz (one estimation per 16.7 ms). The Tobii eye tracker was placed between the television and the chair where the participant was seated. The eye tracker was 23.6 inches away from the participant's chair. The participant was given a neck support pillow and asked to not move his/her head throughout the attention task.Tobii Studio Analysis Software (Tobii Technology, Danderyd, Sweden) was utilized to collect data and derive attention indices (i.e., total visit duration, total fixation duration, total fixation count). Please see the Data Preparation section below for information on the variables used for analyses.

Social Stressor and Indices of Reactivity and Recovery

Social Stressor Task. Participants were asked to give a 3-minute speech on whether radio and TV have become too explicit. The research assistant provided the participant with the following instructions taken from Mansell et al. (1999): ‘‘The next part of this experiment is an assessment of your social skills and public speaking ability. Now I am going to ask you to make a speech on a controversial topic. I will stay here to watch you give the speech and rate you on several different measures of the effectiveness of your presentation. This video camera is going to record you so that later some expert psychologists can make ratings of your ability as well. I won't be giving you the topic of the speech until thirty seconds before I start the camera and you begin the speech'' The chosen topic has been used in previous social anxiety studies (e.g., Rodebaugh et al., 2010) and was shown to effectively induce stress.

Nature video. After the speech task, participants were asked to watch a neutral nature video on parrots in Australia for 30 minutes, in order to aid in their recovery from the social stressor and provide a venue for PEP.

Subjective distress ratings. Participants were asked to rate their affective state (levels of: nervousness and anxiety) on a scale ranging from 0 (not at all) to 10 (very much) at varying time points across the study (see Figure 3). Both anxiety and nervousness ratings are reported on in relation to Aim 1 (i.e., subjective emotional reactivity) whereas only anxiety ratings are reported on in relation to Aim 2 (i.e., subjective emotional recovery) as this was the only emotional rating provided at the recovery time point.

The nervousness rating obtained at stressor onset (i.e., immediately following the announcement about the speech task) constituted the *subjective emotional reactivity* measure. *Subjective emotional recovery* was defined as the time it took individuals to return to their baseline distress ratings.

Galvanic skin response (GSR). Physiological indicators of affect and arousal were collected using BioLab Acquisition Software (Version 3.0.5, MindWare Technologies Ltd., CITY, OH). Specifically, electrodermal activity was measured by attaching two Ag/AgCl electrodes (Model 93-0102-00; MindWare Technologies) to the participants' non-dominant palm, as sweat gland density is high in this area (Lykken & Venables, 1971). Two indices related to GSR were collected: (1) Mean skin conductance levels (SCL), reflecting the tonic level of electrical conductivity of skin across a predetermined time frame (see below for details), and (2) Skin conductance response (SCR) indicating the phasic change in electrical conductivity of skin of a minimum of 0.05 microsiemens (μS; Braithwaite et al., 2013).

Skin conductance data were collected in three different phases. (1) Right after completing the self-report questionnaires and before starting the computer tasks, a *baseline* reading was obtained from participants for 5 minutes while they sat still. (2) The *reactivity* period occurred immediately after the participants were told that they were going to give a videotaped speech in 3 minutes. During this time, participants sat quietly in front of the computer waiting to give their speech. This period was used as the reactivity period due to the anticipation anxiety expected to be experienced by participants. Physiological reactivity to stress was measured by the number of SCRs during the 3-minute speech anticipation period (i.e., stressor onset). (3) The *recovery* period was a 30 minute time frame following the stressor (i.e., speech) where participants watched a neutral, non-emotionally provocative documentary film. *Physiological recovery* from stress was measured by the time it took individuals to return to their baseline mean SCL after the speech.

Self-report Questionnaires.

Demographics. Participants were asked to provide basic demographic information including, but not limited to, age, sex, race, annual income, and years of education.

Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998). The SIAS is a 20 item self-report inventory that assesses distress when talking and interacting with other people. The SIAS evaluates several aspects of this distress, including fears of sounding boring, unintelligent, running out of words, and being ignored. The inventory also assesses the emotional response associated with these fears such as anxiety and worry. The responses are rated on a 5-point Likert scale from 0 (not at all) to 4 (extremely). Respondents are asked to indicate the extent to which the statement applies to them (e.g. "I have difficulty talking with other people"). The SIAS has demonstrated excellent reliability (r =.92) and internal consistency (α =.94; Mattick & Clarke, 1998).

Thoughts Questionnaire - Modified (TQ; Edwards et al., 2003). The TQ is a 29-item self-report questionnaire designed to assess ruminative thoughts characteristic of post-event processing in social anxiety (e.g. perceptions of anxiety, negative evaluation from others). The TQ includes negative (e.g. "how many mistakes I made") as well as positive (e.g. "my speech was good") items. Individuals are asked to respond to how often they thought about each item after a socially evaluative situation. The TQ has shown to have excellent internal consistency (α = .90; Edwards et al., 2003). We adapted this scale for use in the current study by eliminating 6 of the items that were not applicable to this study (See Appendix A). The responses are rated on a 5-point Likert scale from 0 (never) to 4 (very often).

Chapter 3: Data Preparation

A Priori Power Analyses

Power analyses were conducted using the gPower software program (Faul & Erdfelder, 1992) to determine the appropriate sample size needed for this study. Results indicated that a sample of 55 individuals would yield an 80% chance of detecting a small sized effect (i.e., f = .15) with an alpha value of .05. Due to the lack of previous research to suggest a greater than a small sized effect, 66 participants were recruited for the current study.

Data Preparation

All data was screened prior to primary data analyses. The internal reliability of the self-report measures was examined using Cronbach's alpha. Both the SIAS and the TQ demonstrated good internal consistency (α*'s* = .82 & .89, respectively). Descriptive statistics were examined for all primary variables of interest in order to identify outliers and errors in data entry. Upon examination of observed and predicted values scatterplots, it was determined that the assumptions of the linear model were met.

Eye-tracking data

Prior to conducting data analyses, it was determined that participants with less than 70% recorded eye gaze data would be excluded, in line with standard eye-tracking data-cleaning procedures. Eleven participants' data were removed due to insufficient eye gaze data collection, resulting in a final sample of 55 participants used in all analyses. Per the power calculations outlined above, this N still provided sufficient power to test the proposed analyses. The mean percentage of eye gaze data collected in the final sample was 87.54% (*SD* = 7.60).

Three attention indices towards threatening images (i.e., anger and disgust stimuli) were calculated using the Tobii Studio software: *total visit duration* (TVD) which refers to the total time spent looking at images in an area of interest (AOI; e.g. all disgust images), *total fixation duration* (TFD) computed by summing the duration of all fixations within an AOI, and *total fixation count* (TFC) which indicates the total number of times of fixations on an AOI. These three indices were calculated for both the neutral-anger and neutral-disgust image pairs.

To calculate an index of AB to threat for each participant, we subtracted the mean of the neutral indices (neutral-anger and neutral-disgust) from the mean of the respective threat indices (anger and disgust) in line with previous research (Armstrong et al., 2010). For instance, *AB to disgust* was computed by subtracting the mean attention index for neutral-disgust images from the mean attention index for disgust images. A score of zero indicated the absence of an AB, whereas a positive score indicated AB towards threat and a negative score indicated AB away from threat.

In line with extant research (e.g., Schofield et al., 2012), AB calculated using the TVD index were determined *a priori* to serve as the primary AB measures. However, we also calculated AB using the TFD and TFC indices to obtain secondary AB measures. In the remainder of the report, the acronyms TVD:AB-disgust and TVD:AB-anger will be used to refer to the disgust and anger

AB indices calculated using the TVD index. Results involving the secondary AB indices (i.e., total fixation duration and total fixation count) will be reported using the acronyms: TFD:AB-disgust, TFD:AB-anger, TFC:AB-disgust, and TFC:AB-anger.

Galvanic skin conductance data

Skin conductance data were cleaned using the data analysis software provided by Mindware Technologies Ltd. (Version 3.0.15, Gahanna, OH). Upon examination of data files, three participants were excluded due to insufficient data collection caused by sensor malfunctioning. Valid data were collected from 63 participants. Traditionally, video files are examined to identify any gross body movements that may artificially influence physiological responding. Unfortunately, in the current investigation video data was not collected due to a glitch in the video function of the Biolab Acquisition Software (Version 3.0.5, MindWare Technologies Ltd., CITY, OH). We therefore elected to include all participants with sufficient skin conductance data in the data analyses.

Chapter 4: Results

Preliminary Analyses.

Manipulation Check of the Social Stressor. Manipulation checks were conducted to determine whether the social stressor (i.e., speech task) was effective in increasing subjective emotional distress and physiological reactivity. To determine whether subjective nervousness in response to the speech task was significantly greater than baseline levels of nervousness, we conducted a paired samples t-test between stressor onset and baseline subjective nervousness scores. Results revealed that stressor onset nervousness scores (M = 2.70, SD = 2.40) were significantly greater than those at baseline (M = 1.35, SD = 1.78), $t(54) = 4.62$, $p < .01$. A second paired samples t-test was conducted to compare the baseline and stressor onset physiological responding (i.e., SCL) scores. Findings demonstrated a significant difference in the expected direction from baseline to (M = 1.39, SD = 1.03) to stressor onset SCL (M = 2.31, SD *=1.49*), $t(54) = 6.40$, $p < .01$. Thus, the anticipation of the speech task successfully elevated both self-reported and physiological indices of nervous responding across the sample.

Role of Social Anxiety Symptoms. Because the current study conceptualized AB-disgust as a cognitive factor that plays a role in social anxiety symptoms but does not directly investigate social anxiety symptoms per se, it was important to demonstrate whether social anxiety symptoms are indeed associated with the main study variables. Thus, prior to examining the outlined study hypotheses, we sought to examine the association between the main variables of interest and levels of social anxiety. Specifically, we conducted correlational analyses between SIAS scores and the following variables: TVD:AB-anger, TVD:AB-disgust, emotional and physiological reactivity and recovery indices, and PEP. Table 1 provides a summary of all correlations, means and standard deviations. Results demonstrated that SIAS scores were significantly correlated with TVD:AB-disgust, emotional reactivity, physiological reactivity, and PEP. The association between physiological recovery and SIAS scores was in the unexpected (i.e., negative) direction, such that those with higher SIAS scores took a shorter period of time to return to their baseline SCL. SIAS scores were not correlated with subjective emotional recovery from the social stressor.

As a follow-up analysis to the positive association between SIAS scores and subjective emotional and physiological reactivity and to examine whether the stress manipulation worked as hypothesized, we sought to determine whether the social stress task had a differential effect on individuals high on social anxiety compared to those who were low. The sample was split into two using the mean SIAS score as a cut-off (M = 20.38); independent samples t-tests were conducted to compare the two groups on reactivity indices. We first considered emotional reactivity ratings. Both high (M = 3.29, SD = 2.55) and low SIAS (M = *2.16*, SD = 2.11) scorers experienced an increase on the subjective emotional reactivity measure. The difference for both groups from baseline to the stressor onset period was in the expected direction and trending toward significance ($t(51) = 1.73$, p = .09). With respect to SCL, we found that the high-SIAS group (M =

2.76, *SD* =1.59) experienced significantly greater elevations during the reactivity period compared to those with lower social anxiety symptoms (*M* =1.80, *SD* =1.22), $t(53) = 2.46$, $p < .05$, as expected.

Associations between the AB to Threat Indices and Variables of Interest. Given that the main focus of the current study is on AB to threat as it relates to subsequent information- processing, we first wanted to examine correlations between the two different types of AB to threat (TVD:AB-anger & TVD:AB-disgust) and the outcome variables of interest (i.e., subjective and physiological reactivity and recovery, PEP) prior to investigating the main aims of the study. Both AB to threat indices were significantly and very strongly correlated with one another ($r = .83$, $p < .01$). The associations between TVD:AB-anger and the following variables were all non-significant: subjective emotional reactivity ($r = .22$) and recovery ($r = .01$), physiological reactivity ($r = -.03$) and recovery ($r = .06$), and PEP ($r = .03$; all *p's* > .10). In contrast, TVD:AB-disgust was significantly correlated with most variables of interest with the exception of subjective and physiological recovery (see Table 2). TVD:AB-disgust appeared to drive what is considered a *threat bias* in this study. This was consistent with the findings of previous studies indicating that individuals with social anxiety rate disgust faces more negatively than anger faces (Amir et al., 2010). We therefore elected to use TVD:AB-disgust as the primary AB to threat variable in examination of the main study hypotheses.

In order to determine whether an AB existed in the overall sample, we conducted a one-sample t-test to determine whether the mean TVD:AB-anger and TVD:AB-disgust scores differ from zero. Findings demonstrated an overall AB to anger, $t(54) = 2.36$, $p < .05$, but *not* to disgust, $t(54) = 1.45$, $p = .15$. We then conducted a paired samples t-test to examine AB scores as a function of social anxiety symptoms and found support for the presence of an AB to anger *as well as* to disgust among high (anger $M = 6.32$, $SD = 9.59$; disgust $M = 6.72$, $SD = 12.56$) but not low (anger $M = .06$, $SD = 11.45$; disgust $M = -2.23$, $SD = 12.43$) SIAS scorers, $t(52) = 2.18$, $p < .05$ and $t(52) = 2.62$, $p < .05$, respectively. These results indicate that AB to threat stimuli is more likely to be experienced by individuals with greater social anxiety symptoms.

Aim 1: The Relationship between AB to Threat and Stress Reactivity.

For Hypothesis 1.1, we projected that greater AB to threat would be associated with greater *subjective emotional reactivity* in response to a stress inducing speech task. To examine this prediction, we first explored the correlations between TVD:AB-disgust and anxiety and nervousness ratings at stressor onset (i.e., when individuals were told that they would give a speech in three minutes). A significant positive correlation was found between TVD:AB-disgust and self-reported nervousness following the stressor ($r = .32$, $p < .05$). The association between TVD:AB-disgust and self-reported anxiety was in the expected direction; however, it did not reach the *a priori* significance level ($r = .26$, $p = .05$).

Given the significant positive association between emotional reactivity at baseline and that immediately at stressor onset (i.e., following the announcement that participants will give speech in 3 minutes; $r = .51$, $p < .01$), we decided to rule out the possibility that greater elevated nervousness at baseline accounted for the relationship noted above. We therefore sought to determine whether TVD:AB-disgust would be associated with the change in nervousness ratings from baseline to stressor onset. To that end, we first calculated a change score by subtracting self-reported nervousness at baseline from that at stressor onset. Results revealed a significant positive association between TVD:AB-disgust and the change in nervousness from baseline to stressor onset ($r = .33$, $p < .05$), indicating that the association between TVD:AB-disgust and subsequent elevations in nervousness at stressor onset was not accounted for by nervousness at baseline.

We next considered the correlation between AB-disgust and nervousness for each of the secondary AB indices. Results revealed that nervousness at stressor onset was significantly associated with both TFD:AB-disgust ($r = .30$, $p < .05$) and TFC:AB-disgust ($r = .32$, $p < .05$), indicating that the duration of uninterrupted attention on disgust images, and the number of times attended to disgust images were both linked with nervous responding in response to social stress. Change in nervousness from baseline to stressor onset was positively correlated with TFD:AB-disgust ($r = .33$, $p < .05$) but not TFC:AB-disgust ($r = .22$, $p = .11$). This demonstrates that the extent to which one dwells on disgust stimuli and not merely the number of times one switches her/his attention back and forth between disgust and neutral stimuli influences subsequent subjective distress response under social stress. Correlations further revealed a positive significant relationship between TFC:AB-disgust and anxiety ($r = .28$, $p < .05$). The association between TFD:AB-disgust and anxiety was in the predicted direction; however, it was not significant at the $p < .05$ level ($r = .26$, $p = .06$).

With respect to hypothesis 1.2, we theorized that AB to threat would be associated with *physiological reactivity* in response to a laboratory stressor as assessed by the number of SCR at stressor onset. Correlations revealed no significant associations between TVD:AB-disgust and SCR ($r = .07$, $p = .62$). Similarly, TFD:AB-disgust ($r = .08$, $p = .57$) and TFC:AB-disgust ($r = .08$, $p = .57$) were not significantly linked with SCR. Together, these results point to the lack of an association between physiological responding and AB to threat.

Aim 2: The Relationship between AB and Stress Recovery.

For Hypotheses 2.1 and 2.2, we predicted that greater AB to threat would be associated with impaired subjective and physiological stress recovery. To examine this association, correlation analyses were conducted between TVD:AB-disgust and the time it took individuals to return to baseline (1) self-reported anxiety and (2) SCL. Contrary to our hypotheses, no significant associations were found between either TVD:AB-disgust and time to baseline subjective anxiety levels following the speech task ($r = .01$, $p = .93$), or TVD:AB-disgust and time to physiological recovery ($r = -.01$, $p = .93$).

Similar to our analyses examining stress reactivity, we also wanted to consider the relationship between stress recovery and the alternative, secondary AB-disgust indices. Results revealed that subjective stress recovery was not significantly linked with either TFD:AB-disgust ($r = .00$, $p = .99$) or the TFC:AB-disgust ($r = .06$, $p = .66$). In addition, there were no significant associations between physiological stress recovery and TFD:AB-disgust (*r* = -.04, *p* = .76), or the TFC:AB-disgust (*r* = -.04, *p* = .76).

It was further projected in Hypothesis 2.3 that AB to threat would moderate the relationship between self-reported emotional reactivity and recovery. Specifically, we predicted that individuals with greater AB to threat who also exhibit greater emotional reactivity to the social stressor would report the greatest impairment in subjective emotional recovery from social stress (i.e., longer time to return to baseline nervousness ratings). To test this relationship using the procedures outlined by Holmbeck (2002), the predictor (nervousness at stressor onset) and the moderator (TVD:AB-disgust) were first centered, following which the interaction term was calculated. The centered predictors and the interaction term were then simultaneously entered into a multiple regression equation with subjective emotional recovery (i.e., time to baseline subjective nervousness) as the outcome variable. The interaction term was not significant (β = .01, *t* (48) = 1.56, *p* = .13), indicating that TVD:AB-disgust did not moderate the relationship between self-reported emotional reactivity and recovery.

Aim 3: The Relationship between AB and PEP.

With respect to Hypothesis 3.1, we expected that greater AB to threat would be associated with higher levels of PEP during the recovery period. Contrary to our predictions, correlational analyses between TVD:AB-disgust and PEP demonstrated no significant associations (*r* = .06, *p* = .65). Correlations using secondary AB indices produced similar results: no links were found between either TFD:AB-disgust and PEP (*r* = .05, *p* = .74) or TFC:AB-disgust and PEP (*r* = .06, *p* = .66).

Aim 4: The Relationship between AB, Stress Reactivity, Stress Recovery and PEP.

For Hypothesis 4.1, it was expected that greater subjective emotional reactivity and slower subjective recovery would be associated with greater PEP. Correlational analyses revealed that greater nervousness at stressor onset was associated with greater subsequent PEP ($r = .49$, $p < .01$). Similarly, a significant positive association was found between subjective emotional recovery and PEP, such that the longer individuals took to return to their self-reported nervousness level, the more PEP they experienced ($r = .44$, $p < .01$). We furthermore examined whether emotional reactivity and recovery would predict PEP. A stepwise linear multiple regression analysis was conducted with nervousness and subjective emotional recovery entered in the first and second steps, respectively, predicting PEP. The first step in the model with nervousness predicting PEP was significant, $F(1,51) = 15.67$, $p < .01$.and explained 23% of the variance. When subjective emotional recovery was entered in the second step, there was a significant incremental change, with the overall model explaining 30% of the variance, $F(2,50) = 7.97$, $p <.01$. In line with our expectations, subjective emotional reactivity ($\beta = 1.68$, $t\ (50) = 2.94$, $p < .01$) and subjective emotional recovery ($\beta = 2.52$, $t\ (50) = 2.28$, $p < .05$) both significantly and independently predicted PEP.

It was further predicted in Hypothesis 4.2 that greater subjective emotional reactivity would mediate the relationship between AB to threat and PEP. As described above, although TVD:AB-disgust was not significantly associated with PEP, we did find support for (a) TVD:AB-disgust predicting subjective emotional reactivity ($\beta = .058$, $t\,(51) = 2.38$, $p < .05$), and (b) subjective emotional reactivity, in turn, predicting PEP ($\beta = 2.29$, $t\,(50) = 3.95$, $p < .01$), controlling for TVD:AB-disgust. We therefore used the distribution of product of the coefficients method (PRODCLIN; Hayes & Scharkow, 2013) to examine the significance of the indirect effect. The unstandardized path coefficients and standard errors of the path coefficients for the indirect effect of TVD:AB-disgust on PEP via subjective emotional reactivity were entered into PRODCLIN. The results yielded lower and upper 95% confidence limits of 0.01 and 0.28. Because the resulting interval from this computation did not involve zero, the indirect effects were found to be significant (MacKinnon et al., 2007).

Additional Analyses: Do results differ based on SIAS scores?

In an attempt to help shed light on why many of our hypotheses were not supported, we set out to examine whether any of the relationships considered might vary depending on levels of social anxiety. Similar to the interaction detailed above in relation to Aim 2, we relied on the technique outlined by (Holmbeck, 2002)'s to examine whether SIAS scores might moderate the relationships between TVD:AB-disgust and (1) subjective emotional reactivity, (2) physiological reactivity, (3) subjective emotional recovery, (4) physiological recovery, and (5) PEP. Results revealed that none of the interaction terms were significant controlling for main effects (*all p's* > .05). This indicates that levels of social anxiety did not contribute to the unexpected findings outlined above in relation to Aims 1, 2, and 3.

Chapter 5: Discussion

The intense and pervasive fear of negative evaluation and associated avoidance that represent the hallmark features of SAD, debilitate the lives of millions of individuals afflicted with this condition. It is therefore vital to better understand malleable vulnerability factors—such as AB to threat—that may reinforce these symptoms, as these factors may subsequently be targeted in prevention or treatment efforts. Past research has supported the role of AB to threat as a cognitive vulnerability factor for SAD. As AB to threat occurs outside of conscious awareness upon entry to a social environment, it is possible that the negative framework it provides for individuals to perceive their surroundings has implications for subsequent late-stage information processes that occur within conscious awareness (e.g., emotional and cognitive processes).

Our investigation extends previous work in the area of AB to threat in social anxiety by demonstrating links between early- and late-stage information-processing that constitute parts of the cognitive-behavioral model of social anxiety. The findings support past studies by demonstrating an association between AB-disgust and social anxiety symptoms. Results also extend extant research by providing evidence for the association between AB-disgust and subjective emotional reactivity to a social stressor, which in turn, is positively related to PEP. Although no support was found for an association between AB-disgust and subjective emotional recovery, results revealed that along with subjective emotional reactivity, emotional recovery predicted PEP. Contrary to expectations, physiological reactivity and recovery were not found to be associated with AB-disgust. Importantly, we considered whether the relationships examined differed depending on levels of social anxiety symptoms. We found that the interactions considered between SIAS scores and AB-disgust in relation to subjective emotional reactivity, physiological reactivity, subjective emotional recovery, physiological recovery, and PEP did not modulate the predicted relationships among variables of interest in any way.

Results demonstrated an association between AB-disgust and subjective emotional reactivity measured by self-reported nervousness ratings following the onset of the social stressor (i.e., announcement that participants will give a speech in three minutes). This finding may indicate that early preferential attention influences the subsequent perception of information in the environment. If one becomes hypervigilant after detecting threat in the environment via an AB-disgust, the chances of perceiving danger in a social performance situation (e.g., negative evaluation, scrunity) and reacting more emotionally are increased. Furthermore, controlling for baseline emotional reactivity scores, the incremental change in nervousness from baseline to stressor onset was also significantly associated with AB-disgust, ruling out the possibility that elevated baseline nervousness artificially caused the link with AB-disgust. Understanding the relationship between AB-disgust and emotional reactivity are important because retraining AB to threat may help in preventing the cascade of events within the cognitive model that exacerbate SAD symptoms (Amir et al., 2009).

We employed three different attention indices (i.e., TFC, TFD, and TVD) to investigate the association between AB-disgust and subsequent emotional and cognitive responding following a social stressor. Therefore, a brief discussion on how these indices compare to one another is in order. The TFC index provides a count of the number of times one fixates on each stimulus type (i.e., disgust, anger, or neutral). This index constitutes a surface-level measure of attention, as it does not reflect the relative gaze duration on each stimulus, but rather indicates how many times one fixated on the neutral stimulus compared to the emotional stimulus. In contrast, the TFD index takes into account the relative duration of fixation across stimulus types. A fixation is defined as uninterrupted attention for at least 100ms on any particular stimulus (Buckner et al., 2010). For instance, the TFC index may indicate that an individual fixated on the neutral stimulus three times and on the disgust stimulus six times. This index, therefore, does not capture the relative duration of each fixation across different types of stimulus.

The TVD measures the total amount of time spent attending to each type of facial stimulus (i.e., it includes the total duration of all fixations and non-fixations) and is the most inclusive indicator of overall preconscious attentional preference. If the TVD index indicates a significant difference between the amount of time spent gazing at the disgust stimulus as opposed to the neutral one, when the TFD and TFC indices show no such difference, it would be reasonable to conclude that the person kept going back and forth between the two faces continuously without fixating on one (or else it would have been detected in TFD). In contrast, if the TFD and TFC indices point to significant differences between two stimuli when the TVD index does not, potential errors in data entry should be examined because the presence of significant fixation latencies should be captured by TVD which is a more inclusive measure than both TFD and TFC.

Given the considerations outlined above, we relied on the TVD as the primary attention index, though it should also be noted that the association between AB-disgust and emotional reactivity was replicated using the secondary AB indices. Thus, the results derived from all three attention indices were in agreement to demonstrate that individuals who spend more time viewing disgust stimuli (i.e., TVD), those who fixate on disgust images for longer durations (i.e., TFD), or those who attend to them more often (i.e., TFC) tended to get more nervous in response to being asked to give an impromptu speech. The convergence of results of all attention indices points to the robustness of this link.

Contrary to expectations, no significant associations were found between AB-disgust and SCR at social stressor onset with any of the attention indices. It is possible that the relationship of AB-disgust with reactivity to social stressors is qualitatively different at the subjective and physiological levels. AB-disgust is a cognitive bias that according to our results colors one's *perception* of his/her surroundings, and in that sense is qualitatively closer to one's *perception* of how they feel in the face of social threat. However, physiological reactivity as measured by skin conductance responses represents arousal at the basic biological level. It is possible that the effects of an early preconscious attentional process do not extend beyond *perceived* processes to affect *actual* physiological responding. It is equally plausible that skin conductance is not a sufficiently sensitive index of physiological responding in a social performance situation.

Unsurprisingly, we did not detect a significant association between AB-disgust and subjective emotional recovery, regardless of which of the three attention indices was used. Closer examination of the data showed that 59% of the sample (*N* = 39) reported that their distress rating was down to zero by the end of the speech task demonstrating that the majority of the participants were no longer distressed by the time they entered the recovery period. In other words, due to the quick rate with which this nonclinical sample returned to their baseline state, and because we did not include a subjective distress rating between stressor-onset and end of speech (~6 minutes), one possibility is that we missed the window wherein recovery occurred. It is also possible that there is, in fact, no relationship between AB-disgust and subjective emotional recovery. That is, it may be that AB-disgust only results in rapid elevations in emotional reactivity which then returns to normal levels quickly, resulting in fast recovery rates. In addition, no evidence was found for an interaction between AB-disgust and subjective emotional reactivity in predicting subjective emotional recovery. In other words, individuals high and low on AB-disgust did not show differential rates of subjective emotional recovery as a function of their subjective emotional reactivity levels. This was not surprising, given that 59% of the sample had already recovered at the end of the speech task (i.e., before the start of the recovery period), limiting the variability in our subjective recovery index.

Consistent with our findings related to subjective emotional recovery, no significant associations were found between AB-disgust and time to physiological recovery. The results using the secondary attention indices produced similar null results. In line with the measurement of subjective emotional recovery, physiological recovery was measured as the time it took individuals to return to baseline. Upon closer examination of the skin conductance data, we found that 57% of the sample returned to their baseline skin conductance level within 3 minutes following the end of the speech. The use of a nonclinical sample may have contributed to this quick recovery, and it is possible that AB-disgust might be associated with recovery in a clinical sample with more severe symptomatology.

None of the AB-disgust indices were significantly related to late-stage cognitive processing captured by PEP. There are a number of possible explanations for these findings. Given the association of AB-disgust with subjective emotional *reactivity* but not subjective emotional *recovery,* it is possible that early-stage cognitive biases create a strong emotional reaction that dissipates relatively quickly, not leaving sufficient time to influence individuals' thoughts and reflections about the social stressor. Further, it is important to keep in mind that the current study was conducted with a nonclinical sample. Therefore it may be that individuals with nonclinical social anxiety symptoms did not engage in extensive rumination following the stressor. In other words, they may be better at recognizing ruminative processes—such as those captured by the PEP measure— and may therefore be better at reappraising the situation in a more constructive way. There may also be methodological reasons preventing us from detecting an association between AB-disgust and PEP. It is possible that the PEP assessment was too far removed from the stress induction (around 35 minutes) for a nonclinical sample. Because our PEP measure is a modification of the original measure, we were unable to assess whether the levels of PEP observed in this sample were lower than that in other studies. However, if our PEP levels were indeed significantly lower than that in other samples and PEP occurred and ended within the first five minutes of the recovery period (similar to our results with the subjective and physiological indices), individuals may have underestimated the extent to which they ruminated when asked how much they thought about their performance between stress induction and the end of the movie. This may have resulted in us not catching the PEP effect. Chen et al. (2013) had found that individuals who attended to non-task information while giving a speech evaluated their performance more poorly and engaged in more PEP compared to those who focused on task-relevant information. This study, however, examined conscious attention. Considering the findings of the current study, if there is indeed no association between AB-disgust, which occurs outside of awareness, and PEP, this could indicate that attentional focus outside of one's awareness does not affect PEP through one's performance evaluation. Our null findings on the hypothesized association between AB-disgust and PEP may be better interpreted in light of the association that emerged between AB-disgust and subjective emotional reactivity as well as that between subjective emotional reactivity and PEP.

In line with our expectations, subjective emotional reactivity and subjective emotional recovery both significantly predicted PEP. Correlational analyses revealed that greater nervousness at stressor onset was associated with greater subsequent PEP. Similarly, a significant association was found between subjective emotional recovery and PEP, such that the longer individuals took to return to their baseline nervousness level, the more PEP they experienced. One's strong reaction to a stressor may signal the salience of the information, which may then trigger the person to elaborate on the situation. Finally, while AB-disgust did not have a direct impact on PEP, the indirect effects were significant such that AB-disgust significantly predicted subjective emotional reactivity at stressor onset. Subjective emotional reactivity, in turn, significantly predicted PEP. Therefore, it appears that AB-disgust affects the extent to which one feels distressed under social pressure, which subsequently influences ruminative tendencies about one's social performance. This is interesting because it suggests that interventions that target AB-disgust or one's subjective emotions in social situations may indirectly decrease downstream tendencies to engage in PEP, an important maintenance factor for social anxiety.

Some limitations are worth noting. First, we used a nonclinical sample in the present study, which limits the generalizability of our results. For instance, subjective emotional recovery may be more impaired in a clinical sample which may influence the examined relationships with AB-disgust. Thus, future research may benefit from examining the associations among AB-disgust, subjective and physiological reactivity and recovery, and PEP with a clinical sample of individuals with SAD. Second, we employed a within-subjects design where all subjects were exposed to all experimental procedures. The absence of a control group and randomization prevent us from deriving causality among the variables of interest (i.e., subjective emotional reactivity was triggered by the social stressor task). Future studies using a randomized controlled design may be helpful in examining whether AB-disgust has a causal effect on subsequent emotional, physiological, and cognitive processes. Third, even though the social stressor (i.e., speech task) appeared to have elevated physiological responding from baseline to stressor onset, it is possible that skin conductance is a better indicator of event-based physiological arousal rather than that of the overall stress response across a predetermined time frame (i.e., 3-minute reactivity period). Future studies may benefit from employing a more sensitive physiological assessment of physiological reactivity and recovery such as cortisol (Condren et al., 2002).

In conclusion, the present study aimed to extend previous research on AB beyond an examination of the links between social anxiety symptom severity, by considering the association among different components of the cognitive-behavioral model (i.e., emotional, physiological, and cognitive) under social stress using a nonclinical sample. Results demonstrated that AB-disgust, as an early-stage bias of information-processing influences subjective emotional reactivity to a social stressor and that subjective reactivity subsequently affects PEP, a late-stage cognitive process. Perceived emotional reactivity to social stressors appears to influence cognitive responses to one’s own perceived social performance. This may have implications for addressing social anxiety symptoms in treatment. Clinicians may consider processing subjective emotional responding in social situations to indirectly target PEP and the cognitive-behavioral cycle of symptoms.

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Figures

Figure 1. *The cognitive-behavioral maintenance model of social anxiety symptoms*

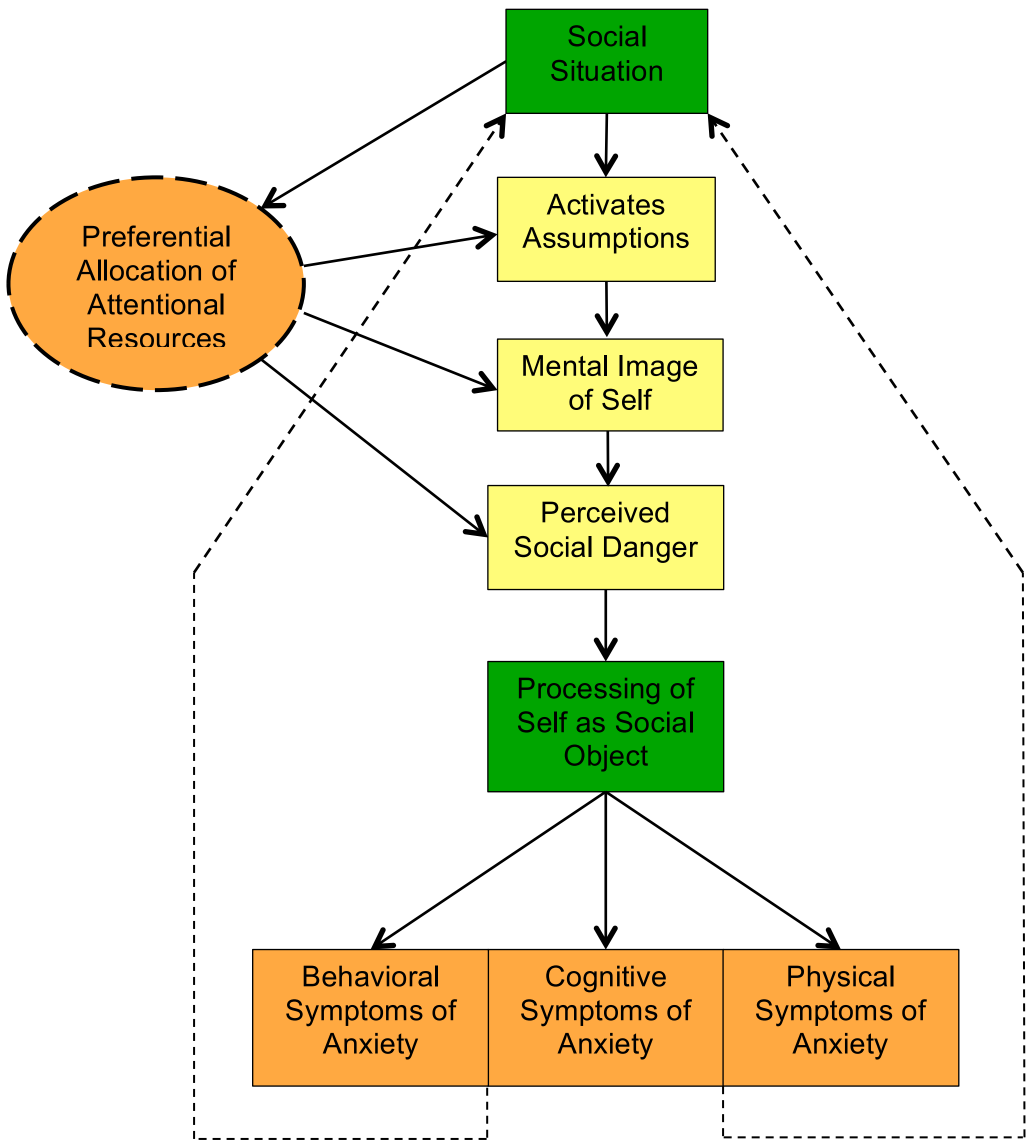


Figure 2. *Sample trial from the attention task*

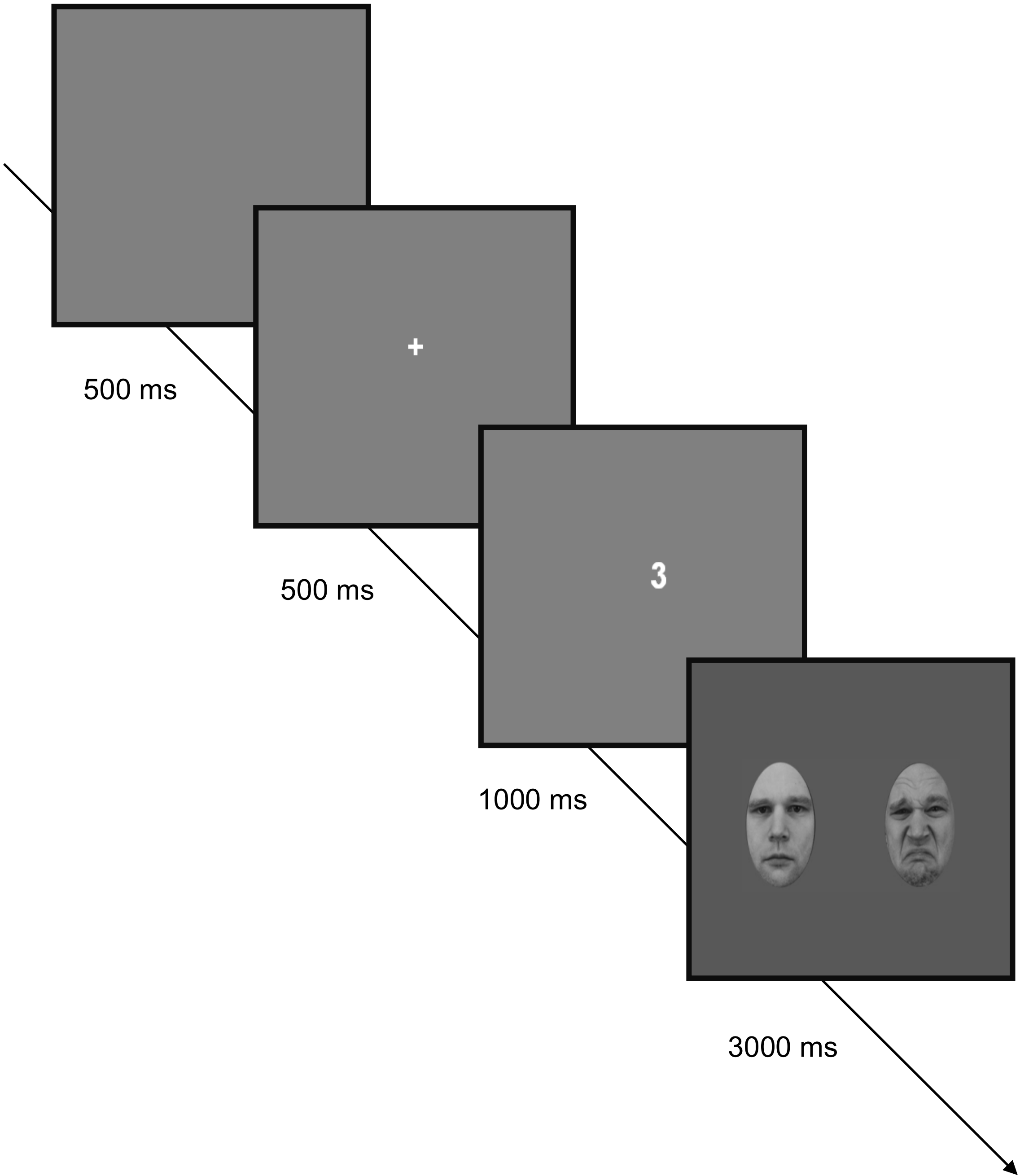


Figure 3. *Schematic of the current study*

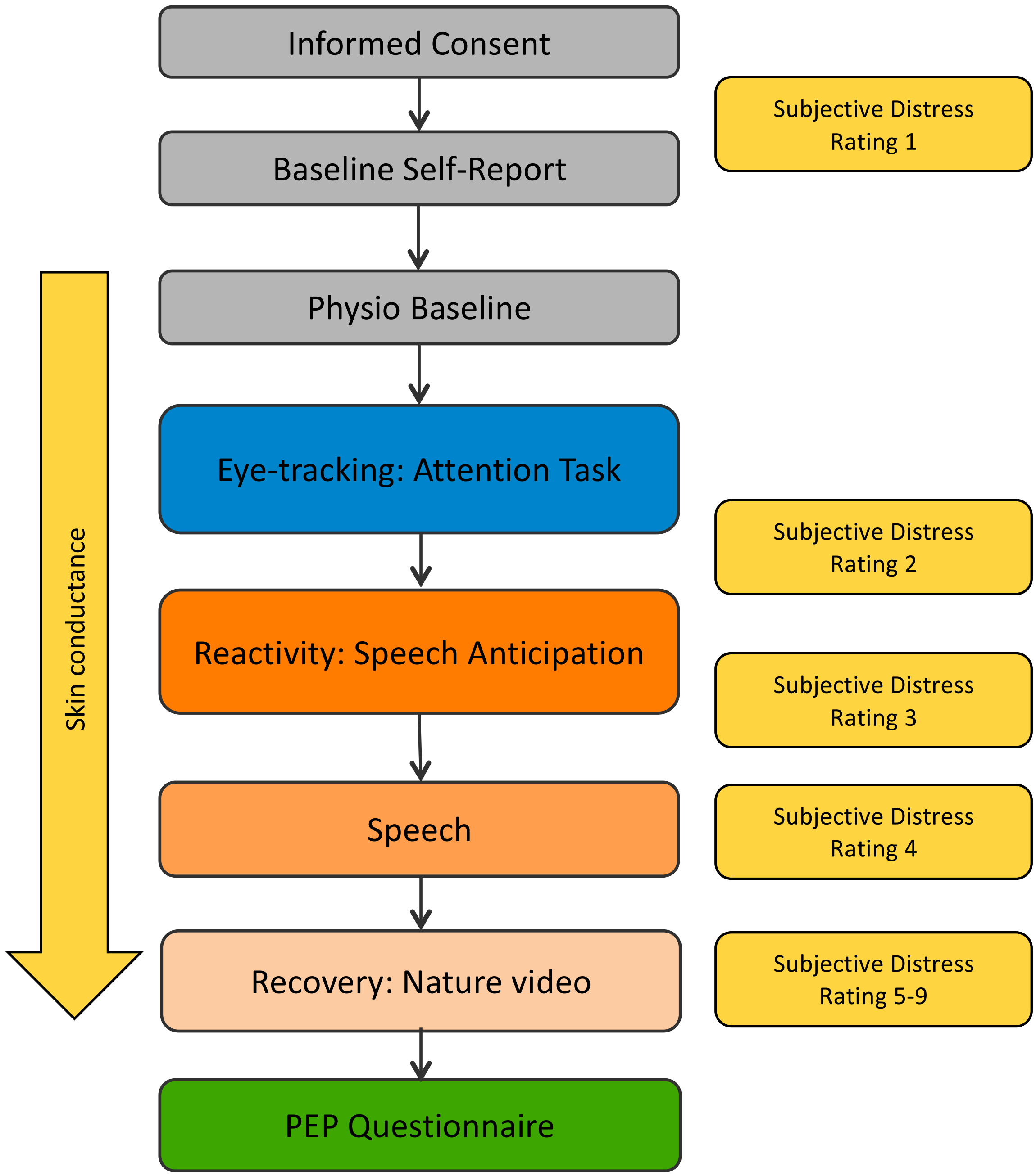
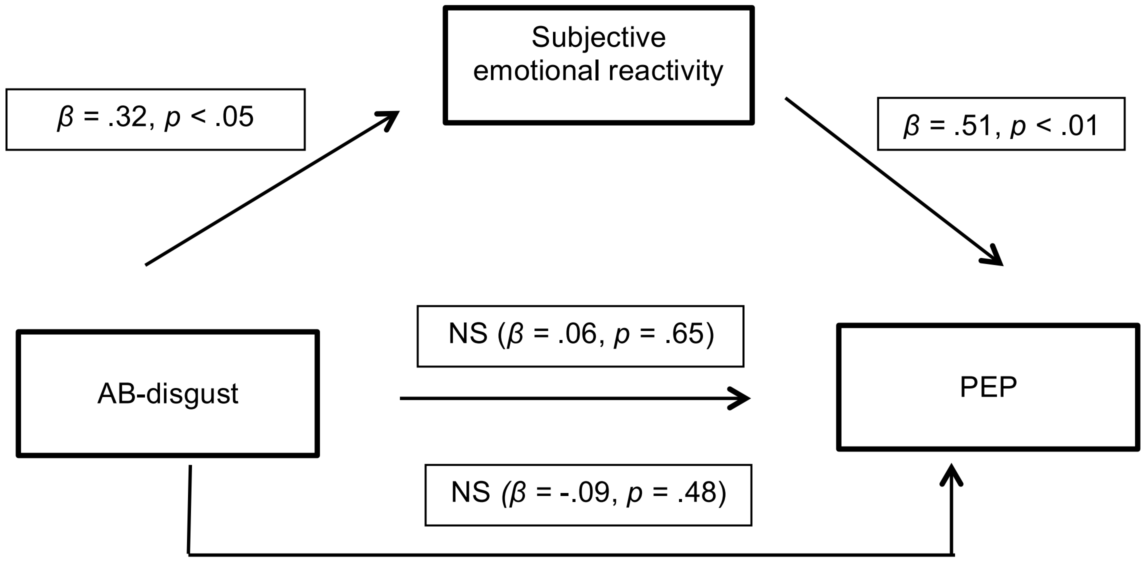


Figure 4. *The indirect effect of AB-disgust on PEP through subjective emotional reactivity*



Tables

Table 1. *Pearson correlations, means, and standard deviations between SIAS and primary variables of interest*.

Variables of Interest	SIAS	Mean (SD)	Range
AB anger	.26	3.42 (10.76)	-34-32
AB disgust	.31*	2.54 (13.06)	-31-36
NER1	.33*	1.45 (1.83)	0-7
NER3	.33*	2.70 (2.41)	0-8
Baseline_SCL	.21	1.37 (1.00)	.03-4.27
React_meanSCL	.19	2.36 (1.48)	.13-7.10
React_#SCR	.29*	19.34 (12.40)	0-46
Subj.Recov	.07	59% returned to baseline by end of speech	0-5
Physio.Recov	-.30*	3.16 minutes (1.89)	0-9.76
PEP	.51**	14.68 (10.53)	.00-51
SIAS_tot	-	20.38 (10.89)	0-50

Note. AB.anger = Attention bias to anger; AB.disgust = Attention bias to disgust; NER1 = Nervousness at baseline; NER3 = Nervousness at stressor onset; Baseline_SCL = Baseline skin conductance level; React_mean SCL = mean skin conductance level at stressor onset; React_#SCR = number of skin conductance responses at stressor onset; Subj.recov = time to baseline subjective anxiety level; Physio.recov = time to baseline skin conductance level; PEP = Post-event processing score; SIAS_tot = SIAS total score

* p < .05, ** p < .01

Table 2. *Pearson correlations between AB variables and primary variables of interest.*

Variables of Interest	**TVD:AB-anger**	**TVD:AB-disgust**
NER1	.04, *p* = .77	-.03, *p* = .82
NER3	.22, *p* = .12	.32*
Baseline_SCL	-.07, *p* = .61	.04, *p* = .76
React_meanSCL	-.06, *p* = .69	.06, *p* = .68
React_#SCR	-.03, *p* = .83	.07, *p* = .62
Subj.Recov	.01, *p* = .92	.01, *p* = .93
Physio.Recov	.06, *p* = .68	-.01, *p* = .94
PEP	.03, *p* = .82	.06, *p* = .65
SIAS_tot	.26, *p* = .06	.31*

Note. TVD:AB.anger = Attention bias to anger; TVD:AB.disgust = Attention bias to disgust; NER1 = Nervousness at baseline; NER3 = Nervousness at stressor onset; Baseline_SCL = Baseline skin conductance level; React_mean SCL = mean skin conductance level at stressor onset; React_#SCR = number of skin conductance responses at stressor onset; Subj.recov = time to baseline subjective anxiety level; Physio.recov = time to baseline skin conductance level; PEP = Post-event processing score; SIAS_tot = SIAS total score

* $p < .05$

Appendix A

Thoughts Questionnaire - Modified

Please rate each statement as to how often you thought about that aspect in the time since you gave the speech.

0- Never; 1- Not Often; 2- Sometimes; 3- Often; 4- Very Often

1) My speech was good.
2) I could have done much better.
3) How anxious I felt.
4) The investigator liked me.
5) If my blushing/sweating/dry mouth/shaking was obvious.
6) How well I handled it.
7) How bad my speech was.
8) I made a fool of myself.
9) How much I enjoy these situations.
10) How I always do badly in this type of situation.
11) I must have looked stupid.
12) How smoothly it all went.
13) How self-conscious I felt.
14) What a failure I was.
15) How many mistakes I made.
16) How confident I felt.
17) I came across as self-assured.
18) How awkward I felt

19) That I was at my best.

20) How fast my heart was pounding.

21) I didn’t make a good impression.

22) Other aspects of the situation.

23) The situation overall

Appendix B

KDEF face stimuli selected for the attention task

Practice Trials

Female	Male
AF05NES	AM14HAS
AF05ANS	AM14NES
AF03ANS	AM17NES
AF03NES	AM17DIS
AF22HAS	AM06NES
AF22NES	AM06ANS

Set A

Happy-Neutral		Angry-Neutral		Disgust-Neutral	
Female	Male	Female	Male	Female	Male
AF28NES	AM16NES	AF19NES	AM07NES	AF29NES	AM25NES
AF28HAS	AM16HAS	AF19ANS	AM07ANS	AF29DIS	AM25DIS
AF32HAS	AM10NES	AF29ANS	AM26ANS	AF01DIS	AM18NES
AF32NES	AM10HAS	AF29NES	AM26NES	AF01NES	AM18DIS
AF31HAS	AM24HAS	AF21NES	AM05NES	AF07DIS	AM34NES
AF31NES	AM24NES	AF21ANS	AM05ANS	AF07NES	AM34DIS
AF06NES	AM09HAS	AF16ANS	AM17ANS	AF13NES	AM12NES
AF06HAS	AM09NES	AF16NES	AM17NES	AF13DIS	AM12DIS
AF10HAS	AM11NES	AF33ANS	AM01ANS	AF20DIS	AM05DIS
AF10NES	AM11HAS	AF33NES	AM01NES	AF20NES	AM05NES
AF09NES	AM26HAS	AF15NES	AM15NES	AF02DIS	
AF09HAS	AM26NES	AF15ANS	AM15ANS	AF02NES	
AF01HAS	AM25NES	AF22NES	AM08ANS	AF09NES	
AF01NES	AM25HAS	AF22ANS	AM08NES	AF09DIS	
AF31HAS	AM04HAS	AF01ANS	AM12NES	AF32NES	
AF31NES	AM04NES	AF01NES	AM12ANS	AF32DIS	
AF26HAS	AM03HAS		AM35ANS		
AF26NES	AM03NES		AM35NES		
AF15NES			AM18NES		
AF15HAS			AM18ANS		
AF17HAS			AM28NES		
AF17NES			AM28ANS		
AF20HAS			AM23ANS		
AF20NES			AM23NES		

Set B

Happy-Neutral		Angry-Neutral		Disgust-Neutral	
Female	Male	Female	Male	Female	Male
AF21HAS	AM02NES	AF09NES	AM03ANS	AF04DIS	AM35DIS
AF21NES	AM02HAS	AF09ANS	AM03NES	AF04NES	AM35NES
AF13HAS	AM29NES	AF14ANS	AM11ANS	AF03NES	AM06DIS
AF13NES	AM29HAS	AF14NES	AM11NES	AF03DIS	AM06NES
AF34NES	AM31NES	AF25ANS	AM09ANS	AF15NES	AM32DIS
AF34HAS	AM31HAS	AF25NES	AM09NES	AF15DIS	AM32NES
AF14NES	AM23HAS	AF13NES	AM22NES	AF16DIS	AM23NES
AF14HAS	AM23NES	AF13ANS	AM22ANS	AF16NES	AM23DIS
AF27NES	AM32NES	AF26ANS	AM02NES	AF34DIS	AM28DIS
AF27HAS	AM32HAS	AF26NES	AM02ANS	AF34NES	AM28NES
AF30HAS	AM12HAS	AF35ANS	AM24NES	AF14NES	AM16NES
AF30NES	AM12NES	AF35NES	AM24ANS	AF14DIS	AM16DIS
AF05NES	AM28HAS	AF32ANS		AF19NES	AM04NES
AF05HAS	AM28NES	AF32NES		AF19DIS	AM04DIS
AF04NES	AM17NES	AF02NES		AF10NES	AM24NES
AF04HAS	AM17HAS	AF02ANS		AF10DIS	AM24DIS
		AF23NES		AF33DIS	AM03DIS
		AF23ANS		AF33NES	AM03NES
		AF17NES			AM01DIS
		AF17ANS			AM01NES
					AM22DIS
					AM22NES
					AM11DIS
					AM11NES
					AM13NES
					AM13DIS

Notes. F = female, M = male, NES = neutral stimuli, HA = happy stimuli, AN = angry stimuli, DI = disgust stimuli, S = straight angle, A = appeared in Set A in original Karolinska study.