THE EFFECTS OF SELF-IMAGERY ON COGNITIVE PROCESSES WITHIN SOCIAL ANXIETY

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Abstract: Cognitive models of social anxiety suggest that negative mental self-imagery maintains social anxiety. Much research posits social anxiety is accompanied by increased negative self-imagery; however, little research investigates self-imagery's impact beyond performance in social interaction. This study aimed to investigate the relationship between social anxiety and task effectiveness and efficiency using behavioral data and measures of neural activity (i.e., Event Related Potentials). Furthermore, manipulations in self-imagery were used to investigate its moderating effects. Twenty five individuals with high and 23 with low levels of social anxiety completed three self-imagery manipulations and completed a Go/No-go task after each manipulation. Results indicated that individuals with high levels of social anxiety performed equally well as the individuals with low social anxiety. Importantly, those with high levels of social anxiety showed slower reaction times during the task and decreased efficiency of neural recruitment. These results support the attentional control theories assertions that social anxiety is often more associated with poor efficiency than it is with poor effectiveness. Unexpectedly, no interactions with self-imagery were observed, which may suggest that individuals with social anxiety show decreased efficiency, generally, when engaging in self-focused attention. Further research is necessary to determine the potential moderating effects of self-imagery within social anxiety often posited by cognitive models.

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CHAPTER I

INTRODUCTION

Social anxiety disorder is one of the most common forms of psychopathology, affecting between 7 – 12 percent of the population a year (Kessler et al., 2005; Kessler et al., 2012). Based on clinical definitions (APA, 2013) and ample research (e.g., Brown, Campbell, Lehman, Grisham, & Mancill, 2001; Buckner, Farris, Schmidt, & Zvolensky, 2014; Caplan, 2007), this disorder is associated with significant impairment (e.g., avoidance, decreased social performance) and distress (e.g., loneliness). As a result, theoretical models have been developed to explain the factors that sustain this debilitating condition (Clark & Wells, 1995; Rapee & Heimberg, 1997). Within these perspectives, negative self-imagery is posited to play a large role in the maintenance of social fears. Specifically, holding a negative self-image of oneself in mind will increase cognitive, psychological, and behavioral symptoms of anxiety, thus leading to an even more skewed mental representation of the self. This cycle likely contributes to the maintenance of social anxiety symptomology (Clark & Wells, 1995; Rapee & Heimberg, 1997). However, research evaluating the role of self-imagery in social anxiety has, largely, been limited to the effects on social performance measures (self-report and observer report of performance during social situations). The purpose of this study is to investigate how self-imagery influences cognitive processing as well as corresponding neural activation.

Cognitive models of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997) suggest that when entering a social situation, an individual with social anxiety will prioritize external and internal threat related stimuli (e.g., Hirsch & Clark, 2004; Hirsch, Clark, Mathews, & Williams, 2003). This leads to attentional biases towards both external information related to the threat, as well as a self-focus bias. This bias is shown through anxiety related thoughts, physiology, and behavior which are related to the threat (Clark & Wells, 1995; Rapee & Heimberg, 1997). Specific to self-focused attention, research indicates that individuals with high levels of social anxiety engage in more negative self-imagery in relation to social situations (e.g., Blasi, Cavani, Pavia, Baido, Grutta & Schimmenti, 2015; Moscovitch, Gavric, Merrifield, Bielak, & Moscovitch, 2011) and that those negative self-images lead to enhanced anxiety (worry), poorer performance, and further self-focused attention (e.g., Brozovich & Heimberg, 2013; Hirsch & Clark, 2004; Hirsch, Clark, Mathews, & Williams, 2003). For example, Hirsch, Clark, Mathews, and Williams (2003) used a variation of the Hackman (1998) self-imagery manipulation to induce self-focused attention, in which participants recalled recent positive and negative social situations and were told to imagine what they looked like in those situations while having a conversation with another participant. Results found that individuals with social anxiety who held a negative self-image in mind had greater anxiety, more processing of physiological symptoms, and performed worse in the conversation, compared to when they held a neutral self-image in their head. Thus, this style of self-focused attention typically increases the fear of the threat of negative evaluation and current anxiety symptomology (e.g., Makkar & Grisham, 2011; Stopa & Jenkins, 2007; see Hirsch, Clark, & Mathews, 2006, for a review).

Eysenck, Derakshan, Santos, and Calvo (2007) proposed a model that explains how worry and negative self-focused attention affect individuals with anxiety and may lead to poorer social and task performance as well as exasperated anxiety. Because cognitive resources have a limited capacity (Baddeley, 2003, 2012; Moran, 2016), the attentional control theory suggests that enhanced self-focused attention (i.e., enhanced processing of threat related information) and anxiety both take up a portion of cognitive resources, thus limiting the amount of resources allocated to the task at hand (Eysenck et al., 2007). Eysenck et al. (2007) proposed that worry (e.g., worrying about one's self-image) is related to enhanced internal threat focus, thus individuals with social anxiety also will engage in enhanced threat focus which takes up attentional resources. Research on social anxiety, based on this framework, shows that these individuals often display deficits in tasks that involve the executive control function of working memory, indicating that anxiety and self-focused attention lead to poor task performance (e.g., Ansari & Derakshan, 2011; Derakshan, Ansari, Hansard, Shoker & Eysenck, 2009).

In addition, Eysenck et al. (2007) proposed that task performance involves two components: effectiveness and efficiency. Effectiveness is how well one completes the task, frequently assessed using error rates. Efficiency is the amount of effort put forth to complete the task, such as length of time in selecting a correct response and how much neural activity is used to complete the task correctly. It is argued that when effectiveness deficits are not seen, it is possible that deficits in efficiency may occur (Eysenck et al., 2007). Research in this area has focused primarily on inhibition, which is one executive control function that seems to be influenced by anxiety. Inhibition involves maintaining attention towards the task at hand, ignoring irrelevant information, controlling responses to task irrelevant behavior, and only responding to task relevant stimuli (Miyake et al., 2000). Inhibition deficits have been found in individuals with high levels of trait anxiety in both effectiveness, and more so, in efficiency (Grillon et al., 2016; Judah, Grant, Mills, & Lechner, 2013; Righi, Mecacci, & Viggiano, 2009).

Generally, research finds that individuals with anxiety can perform as well as other individuals leading to normal effectiveness, but use more effort to complete the task leading to poor efficiency (Derakshan et al., 2009; Righi, Mecacci, & Viggiano, 2009). For example, the Go/No-go task is a measure of inhibition, in which individuals are shown a series of stimuli and told to respond by pressing a button to certain stimuli and inhibiting a response to other stimuli. The stimuli that require an inhibition response are less frequent, leading the participant to begin responding with a prepotent response to the presented stimuli. When an infrequent, to-be-inhibited stimulus appears, it requires the inhibition of the prepotent response. This is used as the measure of inhibition. A meta-analysis by Wright, Lipszyc, Dupuis, Thayapararjah, and Schachar (2014) found that anxiety disorders consistently showed deficits in the ability to inhibit the prepotent response. These findings, in addition to other studies (e.g., Grillon, Robinson, Krimsky, O'Connell, Alvarez, & Ernst, 2016), suggest that anxiety impairs inhibition performance (i.e., increased error rates). However, other studies have failed to find performance deficits, although individuals with anxiety still displayed efficiency deficits (i.e., longer latency to respond, more neural activity; Righi et al., 2009). With somewhat conflicting results, it is important to examine and compare both behavioral and psychophysiological measures to truly understand the impact that anxiety has on cognitive performance.

Psychophysiological activity offers a unique perspective towards the investigation of effectiveness and efficiency, as researchers are able to collect neural activity (efficiency) along with behavioral responses (effectiveness) within the same task. Collecting neural activity is useful as it provides a direct measure of the effort it takes for an individual to respond (or inhibit) to a task. Research using electroencephalography suggests that event-related potentials (ERP's; neural activity directly related to a stimulus or response) can be used to measure the effort an individual puts towards a task and have been shown to be sensitive to, and influenced by, different levels of trait anxiety (e.g., Meyer, Hajcak, Torpey-Newman, Kujawa, & Klein, 2015; Owens, Derakshan, & Richards, 2015; Savostyanov, Tsai, Liou, Levin, Lee, Vurganov, & Knyazev, 2009) and specifically social anxiety (e.g., Ansari & Derakshan, 2011a, 2011b; Judah et al., 2013; Moser, Hajcak, Huppert, Foa, & Simons, 2008; Righi, Mecacci, & Viggiano, 2009). For example, Sehlmeyer et al., (2010) found that the N2 (an ERP component associated with attentional resources allocated to the task at hand; Luck, 2014; Jodo & Kayama, 1992) and the P3 (an ERP component associated with resource allocation used in processing the stimulus; Isreal, Chesney, Wickens, & Donchin, 1980; Luck, 2012, 2014) are larger for individuals with anxiety compared to individuals without anxiety when attempting to inhibit a prepotent response. These results support additional findings that individuals with trait anxiety recruit more neural resources when attempting to inhibit responses (Henderson, 2010; Hum, Manassis, & Lewis, 2013; Judah et al., 2013; Moser, Huppert, Duval, & Simons, 2008; Owens, Derakshan, & Richards, 2015; Righi, Mecacci, & Viggiano, 2009; Wauthia & Rossignol, 2016; Wauthia & Rossignol, 2016).

According to the attentional control theory (Eysenck et al., 2007) and corresponding research (e.g., Judah et al., 2013; Moser et al., 2008; Righi, Mecacci, & Viggiano, 2009), individuals with anxiety will generally recruit more neural resources to complete a task; however, some findings show decreased neural activity. Because individuals with anxiety preferentially allocate neural resources to threatening information, they have less resources to allocate to the task at hand. For example, Judah et al. (2013) had participants complete an inhibition task while manipulating self-focused attention. The results showed that individuals with social anxiety demonstrated overall greater effort for inhibition trials (i.e., longer latencies, increased neural activity); however, on self-focus trials, they showed decreased neural activity. This effect was not found for individuals low in social anxiety. Therefore, these results support the attentional control theory's proposal that anxiety related cognitive activity leads to decreased neural resources to other tasks (Eysenck & Derakshan, 2011; Eysenck et al., 2007). This implies that tasks involving threatening information or stimuli will produce decreased neural activity, whereas tasks that do not involve threat will produce increased neural activity.

In summary, the current state of research indicates that social anxiety is associated with skewed and disproportionate levels of negative self-imagery (e.g., Blasi, Cavani, Pavia, Baido, Grutta & Schimmenti, 2015; Moscovitch, Gavric, Merrifield, Bielak, & Moscovitch, 2011). Models of social anxiety suggest that negative self-imagery is a maintenance factor for social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997). The attentional control theory (Eysenck et al., 2007) proposes that impairments in social anxiety are present because working memory has a limited capacity and that those with social anxiety process and focus on threat related information (internal, external) at a higher rate than individuals without social anxiety, which leads to diminished cognitive resources allocated to tasks related to inhibition. Moreover, diminished cognitive resources appears to present itself in psychophysiological studies of neural activity, such that those with social anxiety exhibit enhanced neural recruitment (poor efficiency) to compensate for the diminished resources due to anxiety, although display decreased neural recruitment when attention is focused on threat related information.

The current study used the Go/No-go task while collecting ERP's to investigate how manipulations of negative self-imagery affect the effectiveness and efficiency of inhibition. In line with the attentional control theory (Eysenck et al., 2007), differences in effectiveness between high and low socially anxious individuals were not expected; however, it is hypothesized that individuals with high social anxiety would show hindered efficiency in the Go/No-go task shown by 1) longer inhibition response latencies to the to-be-inhibited stimuli, 2) enhanced levels of neural activity (N2, P3) to inhibit a response. In addition, when processing negative self-imagery, individuals with social anxiety would display overall decreases in neural activity to the task compared to the neutral and positive self-images as well as compared to the individuals with low social anxiety.

CHAPTER II

REVIEW OF LITERATURE

Social Anxiety

Social anxiety disorder (SAD) is one of the most common anxiety disorders and affects between 7 - 12% of the population each year (Kessler et al., 2005; Kessler et al., 2012). Socially anxious individuals exhibit persistent and debilitating fear and anxiety in social situations in which they face the possibility of negative evaluation (American Psychiatric Association [APA], 2013). A core feature of SAD is a strong desire to be socially liked and accepted, but a debilitating insecurity in his or her abilities to achieve that goal (Clark & Wells, 1995). Social anxiety is a common human experience, whereas SAD is when the anxiety and fear become debilitating, interfering, and impairing. A distinction is necessary; however, social anxiety is thought to lay on a continuum, in which the only difference between subclinical social anxiety and SAD is the level of impairment (Ruscio, 2010; Ruscio, Haslam, & Suscio, 2006). A taxometric analysis by Ruscio (2010) attempting to find an underlying taxa (or category) that would distinguish SAD from normal social anxiety found no taxa. This finding, along with findings that individuals with SAD and subclinical social anxiety have the same type of symptomology (Purdon, Antony, Monteiro, & Swinson, 2001) and attentional and processing biases (Bradley, Mogg, Millar & Bonham-Carter, 1997; Clark, & McManus, 2002; Öhman, 1986), suggests that social anxiety is a dimensional construct.

Social anxiety has negative outcomes (APA, 2013), including higher levels of cigarette use and nicotine dependency (Buckner, Farris, Schmidt, & Zvolen-sky, 2014; Lopes et al., 2002), loneliness (Caplan, 2007; Mahon, Yarcheski, Yarcheski, Cannella, & Hanks, 2006), and decreased occupational functioning and satisfaction (APA, 2000). In addition, those with SAD experience high rates of depressive symptoms (Brown, Campbell, Lehman, Grisham, & Mancill, 2001; Schneier, Johnson, Hornig, Liebowitz, & Weissman, 1992). Because social anxiety is so highly prevalent and has many negative outcomes and consequences, it is important to understand and investigate causal and maintenance factors. Therefore, cognitive models of social anxiety will be discussed.

Cognitive Models of Social Anxiety

Cognitive models of SAD (Clark & McManus, 2002; Clark & Wells, 1995; Heimberg, Brozovich, & Rapee, 2010; Peschard & Philippot, 2015; Rapee & Heimberg, 1997) have become very popular modalities to conceptualize social anxiety over the past two decades. Similar to other cognitive models in psychology, these models suggest that cognitive processes and information processing (attention, perception, and interpretation) contribute to the development and maintenance of SAD symptomology. According to these frameworks, individuals with SAD typically process information, pay attention to information, and form belief systems that contribute to the cyclical nature of social anxiety. For example, an individual with social anxiety may believe that he or she is boring, unable to hold a conversation, or lacks socially acceptable and redeeming qualities. During social situations, that individual will perceive internal and external information in such a way that will reinforce his/her negative beliefs, thus contributing to the disorder (Clark & Wells, 1995; Rapee & Heimberg, 1997).

The Clark and Wells (1995) and Rapee and Heimberg (1997) models are similar in many ways. They both suggest that a distorted self-representation or self-image is key to the development of anxious symptomology during social situations. Upon entering a social situation in which negative social evaluation is possible, individuals with SAD will create a self-image of what they think they look like in the eyes of others (Clark & Wells, 1995; Rapee & Heimberg, 1997). These self-images are created and influenced by the perception of current behavioral, cognitive, and physical symptoms along with the likely already-distorted self-image and autobiographical memory the individual with social anxiety holds of him/herself. For example, an individual with social anxiety will preferentially allocate attentional resources to responses to anxiety (anxious symptomology; e.g., sweating, blushing, squirming around, and negative self-talk), which will influence the self-image they hold, such that if the individual with social anxiety perceives that he/she is sweating more, then he will picture himself as sweating more (Clark & Wells, 1995). Because this new self-image (i.e., overly perspiring) is perceived as less desirable, it leads to further anxious symptomology and attention is allocated towards it. This process has been termed emotional reasoning (Burns, 1980), ex-consequentia reasoning (Arntz, Rauner, & van den hout, 1995) and processing of felt sense (Teasdale & Barnard, 1993), in which one's feelings or thoughts are perceived to be true and apparent to others. For example, an individual with social anxiety may mistake feeling judged or humiliated without actually being judged or humiliated. This same cyclical pattern is shown for both cognitive and symptoms of anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997).

The largest difference between Clark and Wells (1995) and Rapee and Heimberg (1997) models is where the focus of the allocation of attentional resources rests. Whereas Clark and Wells (1995) argue that there is a self-focused preferential allocation of attention (i.e., anxious thoughts, negative self-talk, worry, physiological symptoms of anxiety, behavioral symptoms of anxiety), Rapee and Heimberg (1997) posit that in addition to the self-focused attention, there also is preferential allocation to external threatening cues that threaten one's self-representation. For example, an individual with social anxiety in a social situation would devote their cognitive resources to anxious thoughts and symptomology based on threatening stimuli in the environment that indicate the realization of the feared outcome. Regardless of where the individual is preferentially allocating attention (i.e., internal or external), that individual is paying less attention to the task at hand. In both models, this paradigm tends to lead to poor performance in social situations due to the lack of attentional resources allocated towards the conversation. Interestingly, the preferential allocation of attentional resources towards threat used as a coping mechanism for social anxiety may actually lead to the increased likelihood of the feared consequence and negative social evaluations.

Empirical Support for Cognitive Models

Cognitive models of social anxiety posit that individuals with social anxiety have skewed and proportionally more negative self-images (mental representation) in relation to social situations (Hirsch & Clark, 2004; Rapee & Heimberg, 1997). This mental representation is not an objective representation of the self, but is more of a distorted interpretation or perception of what the self looks like. A study by Moscovitch, Gavric, Merrifield, Bielak, and Moscovitch (2011) had 80 undergraduates (41 = high and 39 = low in social anxiety) complete the Waterloo Images and Memories Interview (WIMI). The WIMI is a modified version of the Autobiographical Interview (AI; Lavine, Svoboda, Hay, Winocur, & Moscovitch, 2002) and was designed to assess the accessibility and nature of individual's mental images as autobiographical recollections. Results suggested that individuals with social anxiety had higher rates of negative imagery, closer links between negative imagery and past negative social events, higher detail for negative vs. positive imagery, as well as felt more negative emotions and cognitions around those mental representations. Similar results have been shown in various studies (Blasi, Cavani, Pavia, Baido, Grutta & Schimmenti, 2015; Chiupka, Moscovitch & Bielak, 2012; Hackmann, Clark, & McManus, 2000; Hackmann, Surawy, & Clark, 1998; Hirsch & Clark, 2004; Moscovitch, Chiupka, & Gavric, 2013; Moscovitch, Gavric, Merrifield, Bielak, & Moscovitch, 2011; Schreiber & Steilm, 2013; Vassilopoulos, 2012). These results suggest that both those with and without social anxiety have negative autobiographical memories and self-imagery; however, those with social anxiety have an elevated level of negative imagery.

This mental representation in social anxiety likely has many sources: 1) autobiographical recollection of past social events, 2) actual images of the self (photographs), and 3) internal and external cues (Heimberg, Brozovich, & Rapee, 2010; Morgan, 2010; Rapee & Heimberg, 1997). Autobiographical memories and actual images of the self are used to create a base-line self-image, which internal (e.g., heart-rate, sweating, thoughts, safety behavior) and external (e.g., others facial expression, reactions, body language, verbal language) cues modify (Rapee & Heimberg, 1997). Therefore, ones' self-image is constantly fluctuating. For example, an individual may hold a neutral self-image based on past experiences and photos of the self; however, others snickering, giggling, in combination with sweating and an accelerated heart rate will lead to the neutral self-image to turn into a negative one.

One of the more studied aspects related to mental self-imagery is the individual's perceived social performance. Generally, research suggests that individuals with social anxiety perceive their own performance in social situations as worse than it actually is (e.g.,Hirsch & Clark, 2004; Hirsch, Clark, Mathews, & Williams, 2003; Hirsch, Meynen, & Clark, 2004; Moscovitch, Gavric, Merrifield, Bielak, & Moscovitvh, 2011; Rapee & Heimberg, 1997). In other words, upon entering a social situation their mental self-representation of their performance is starting off more negative, which contributes to negative evaluations about self-performance. For example, Hirsch, Clark, Mathews, and Williams (2003) had patients with social phobia participate in two conversations with strangers: one while holding a neutral self-image in mind and one while holding a negative self-image. Participants rated their anxiety symptomology and performance after both conversations. Results found that holding a negative self-image in mind during a conversation led to more anxious symptomology as well as worse self-rated performance compared to the neutral control. These results have been supported through additional research on this topic (e.g., Makkar & Grisham, 2011; Stopa & Jenkins, 2007; see Hirsch, Clark, & Mathews, 2006, for a review), as well as findings that socially anxious individuals are affected by negative self-imagery manipulations more than individuals without anxiety (e.g., Brozovich & Heimberg, 2013; Hirsch, Meynen, & Clark, 2004; Makkar & Grisham, 2011; Stopa & Jenkins, 2007; Vassilopoulos, 2005). In addition, findings are consistent that individuals with social anxiety perceive the self as performing worse only for social situations, and not for non-social settings (e.g., Efran & Korn, 1969).

This last finding suggests that the mental self-representation and perceptual distortions are specific to social situations. Together, these results imply that higher levels of social anxiety are related to more negative self-imagery, which leads to skewed perceptions of performance, which, in turn, leads to more skewed self-images. It is the cyclical nature between self-image and perception that cognitive models of social anxiety suggest is a maintenance factor.

An additional component to the cognitive models of social anxiety is that the individual's self-image is compared to the perceived expectations that the audience holds for the individual. In other words, the socially anxious person compares his or her self-image in a social situation with what he or she thinks the audience expects from him or her. In order to avoid negative evaluation, the socially anxious individual feels compelled to act and be perceived in the manner that the audience anticipates and desires. If the individual has a self-image that is not meeting the perceived expected standards of the audience, then the individual feels there is a high likelihood of negative evaluation. Thus, the greater the discrepancy between the self-image and perceived expectation, the more anxious symptomology will be experienced (Clark & Wells, 1995; Rapee & Heimberg, 1997; Schlenker & Leary, 1982; Wallace & Alden, 1991). Research suggests that individuals with social anxiety have beliefs that others hold expectations of them that they cannot meet (Schlenker & Leary, 1982; Wallace & Alden, 1991). One study evaluating this phenomenon split 96 undergraduates into high and low socially anxious groups and presented them with a paradigm to measure self-established standards and self-efficacy to meet those standards (Wallace & Alden, 1991). Participants completed conversations in the lab to simulate everyday conversation. Participants rated the level of performance (i.e., how well they would have to converse), their ability to meet that level of performance, and judged whether the conversation was a successful or unsuccessful interaction. These results found that socially anxious individuals believe that others (the experimenter and the other party of the conversation) had standards for the conversation that the individual with social anxiety could not meet; whereas, the non-anxious individuals believed they had the skills to meet the audience expectations. Similar results have been found using different methodology, such as within getting-to-know-you paradigms (e.g., Doerfler & Aron, 1995; Laurenti, Bruch, & Haase, 2008) and responding to questions tasks (e.g., Strauman, 1989). Overall, it appears that those with social anxiety views themselves as less able to meet the expectations of others, which can facilitate negative imagery.

In addition to having discrepancies between self-images and expectations, individuals with social anxiety rate these discrepancies as more likely to lead to negative evaluation. For example, Voncken, Bögels, and de Vries (2003) assessed the level of judgmental bias or probability they expected to be negatively evaluated in various situations among individuals with social anxiety and a control group. Participants arranged 4 outcomes (positive, neutral, mildly-negative, and profoundly-negative) from least to most likely to occur during social situations. Results showed that the social anxiety group reported a negative evaluation was more likely to occur than a positive one, whereas this bias was not shown in the non-anxious group, indicating a judgmental bias. Other studies have similarly found that individuals with social anxiety will assume that a negative outcome is more likely than a non-anxious person (Foa, Franklin, Perry, & Herbert, 1996; Lucock & Salkovskis, 1988; Poulton & Andrews, 1994; Spence, Donovan, & Brechman-Toussaint, 1999).

If a socially anxious individual perceives a discrepancy between their self-image and the audience expectation, the fear of negative evaluation will trigger a fear response, since fear of negative evaluation is the key feature of social anxiety. Cognitive theories suggest that this fear response consists of cognitive, behavioral, and physical symptoms (Clark & Wells, 1995; Rapee & Heimberg, 1997). Rapee and Heimberg (1997) posit that as the probability for negative evaluation increases, so does the state anxiety and fear response. One early study evaluating this had individuals with and without social anxiety partake in three-minute role-playing interactions and one impromptu speech (Beidel, Turner, & Dancu, 1985). After each task, participants completed self-report measures of anxiety, cognitive symptomology, behavioral symptomology and psychological arousal. As expected, individuals with high social anxiety experienced significantly more anxiety during each task, in addition to more physiological activation (e.g., sweating, heart-rate), negative thoughts, and avoidance behavior. Similar symptomology presentation has been shown in numerous other studies (e.g., Stopa & Clark, 1993; Turner, Beidel, & Larkin, 1986).

Individuals with social anxiety experience a common set of cognitions, behavior, and physiology in relation to their anxiety. Research suggests that common cognitions in individuals with social anxiety are related to higher levels of negative self-evaluation and irrational beliefs (e.g., Gormally, Sipps, Raphael, Edwin, & Varvil-Weld, 1981; Stopa & Clark, 1993). In addition, individuals with social anxiety typically engage in safety behaviors, or behaviors aimed towards avoiding or decreasing the likelihood of negative evaluation, during social situations (e.g., standing in the back of the room, talking very little, holding on to objects to avoid shaking, avoiding eye-contact; Hofmann, 2007; McManus, Sacadura, & Clark, 2008; Rapee & Heimberg, 1997; Beidel, Turner, & Dancu, 1985; Wells, Clark, Salkovskis, Ludgate, Hackmann, & Gelderm, 1995). Interestingly, safety behaviors are often a hindrance to desired social skills, thus using safety behaviors to avoid negative social evaluation can actually increase its likelihood. For example, if an individual avoids eye-contact during a conversation as a safety behavior, the observers may perceive the individual as being uninterested, snobby, or arrogant (McManus, Sacadura, & Clark, 2008).

In addition to cognitive and behavioral symptoms described previously, physiological symptoms are significant in the maintenance of social anxiety. Physiological symptoms experienced by those with social anxiety include accelerated heart rate, sweating, blushing, stammering, or feeling faint (APA, 2013; Reich, Noyes, & Yates, 1988; Vassilopoulos, 2005).

Subsequently, these cognitive, behavioral, and physiology symptoms of anxiety experienced during a social situation influence the mental representation of the self, thus creating a more negative self-image or mental representation. This more negative self-image leads to a larger discrepancy between the self-image and audience expectations, thus leading to a higher perceived likelihood of negative evaluation, which leads to and increased cognitive, behavioral, and physiological symptomology. The cyclical nature of these symptoms is a core feature of the cognitive theories of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997).

In addition to the cyclical nature of cognitions, behavior, and physiology symptoms, presented above, cognitive models suggest that individuals will preferentially allocate attentional resources to both internal and external stimuli to monitor the threatening situation (Clark & Wells, 1995; Rapee & Heimberg, 1997). Both Rapee and Heimberg (1997) and Clark and Wells (1995) suggest that individuals with social anxiety will preferentially allocate attention internally. This internal bias of attention manifests itself as focusing on cognitions (e.g., negative self-talk; Stopa & Clark, 1993), perceptions, and physiological symptoms (Johannsson & Ost, 1982; Mansell, Clark, & Elhers, 2003) that are related to the feared situation. Internal attentional bias or self-focus has been shown to be very common in social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997). For example, an individual with social anxiety may enter a conversation and begin to realize that he or she is sweating. Sweating becomes the focus of attention, and then negative self-thoughts percolates and even more anxious physiology arises. The individual preferentially focus on the internal symptoms, manifestations of anxiety, and internalizations of threat while not giving any attention to external stimuli (Clark & Wells, 1995; Rapee & Heimberg, 1997).

Melchior and Cheek (1990) evaluated this phenomenon among 58 college students who completed a conversation with a partner and then rated their performance. Those who scored higher in terms of social anxiety reported spending more time focused on themselves, on their anxious thoughts, and their anxious physiology during the conversation compared to those low in social anxiety. Similar findings have been consistently found (e.g., Hope & Heimberg, 1988; Monfries & Kafer, 1994; Saboonchi & Lundh, 1997, Mellings and Alden, 2000). In addition, research suggests that self-focused attention leads to more social anxiety (Bögels & Lamers, 2002), enhances social anxiety symptomology (Bögels & Mansell, 2004), and exasperates negative self-talk, anxiety, and physiological arousal (Bögels, Alperts, & de Jong, 1996; Wells & Papageorgiou, 1998; Woody, 1996; Woody & Rodriguez, 2000). It is important to mention that self-focused attention occurs not only in clinical patients (Alden, Teschuk, & Tee, 1992; Mansell, Clark, & Elhers, 2003; Melling & Alden, 2000) but also in subclinical populations (Clark & McManus, 2002; Stein, Torgrud, & Walker, 2000). Overall, these findings suggest that individuals with social anxiety engage in heightened levels of self-focused attention when partaking in social situations, and their attention is focused on negative self-talk and physiology, which detrimentally impacts the conversation and contributes to social anxiety.

Although Clark and Wells (1995) focuses less on external attentional biases, Rapee and Heimberg (1997) suggest that individuals with social anxiety preferentially allocate attention towards threat related external stimuli. For example, Mogg, Philippot and Bradley (2004) had individuals diagnosed with social anxiety and a control group complete a dot-probe paradigm. Participants saw pairs of faces side by side. These pictures would disappear and would reveal either a vertical or horizontal orientation of dots (e.g., ":" or "..") behind one of the images. The participant is told to indicate which orientation the dots are in as quickly as possible. The face pairs included a combination either of angry, neutral, or happy faces paired with a neutral face of the same person. Results suggested that the socially anxious individuals were significantly quicker at detecting the orientation of the dot when they followed angry faces when compared to the other faces and to the control group. These results, along with similar studies, suggest that those with social anxiety preferentially allocated their attention to the threatening stimuli, supporting cognitive theories of social anxiety (e.g., Garner, Mogg, & Bradley, 2006; Gilboa-

Schechtman, Foa, & Amir, 1999; Horley, Williams, Gonsalvez, & Gordon, 2003, 2004; Mogg & Bradley, 2002; Musa, Lepine, Clark, & Ehlers, 2003; Spector, Pecknold, & Libman, 2003).

In summary, considerable research has shown support for cognitive models of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997). Moreover, individuals with social anxiety appear to have a negative self-image (mental representation) that impacts their comparisons to expectations, judgements of consequences, and cognitive, behavioral, and physiological symptoms. In turn, these factors then influence the mental representation. The spiraling nature of this anxiety model is thought to be a function of how well an individual can control attention (Moran, 2016). In other words, an individual who has more control of their attention may be able to avoid the negative processing that maintains the cyclical nature of social anxiety. For this reason, working memory models will be discussed.

Working Memory Perspectives

Working memory is typically thought of as a system with a limited capacity, which involves the retention and manipulation of a limited amount of information in service to more complex mental functions (Baddeley, 2003, 2012; Moran, 2016). Many models of working memory exist, however Baddeley's (2003, 2012) multi-component model is most often cited. Baddeley's (2003) tripartite-model suggests that working memory is made up of two slave subsystems (phonological and visuospatial) and the attentional controller (central executive). The phonological and visuospatial system are thought to encompass storage and rehearsal for their respective information modalities. The phonological loop processes auditory/language/phonologically related information, whereas the visuospatial sketchpad processes visually perceived information. The central executive allocates where attention is located as well as which slave system is given resources. The central executive is generally thought to deal with the processing of information, manipulation, and updating information in short-term memory. Due to critical reviews of the tripartite model of working memory being too vague (Kintsch, 1998) and not incorporating the concepts of meaning or long term memory

(Neath, 2000), Baddeley (2012) expanded the model to include an episodic buffer function. The episodic buffer processes information that includes both phonological and visuospatial components, as well as making the connection between short-term memory and long-term memory.

Baddeley's models of working memory have greatly influenced the understanding of working memory, in addition to having the partitioning of working memory into components being supported by the literature (Brooks, 1968; Coltheart, 1993; Della Sala, Gray, Baddeley, Allamano, & Wilson, 1999; Murray, 1968). For example, Brooks (1968) manipulated the mode by which information can be encoded and responded to. Participants completed two tasks: read a sentence and determine whether each word was a noun or not (verbal mode); and hold the image on an "F" in mind and determine whether each corner was at the extreme top or bottom ends (visuospatial mode). In addition, participants were tasked with responding in both tasks via two modalities: verbally stating yes/no (verbal mode) and pointing to yes/no on a paper (visuospatial). The results suggest that when a task involves processing and responding via the same modality the participant was much slower to respond, whereas when the task was in one modality and the response was in another the participant was much quicker. In other words, the verbal-phonological response interfered with the verbal-phonological task (reading a sentence), but did not interfere with the visuospatial task (determine the corners on an "F"). Similarly, the visual/spatial response interfered with the visuospatial task, but did not interfere with the verbal-phonological task. These results suggest that loading the task with either just phonological or just visuospatial components interferes with the processing of information and responding because that underlying working memory component is taxed. When separating the task's nature from the responses nature, there was not interference. Therefore, phonological and visuospatial processing appear to be separate functions within working memory.

Although Baddeley's (2003, 2012) model of working memory has been the dominant theory, a number of other models of working memory have been proposed. An early theory by

Atkinson and Shiffrin (1968) proposed the Modal Model of working memory in which the attention and memory systems could be broken into three portions: sensory memory, short-term memory, and long-term memory, but failed to gain the attention that Baddeley's model received. Cowan's (1999) embedded-processes model of working memory proposes that attention and its limited capacity are the functions of working memory. This model focuses more on attention in general and how various sets of information (long-term memory, relevant information, irrelevant information) become the focus. In addition, Postle and Pasternak (2009) proposed a state model of working memory, in which there are different states of memory (e.g., long term and short term). Through this model, working memory is thought to be a flexible perception and representation of sensation and incoming information we perceive. Thus, whatever information we devote our attention towards is considered in working memory (Postle & Pasternak, 2009).

Generally, regardless of the component types or different functions involved in working memory models, most models agree that working memory has a limited capacity (Atkinson & Shiffrin, 1968; Baddeley, 2003, 2012; Cowan, 1999; Postle & Pasternak, 2009). For example, Lange et al. (2016) had participants complete the Wisconsin Card Sorting Task, in which participants sort series of cards according to rules that periodically change (e.g., stacking by color, stacking by shape), while manipulating the number of rules from 3 to 4. Increasing the number of rules was done to increase the amount of information in working memory, thus loading the working memory system. Results showed that participants performed worse when their working memory was more loaded. Research has constantly shown performance deficits while working memory is loaded (Lavie, 1995; Lavie, 2005; Lavie & Tsal, 1994). Due to the limited capacity of working memory, it is clear that when working memory is loaded down with one task, there are less resources to complete another task.

In order to better understand the limited capacity of working memory, it is imperative to evaluate the specific functions within the executive function. A latent variable analysis by Miyake et al. (2000) discovered three executive functions: Inhibition, Shifting, and Updating. According to Miyake et al. (2000), shifting is the ability to shift back and forth between various tasks; inhibition is the ability to inhibit automatic responses or disruption from task-irrelevant stimuli; updating is the ability to update and monitor what is currently in working memory. To understand how anxiety is related to working memory and executive control, the attentional control theory (Eysenck et al., 2007), one of the most researched theories in this field, will be elaborated.

Attentional Control Theory

Working memory in relation to anxiety has been extensively studied over the past couple of decades (see Moran, 2016, for a review). For example, MacLeod and Donnellan (1993) had individuals with and without social anxiety complete a grammatical reasoning task to measure working memory ability. Participants were shown strings of digits and were told to rehearse the digits in their head. While continuing to rehearse the digits, participants were shown a pair of letters and a corresponding sentence, in which participants had to judge whether the sentence about the letters was true or false. Results showed that the socially anxious group had a more difficult time stating whether the sentence was true or not, compared to both non-socially threatening words and the control group. These results indicate that those individuals with social anxiety had a more difficult time with a task involving working memory. Similar studies also have found that individuals with social anxiety have difficulty performing cognitive tasks (e.g., Ansari & Derakshan, 2011; Derakshan, Ansari, Hansard, Shoker & Eysenck, 2009; Mattia, Heimberg, & Hope, 1993; see Derakshan & Eysenck, 2009 for a review). The cognitive models of social anxiety and working memory models alone do little to explain why socially anxious individuals cannot cognitively perform as well as normal control in these situations.

Eysenck, Derakshan, Santos, and Calvo (2007) developed attentional control theory that helps explicate why and how social anxiety influences cognitive activity. Attentional control theory, established from the processing efficiency theory (Eysenck & Calvo, 1992), suggests that working memory has a limited capacity, and the main working memory function that is affected by anxiety is the executive function or central executive. A main concept of the attentional control theory is the relationship between top-down (executive controlled) and bottom-up (stimulus controlled) attention. This perspective proposes that anxiety increases bottom-up processing, thus decreasing top-down processing, such that those with anxiety will show deficits in tasks that involve top-down processing. This is argued to be the cause for the common finding that social anxiety leads to poorer performance in tasks (e.g., Pacheco-Ungietti, Acosta, Callejas, & Lupianez, 2010; Wieser, Paula, & Mühlberger, 2009). In an early evaluation of these predictions, Rapee (1993) found that, in relation to Baddeley's (2003) working memory model, some effects are found in the phonological loop, but most of the effects are found in the central executive. Eysenck et al., (2007) suggests that worry is the key disruptive factor for anxiety, thus when an individual is devoting attentional resources towards worrying, there are less attentional resources to be devoted to other tasks (e.g., Stroop Task). Pacheco-Unguetti, Acost, Callejas, and Lupianez (2010) had participants complete an attention network task, which measures the executive control network, and found that trait levels of anxiety were associated with deficits in executive functioning, whereas state anxiety did not show those deficits. These results support the attentional control theory, such that pathological anxiety, typically seen in generalized anxiety and social anxiety, is more closely related to executive control deficits compared to simply inducing state anxiety.

The hallmark principle of the attentional control theory is the differentiation between effectiveness (i.e., task performance) and efficiency (i.e., the relationship between effectiveness and how much effort was used for that task performance). Generally, the more effort put forth in a task, the lower the efficiency. Some research shows deficits in task performance for social anxiety (e.g., Pacheco-Ungietti, Acosta, Callejas, & Lupianez, 2010; Wieser, Paula, & Mühlberger, 2009), whereas others do not (e.g., Derakshan & Eysenck, 1998; MacLeod & Donnellan, 1993). The attentional control theory suggests that where there is not a deficit in effectiveness (performance), there may be a deficit in efficiency. In other words, it is possible that someone who is socially anxious will perform well (high effectiveness) even though they may be directing more attentional resources towards threat related tasks, because they may by using additional resources (low efficiency) to perform as well as others. When performance is not effected in a task, efficiency may be. Someone who has anxiety may do as well as an individual will no anxiety in a working memory task, however they may be using more resources to do just as well, therefore having low efficiency. This idea has been supported in a number of studies. For example, Ansari and Derakshan (2011a) split 32 undergraduate participants into high and low social anxiety groups and had each group complete a mixed anti-saccade task while collecting electroencephalography. In this paradigm, the participant was shown a fixation point (e.g., "+") and then a target stimulus (e.g., a black oval) to the left or right periphery. The participant is asked to look away from the target stimulus and direct attention towards the mirror image spot on the opposite side of the screen. The correct response (looking away from the stimuli) requires that the individual inhibit (control their attention) making a reflexive saccade towards the target stimulus as well as making a voluntary motor movement of the eyes towards the mirror image spot (Munoz & Everling, 2004). A typical variation of the anti-saccade task, that was used in this study, is the mixed anti-saccade task, in which the individual is asked to look away from some stimuli (anti-saccade) and look towards some stimuli (pro-saccade) using simple prompts (e.g., "towards" or "away") before the start of each stimuli presentation (e.g., Ansari, Derakshan, & Richards, 2008; Cornwell, Mueller, Kaplan, Grillon, & Ernst, 2012).

Contingent negative variation, which is brain activity collected by the electroencephalography and is thought to be a measure of the amount of resources utilized to respond to the upcoming stimuli was collected in this study. The CNV was used to measure the level of cognitive effort put forth in the task. Results found that there was little difference between high and low anxious individuals for performance (error rates), but those in the high anxiety group showed greater contingent negative variation, indicating higher cognitive effort to complete the task. Similar results illustrating deficits in efficiency have been found in a number of studies (e.g., Fales et al., 2008; Hadwin, Brogan, & Stevenson, 2005; Judah et al., 2013;

Richards, French, Keogh, & Carter, 2000; Smith, Bellamy, Collins, & Newell, 2001; see Derakshan & Eysenck, 2009 for a review). Research involving the attentional control theory has focused primarily on two functions that seem to be influenced by anxiety (i.e., shifting and inhibition). It is thought that the updating function primarily involves memory as opposed to attention, and therefore is less affected by anxiety and less relevant to attentional research (Derakshan & Eysenck, 2009).

Shifting

Shifting is thought to be the fluency and ability to shift attention between multiple sources of information (Miyake et al., 2000). It takes cognitive resources to shift between two tasks, thus individuals with anxiety disorders, who persistently worry, will have diminished attentional resources to shift attention. Tasks that involve the shifting of attention or processing between multiple sources loads highly on the shifting component. Paradigms that involve task-switching typically involve two conditions. The participant completes the same two tasks in both conditions; however in one condition the participant must switch between the two tasks rapidly, whereas the other condition completes each task separately in a sequential order. Switching tasks rapidly in thought to use more attentional resources (Derakshan & Eysenck, 2009).

A study by Ansari, Derakshan, and Richards (2008) investigated how anxiety affects the shifting function. Participants completed a mixed anti-saccade task, in which they alternated between looking towards a stimulus (task 1) and looking away from a stimulus (task 2). It is typically shown that when individuals switch from an anti-saccade trial to a pro-saccade trial their performance increases (i.e., they are faster at completing the pro-saccade) compared to when the participant completes multiple pro-saccades trials in a row. This effect is called the "switching benefit" (Cherkasova, Manoach, Intriligator, & Barton, 2002). Nieuwenhuis, Broerse, Nielen, and Jong (2004) suggest that this finding is due to failures in the consistency of focused attention. Ansari, Derakshan, and Richards (2008) had individuals with high and low anxiety complete a mixed anti-saccade task and found that the low anxious group showed the typical switching benefit, whereas the high anxiety group did not show a switching benefit. These results suggest that anxiety impairs the ability to shift effectively between tasks. Similar studies have corroborated these findings (Derakshan, Smyth, & Eysenck, 2009; Judah et al., 2013).

Inhibition

Derakshan and Eysenck (2009) suggests that the inhibition function requires the use of attentional control to regulate attention and responses in the face of distracting stimuli, as well as maintaining task relevant attention and behavior. It takes mental energy and resources to maintain attention towards the task at hand, ignore irrelevant information, and control responses to task irrelevant behavior, and only respond to task relevant stimuli. The ability to do these functions can be understood through the race model proposed by Logan and Cowan (1984). Logan and Cowan (1984) suggest that a “go” process, which tell the body to respond to a stimulus, is in competition with the “stopping” process, which tells the body to inhibit a response.

Logan and Cowan (1984) use a stop-signal task to illustrate and support their theory. Participants are shown a series of visual stimuli and told to respond (e.g., press a button) as fast as they can to a specific stimulus (go-signal). A portion of the go-signal trials will have an auditory sound (e.g., "beep"; stop-signal) after the stimuli presentation, which indicates to the participant that they should withhold from responding to the stimuli. The time between the go-signal and stop-signal (Stop-signal delay) typically varies. If the stop-signal delay is short, then it is easier and more likely that a response will be inhibited. If the stop-signal delay is long, then it is difficult and more unlikely that a response will be inhibited. As the task proceeds, the stop-signal delay increases in time when the participant is able to inhibit a response. If the participant is unable to inhibit the response, then the stop-signal delay decreases. By doing this, the paradigm determines the participant’s stop signal reaction time, which is the average amount of time required for the participant to inhibit a response after hearing the stop signal (Weinback, Kalalthroff, Avnit, & Henik, 2015). Logan, Cowan and Davis (1994) and Logan and Cowan (1984) used their race-horse model of inhibition to explain that individuals with poor inhibition in the stop-signal task (i.e., longer stop-signal reaction time) have slower inhibition processes, which lead to the longer time necessary to stop or inhibit a "go-process" (Band, van Boxtel, & Logan, 2003).

Ansari and Derakshan (2010) suggest that some inhibitory responses in the literature are made up of two separable functions: Inhibitory control and volitional action control. Inhibitory control is the ability to stop an ongoing process or a prepotent response. Volitional action control is the ability to engage and follow through with an alternative response. This distinction is necessary for tasks that involve both the inhibition of a proponent response and the engagement of an alternative response (i.e., an anti-saccade task). Research by Ansari and Derakshan (2010) using a delayed-mixed anti-saccade task, a variation of the anti-saccade in which participants are shown a traditional anti-saccade task; however, participants are told to not make a saccade (look towards or away the stimuli depending on the trial rules) until they hear an audible beep. Ansari and Derakshan (2010) suggest that controlling reflexive saccades initially after the stimuli presentation is a measure of inhibitory attentional control, whereas the ability to make the correct saccade movements after the audible beep is a measure of volition action control (the engagement in a correct response). Results showed that individuals with social anxiety did not have a problem directing their saccade after the beep, but did show impairments in the ability to control reflexive saccades. These findings corroborate additional research suggesting that anxiety impairs the inhibitory control function and not the volitional action control function associated with inhibition (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Biship, 2009; Calvo, & Eysneck, 1996; Garner, Ainsworth, Guold, Gardner, & Baldwin, 2009; Moran & Moser, 2015; Pacheco-Ungietti, Lupianez, & Acosta, 2009).

Inhibition Tasks

Various research paradigms have been used to determine how anxiety affects inhibitory processes. A commonly used task is the emotional Stroop task, derived from the color stroop task (MacLeod, 1991; MacLeod & MacDonald, 2000). In Emotional-Stroop, tasks participants are shown emotional related written words (e.g., blushing, failure, inadequate) that are printed in numerous colors, while the participant is told to name the color of the word. Slower or error responses suggest that the content of the word has grabbed the participant's attention away from the task of naming the color (Ledley, & Heimberg, 2006). If the participant's attention is drawn to the contextual meaning of the word, that participant is thought to have had a failure in the inhibition of task irrelevant stimuli. One study by Mattia, Heimberg, and Hope (1993) measured the response latencies for color naming for both individuals with social anxiety and matched controls. The stimuli were made up of social threatening, physical threatening, and neutral words in various colors. Results showed that the socially anxious group had longer latencies for all word groups compared to the matched controls; however, the socially threatening words showed the longest latencies for those in the socially anxious group. These finding suggest that individuals with social anxiety have a difficult time inhibiting task irrelevant stimuli in general, but have increased difficulty when that stimuli are threat related. These findings have been corroborated by additional research (Askew, Hagel, & Morgan, 2015; Grant & Beck, 2006; Hope, Rapee, Heimberg, & Dombeck, 1990; Maidenburg, Chen, Craske, Bohn, & Bystritsky, 1996; Masiam, McNeil, Cohn, & Hope, 1999; McNeil et al., 1995; Price, Siegle, & Mohlman, 2012; Rutherford, MacLeod, & Campbell, 2004), including for individuals who are simply shy (DiPino & Riskind, 2000). It is thought that because individuals with anxiety are allocating increased attentional resources towards the meaning of the threatening words, they have less attentional resources to allocate towards the task of naming the color, leading to an inhibition failure (Reinholdt-Dunne, Mogg, & Bradley, 2009; Williams, Mathews, & MacLeod, 1996; Yiend, 2010).

Another common task used to measure inhibition deficits within anxiety is an anti-saccade task, as it measures the ability to control attention using eye-movements. For example, Derakshan, Ansari, Hansard, Shoker, and Eysenck (2009) used a pair of studies to investigate anxiety's relationship to the anti-saccade task. In the first study, participants high and low in anxiety completed a traditional mixed-anti-saccade task, in which the target stimuli was an oval dot. Results showed that the high anxiety group had longer latencies during the anti-saccade trials compared to the low anxiety group, indicating anxiety is characterized by difficulties with inhibition of a prepotent response. In the second study, Derakshan and colleagues (2009) used various facial expressions (angry, happy, and neutral) as the target stimuli to test how threat-related stimuli affects inhibition. Results found that, again, the high anxiety group had longer latencies during the anti-saccade trials compared to individuals with low anxiety, but in addition the anxious group showed even slower latencies in anti-saccade trials for the threat related stimuli. This, along with similar studies, suggests that individuals with anxiety have difficulty with inhibition during the anti-saccade task (Ansari, Derakshan, & Richards, 2008; Cornwell, Mueller, Kaplan, Grillon, & Ernst, 2012; Garner, Ainsworth, Guold, Gardner, & Baldwin, 2009; Reinholdt-Dunne, Mogg, Benson, Bradley, Hardin, Liversedge et al., 2012; Wright, Dobson, & Sears, 2012), and this effects is exacerbated by threat related stimuli (Chen, Clarke, Watson, Macleod, & Guaastella, 2014; Chen, Clarke, Watson, Macleod, & Guaastella, 2015). These results are also shown when specifically looking at social anxiety (Ansari & Derakshan, 2010; Chen, Clarke, Watson, Macleod, & Guaastella, 2015; Judah et al., 2013; Wieser, Pauli, & Mühlberger, 2009).

An interesting feature of using the anti-saccade task is the ability to measure both the effectiveness and efficiency functions of the Attentional Control Theory (Eysenck et al., 2007). Error rates are thought to be a measurement of task performance (effectiveness), whereas latency of anti-saccades are thought to be a measure of how much effort it took to look away (efficiency) (Ansari & Derakshan, 2011a; Ansari & Derakshan, 2011b; Derakshan et al., 2009). Some research shows that anxiety impacts the effectiveness of inhibition tasks (Ansari, & Derakshan, 2010; Garner, Ainsworth, Guold, Gardner, & Baldwin, 2009; Wieser, Pauli, & Mühlberger, 2009), whereas others only find deficits in efficiency (Ansari, Derakshan, & Richards, 2008; Chen, Clarke, Watson, Macleod, & Guaastella, 2015; Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Reinholdt-Dunne, Mogg, Benson, Bradley, Hardin, Liversedge et al., 2012).

Regardless of the type of impairment, it is clear that anxiety detrimentally impacts the ability to control inhibition during an anti-saccade task.

Another task commonly used to measure inhibition is the stop-signal task, which measures the ability to stop a process that already has been initiated (Logan, 1994; Logan & Cowan, 1984). Logan, Cowan and Davis (1994) and Logan and Cowan (1984) used their race-horse model of inhibition to explain that individuals with poor inhibition in the stop-signal task (i.e., longer stop-signal reaction time) have slower inhibition processes, which lead to the longer time necessary to stop a "go-process" (Band, van Boxtel, & Logan, 2003). A meta-analysis by Lipszyc and Schachar (2010) compiled all studies up to 2009 that measured inhibition using a stop-signal task which also measured whether psychopathology affected performance. Results showed that attention deficit hyperactivity disorder, obsessive compulsive disorder, and schizophrenia showed impaired inhibition; however, anxiety showed no deficit. These results seem to contradict theories of anxiety. However, one study by Savostyanov et al. (2009) used a stop-signal task to measure the neural desynchronization (the overall changes in rhythmic nature of brain waves) associated with inhibition in the stop signal task. These results suggest that anxiety may not affect performance (effectiveness) but does affect how efficient (efficiency) the individual is at inhibiting a response, which supports the attentional control theory (Eysenck et al., 2007).

A concern with using stop-signal task research is the reliance on the stop-signal reaction time as a measure of inhibition ability. There are a number of factors that affect stop-signal reaction time that are typically unmentioned in published articles, such as the process of extracting the stop-signal reaction time without controlling for differences in mean reaction time and slowed performance to ensure accuracy (Alderson, Rapport, & Kofler, 2007; Logan, Schachar, & Tannock, 1997).

Another Commonly used task to measure inhibition is the Go/No-go task (Logan, & Cowan, 1984). In the Go/No-go task, participants' inhibition ability is measured by presenting a frequent amount of trials that require a response ("go"-trials; e.g., pressing a button) in addition to a more infrequent number of trials that require the participant to resist making a response ("no-go"-trials; e.g., inhibit pressing a button) (Grillon, Robinson, Krimsky, O'Connell, Alvarez, & Ernst, 2016; Bari & Robbins, 2013). The high frequency of go-trials creates a prepotent go-response to press the button. When the no-go stimuli appear (the stimuli that requires no response), the individual must inhibit the prepotent response to press the button. The ability to inhibit a response to the infrequent no-go stimuli is a measure of the individual's inhibition (Grillon, Robinson, Krimsky, O'Connell, Alvarez, & Ernst, 2016; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997; Wilson, Flinkbeiner, de Joux, Russel, & Helton, 2016). The failure to inhibit the prepotent response during a no-go trial (commission error) has been related to two functions: the lapse of attention to the task due to distracting thoughts (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) and a failure in the inhibition of the prepotent response (Head & Helton, 2013; Peebles & Bothell, 2004). Taken together, these two hypotheses suggest that if the participant is able to maintain attention to the task, the errors measured in the study are a true representation of a failure to inhibit a prepotent response (Grillon, Robinson, Krimsky, O'Connell, Alvarez, & Ernst, 2016; Head & Helton, 2013).

A variation of the Go/No-go task is the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). In this task, participants are shown stimuli, some which require a response and some which require the inhibition of a response, just as the Go/No-go task; however, there are typically a smaller ratio of no-go trails. The less no-go trials lead to an even more persistent prepotent go-response to press the button compared to the traditional Go/No-go task (Peebles & Bothell, 2004; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). In addition to the difference in the ratio of go to no-go trials, the SART typically uses 9 numbers (1-9) as the response buttons. Participants are shown a series of numbers and are told to press the button that corresponds to the number on the screen (go-trials), but are told to not respond to one number (no-go-trials; traditionally the "3"). In general, both the Go/No-go task and the SART are used to measure inhibition.

Although the Go/No-go task appears to be a useful measure of behavioral inhibition, it is infrequently used in the anxiety literature. A meta-analysis by Wright, Lipszyc, Dupuis, Thayapararjah, and Schachar (2014) compiled 318 studies that covered 11 different psychological disorders using the Go/No-go task, and found that anxiety disorders constantly showed deficits in the ability to inhibit the go-response. These findings, in addition to other studies (e.g., Grillon, Robinson, Krimsky, O'Connell, Alvarez, & Ernst, 2016), suggest that anxiety impairs inhibition. However, other studies have failed to find behavioral deficits but did find that individuals with anxiety have to compensate (e.g., more neural activity, longer response latency) more to perform as well as controls (Righi, Mecacci, & Viggiano, 2009). In lieu of these contradictory findings, it is important to gain more precise measures and comparisons of the behavioral data (performance) and the effort it takes to complete these tasks (effectiveness). Although considerable research has used behavioral inhibition tasks to determine possible neural deficits in anxiety, these studies do not offer a clear representation of the neural activity underlying task performance and efficiency.

Psychophysiological (Event Related Potentials)

Using electroencephalography (EEG) offers a valuable insight to neural responses (Luck, 2012), especially in relation to social anxiety (Judah et al., 2013; Moser, Hajcak, Huppert, Foa, & Simons, 2008). EEG is the collection of electrical potentials (voltage) from the brain that are measured using electrodes on the scalp. To obtain Event related potentials (ERP's) from the EEG, the EEG waveform must be segmented. These segments (epochs) are time locked in relation to an event marker in the data file. The ERP segments represent neural activity associated with that event and internal (neural) and external (environmental) noise. The same epoched segments of ERP activity (segments related to the same event) are then averaged to eliminate random error, thus leaving the average brain activity in relation to that event (Luck, 2007, 2012, 2014). Therefore, ERP's are an average of segmented portions of an overall EEG waveform that are time locked (epoched) to a specific event (e.g., stimuli onset, behavioral response). That is, ERP's are the average electrical potentials produced by the brain in relation to specific events. The non-invasiveness and high level of temporal resolution has led to ERP's as being immensely useful measures of neural activity (Luck, 2012, 2014; Luck, Woodman, & Vogel, 2000; Woodman, 2010). Research using ERP's suggests that ERP's are sensitive and influenced by different levels of trait anxiety (e.g., Meyer, Hajcak, Torpey-Newman, Kujawa, & Klein, 2015; Owens, Derakshan, & Richards, 2015; Savostyanov, Tsai, Liou, Levin, Lee, Vurganov, & Knyazev, 2009) and social anxiety (e.g., Ansari & Derakshan, 2011a, 2011b; Judah et al., 2013; Moser, Hajcak, Huppert, Foa, & Simons, 2008; Righi, Mecacci, & Viggiano, 2009).

Although consistent research shows that trait anxiety is related to different neural activity (e.g., ERP's) compared to non-anxious controls, the direction (increase or decrease) of activity has been less consistent (Berggren & Derakshan, 2013). Berggren and Derakshan (2013) suggest that task motivation, cognitive load, and task demands influence the direction of neural activity. Being highly motivated during a task puts an additional load on working memory, thus to complete the task effectively more cognitive resources may be allocated to compensate. An individual with social anxiety may be additionally motivated during a task as they may be anxious about being negatively evaluated during the task, thus leading to increased neural activity (Berggren & Derakshan, 2013; Eysenck & Derakshan, 2011). Cognitive load, as suggested throughout this review, affects task performance such that higher levels of cognitive load lead to diminished cognitive resources to complete the task, which may lead to diminished neural activity related to the task at hand. In relation to physiological symptoms of anxiety, worrying thoughts or focusing on threat related stimuli may serve as a cognitive load, thus leaving less resources to allocate to the task, leading to decreased neural activity towards the task. In addition, the difficulty of the task also may affect neural activity such that less cognitively demanding tasks (single-task paradigms) show less compensatory cognitive recruitment (Bishop, 2009; Ansari and Derakshan, 2011b), whereas more demanding tasks (dual-task paradigms) show more levels of compensation (Ansari and Derakshan, 2011b; Basten, Stelzel, & Fiebach, 2011). Overall, these findings suggest that motivation, cognitive load (e.g., threating stimuli), and task demands are possible moderators to neural activity, specifically in relation to anxiety related neural functioning. Two specific neural components (ERP's) that are related to this project are the N2 and P3.

N2

The N2 is negative going ERP waveform that typically peaks around 200-350 ms after the presentation of the target stimulus. Reports of the N2 stemmed from early research involving Oddball paradigms (Luck, 2014). In the classic Oddball paradigm, participants are shown sequences of frequent stimuli ("X's") with infrequent stimuli ("O's") intermittently displayed in the sequence. Participants develop a typical waveform during the frequent trials, but show an N2 with a larger amplitude when the stimulus is infrequent, thus the N2 was thought to be affected by frequency of stimuli (Folstein, & Van Petten, 2008; Luck, 2014; Näätänen, & Picton, 1986). In addition, early research suggested that the traditional N2 can be broken into three parts: N2a, N2b, and N2c (Luck, 2012, 2014; Pritchard, Shappel, & Brandt, 1991). Luck (2012, 2014) suggests that the N2a is elicited during auditory mismatches, also coined the Mis-Matched Negativity, and occurs at an earlier time (100-200 ms). The N2b and N2c have been shown to be elicited when a deviant stimulus is presented and is task relevant. The N2b name was given to the N2 waveform that appeared over central sites for auditory stimuli, whereas the N2c name was given to the N2 waveform that appeared over posterior cites for visual stimuli (Luck, 2014; Renault, Ragot, Lesevre, & Redmond, 1982). Research using inhibition tasks (i.e., the Go/No-go and stop signal task) shows that the N2 is generally larger for the trials in which inhibition is necessary, which suggests that the N2 can be used as a measurement of attentional resources allocated to the task of inhibiting a prepotent response (Luck, 2014; Jodo & Kayama, 1992).

Researchers have begun to investigate how anxiety affects the N2, in which many of the studies use inhibition related tasks. Sehlmeyer, Konrad, Zwitserlood, Arolt, Falkenstein, and

Beste (2010) had individuals report their level of trait anxiety and complete a Go/No-go task while having EEG measurements collected. They were interested in whether anxiety affected how the individual neurally responded (N2) to the No-go stimuli. Results showed that trait anxiety was related to higher amplitude N2's, such that increased trait anxiety led to increased N2 amplitude. These results, in addition to similar studies (Henderson, 2010; Hum, Manassis, & Lewis, 2013; Owens, Derakshan, & Richards, 2015; Righi, Mecacci, & Viggiano, 2009; Wauthia & Rossignol, 2016) support the attentional control theory, in that individuals use more attentional resources (cognitive effort) to complete a task with the same performance as individuals without anxiety.

P3

The P3 is positive going ERP waveform that typically peaks around 250-500 ms. after the presentation of the target stimulus. Early research on the P3 suggests that it is made up of a couple of distinct components (Luck, 2014; Polich, 2012; Squires, Squires, & Hillyard, 1975). Researchers have broken the P3 into the P3a, which appears in the frontal region, and the P3b, which appears in the parietal region (Squires, Squires, & Hillyard, 1975). Generally, both the P3a and P3b are elicited by unpredictable and infrequent changes in stimuli; however, when researcher discuss the P3 they generally are referring to the P3b (Luck, 2012, 2014). Research finds that the P3 is affected by the probability of stimuli, thus the more infrequent a stimulus type, the larger the P3 associated with that stimulus (Duncan-Johnson, & Donchin, 1977; Luck, 2012, 2014; Pritchard, 1981). More importantly, many researchers suggest that the P3 is a measure of resource allocation used in processing the stimulus (e.g., Isreal, Chesney, Wickens, & Donchin, 1980; Luck, 2012, 2014). For example, Isreal et al. (1980) found that when individuals devote more attentional resources to a task, the P3 was larger. Similar to the N2, researchers have begun to investigate how the P3 is affected by anxiety.

Generally, studies that measure the N2 also measure the P3. For example, Sehlmeyer et al. (2010), who used a Go/No-go task while having EEG measurements collected was, also interested in how the individual's P3 was related to the No-go stimuli for individuals with anxiety. They found that the P3 amplitude was impacted by anxiety; however, to a lesser degree than the N2. Specifically, as trait anxiety increased, the amplitude of the P3 increased. These results suggest that individuals with anxiety may devote more resources to inhibit the stimuli compared to individuals without anxiety. Similar studies also have found that anxiety influences the P3 waveform (Judah et al., 2013; Moser, Huppert, Duval, & Simons, 2008; Wauthia & Rossignol, 2016).

Current Study and Hypothesis

Overall, the current models of social anxiety and the state of research suggests that individuals with high social anxiety have disproportional levels of negative self-imagery and that this imagery acts as a maintaining factor for their social anxiety (e.g., Blasi, Cavani, Pavia, Baido, Grutta & Schimmenti, 2015; Clark & Wells, 1995; Moscovitch, Gavric, Merrifield, Bielak, & Moscovitch, 2011; Rapee & Heimberg, 1997). Due to the attentional bias towards threat related information shown in social anxiety (e.g., Garner, Mogg, & Bradley, 2006; Gilboa-Schechtman, Foa, & Amir, 1999; Hope & Heimberg, 1988; Horley, Williams, Gonsalvez, & Gordon, 2003, 2004; Mellings and Alden, 2000; Mogg & Bradley, 2002; Monfries & Kafer, 1994; Saboonchi & Lundh, 1997; Musa, Lepine, Clark, & Ehlers, 2003; Spector, Pecknold, & Libman, 2003), it was proposed that holding a negative self-image would lead to internal self-focus for those with social anxiety. Research suggests that increased self-focused attention serves as a cognitive load and leads to decreases in the available resources (e.g., Clark & Wells, 1995; Judah et al., 2013; Rapee & Heimberg, 1997). This decrease in cognitive resources presents itself in research paradigms as enhanced neural compensatory recruitment towards tasks that involve the executive function; however, when threat information is incorporated in the task, there appears to a decrease in neural activity, due to the attentional biases towards threat (e.g., Judah et al., 2013; Sehlmeyer et al., 2010).

The current study aimed investigate how manipulating cognitive load and threat focus affects the effectiveness and efficiency of an inhibition. Specifically, self-imagery was manipulated to impose differing levels of cognitive load. Research suggests that individuals with social anxiety tend to focus on threatening information, thus inducing a negative self-image would serve a higher cognitive load for those with social anxiety compared to a neutral and positive self-image (e.g., Hirsch & Clark, 2004; Hirsch, Clark, Mathews, & Williams, 2003). Due to cognitive resources having a limited capacity (Baddeley, 2003, 2012; Eysenck et al., 2007), loading the executive function of individuals with social anxiety, which was expected to result in a decreased amount of resources available to complete the task. To measure the effects of social anxiety and self-imagery, both behavioral (error rates, response latency) and psychophysiological (neural activation) measures was collected to distinguish whether the effects are shown in effectiveness and/or efficiency. Since inhibition is shown to be one of the working memory factors that that is most affected by anxiety, a Go/No-go task was used to (Ansari & Derakshan, 2010; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Biship, 2009; Calvo & Eysneck, 1996).

It was hypothesized that individuals with high and low levels of social anxiety would show similar performance (error rates) in the Go/No-go task; however, the individuals with high social anxiety would show hindered efficiency in the Go/No-go task displayed by 1) longer inhibition response latencies to the to-be-inhibited stimuli, 2) enhanced levels of neural activity (N2, P3) to inhibit a response. In addition, when manipulating self-imagery, individuals with social anxiety would display overall decreases in neural activity to the task compared to the neutral and positive self-images as well as compared to the individuals with low social anxiety, due to threat focusing decreasing neural recruitment. This study was hypothesized to provide support the attentional control theory (Eysenck et al., 2007) and cognitive models (Clark & Wells, 1995; Rapee & Heimberg, 1997), in addition to facilitating the understanding of how influential self-imagery is to social anxiety.

CHAPTER III

METHODOLOGY

Participants

Participants were recruited from the undergraduate student population at a Midwestern university (Oklahoma State University) via an online recruitment system (SONA) and received course credit for participation. Participants initially completed a short form of the Social Interaction Anxiety Scale (SIAS-6; Mattick & Clarke, 1989) as a pre-screener via the online recruitment system. Using an extreme groups approach, those individuals who scored within the group cut-off were recruited into the study ($\leq$ 4 or $\geq$ 7). Participants that met inclusion criteria and agreed to participate completed the SIAS-sf, along with additional measures, to divide the sample into social anxiety groups. Based on previous research (e.g., Judah, Grant, & Carlisle, 2016; Judah et al., 2013), participants were split using cutoffs based on the original standardized sample mean (M = 16.30) and standard deviation (SD = 12.48; Mattick & Clarke, 1989; Rodebaugh et al., 2011). Participants who scored one standard deviation above the standardized mean were placed in the high social anxiety group, and those who scored at or below the standardized mean made up the low social anxiety group. An *a priori* power analysis (Cohen, 1988) using the effect sizes found in previous studies ($\eta 2$ = .14-.17; Judah et al., 2016; Judah et al., 2013) suggested a total of 8-12 to achieve adequate power (β = .80, α = .05). In taking a conservative approach, 48 individual's data were collected. This approach was based on samples used in recent empirical research (Judah et al., 2016; Judah et al., 2013) and in anticipation of potential attrition due to physiological data cleaning and to ensure adequate statistical power.

A total of 69 participants were recruited to participate. Twenty one were excluded due to failure to meet SIAS-sf inclusion criteria leaving a total of 25 individuals in the high and 23 in the low anxiety condition that were included in data analysis. Participants were largely female (69%) and had an average age of 19.08 (*SD* = 1.49). Participant ethnicity consisted of 81.7% Caucasian, 7% African American, 5.6% Latino/a, 1.4% Asian, 1.4% Middle Eastern, and 2.8% reported "Other"

Materials

Social Interaction Anxiety Scale-short form (SIAS-sf; Mattick & Clarke, 1998; Rodebaugh et al, 2011; Rodebaugh, Wood, & Heimberg, 2007). The SIAS-sf is a 17 – item measure of the fear towards social interactions, in which respondents indicate the degree to which statements (e.g., "I get nervous if I have to speak with someone in authority") are characteristic of them on a scale from 0 ("Not at all") to 4 ("Extremely"). Higher scores indicate higher levels of social anxiety. The SIAS has shown adequate internal consistency (Cronbach's $\alpha = .93$; Mattick & Clarke, 1998) which was also shown in the current sample ($\alpha = .93$). (See Appendix B)

Self-imagery Manipulation. Participants were presented with 3 image prompts adapted from Hackman et al. (1998, 2000) to elicit positive, neutral, and negative self-imagery. For the negative self-imagery condition, participants were instructed to recall a time in which they were anxious or embarrassed in a social situation. For the positive self-imagery condition, participants were instructed to recall a time in which they were in a social situation and felt comfortable, calm, and relaxed. For the neutral self-imagery condition, participants were instructed to recall a time in which they were completing a solitary activity and felt relaxed. A neutral self-image condition was used as an additional control based on previous research (Hirsch, Clark, Mathews, Williams, & Morrison, 2006; Ng & Abbott, 2016). If participants were unable to recall a memory of a positive, negative, or neutral event, they were prompted to imagine how they would look and feel if a speech had gone well, gone badly, or if they were watching TV alone, respectively. Once the memory was brought to mind, participants were instructed to close their eyes and visualize this image and report how they felt, appeared, sounded, and how others reacted to them. The participants continued to close their eyes and visualize their self-image to elicit a clear self-image for each situation. The images that were derived from the negative, positive, and neutral image conditions served as the 'negative image', 'positive image', and 'neutral image', respectively. Participants were told to keep the self-image in their mind while completing the task. Each participant completed all three imagery conditions. The order in which participants completed the three imagery conditions was counterbalanced within the anxiety groups. This self-imagery manipulation was derived from previous literature evaluating self-imagery and social anxiety (e.g., Hirsch, Clark, Mathews, & Williams, 2003; Hirsch & Clark, 2004; Hulme et al., 2012; Makkar & Gisham, 2011) and has shown to reliably manipulate self-imagery (e.g., Hirsch, Clark, Mathews, & Williams, 2003; Makkar & Grisham, 2011) with similar valence and vividness between social anxiety groups (Makkar & Grisham, 2011).

Manipulation Check. A self-imagery manipulation check was used based on Ng (2016). Similar manipulation checks have been used in previous studies (e.g., Hirsch, Clark, Mathews, & Williams, 2003; Hirsch, Mathews, Clark, Williams, & Morrison, 2006; Makkar & Gisham, 2011); however, Ng (2016) uses the most comprehensive evaluation of self-imagery. As in Ng (2016), two sets of manipulation checks were used: one directly after each self-image manipulation, and one directly after each Go/No-Go condition. The first manipulation check occured directly after the participant elicited a self-image prior to engaging in the Go/No-go task. It was comprised of six items that were used to assess various aspects of the self-images such as 1) accessibility, 2) vividness, 3) averseness, 4) anxiety-provocation, 5) valence (positive/negative), and 6) strength of the urge to avoid the image. Participants rated each item on an 11-point Likert-type scale from 0 ("not at all") to 10 ("extremely/all the time").

The second set of manipulation checks occured directly after the completion of the Go/No-go task. This manipulation check was comprised of nine-items. The six items from the first manipulation check were re-administered, in addition to 1) how much time they were able to hold the image in their mind during the task, 2) how much of that image was viewed from the observer perspective, and 3) how often the image came to their mind. Participants completed a manipulation check directly after the self-image manipulation and after the Go/No-go task for each of the three self-image manipulations, thus leading to each participant responding to a total of six manipulation checks.

Go/No-go Task. Each participant completed three Go/No-go tasks; one after each self-imagery manipulation. The Go/No-go task was based on the paradigm used in Righi, Mecacci and Viggiano (2009). Participants were seated 70 cm from a computer monitor, which displayed the task. Participants completed a 20-trial practice period with response feedback to ensure they understood the task with a proportion of 50% no-go trials. The task consisted of a fixation cross "+" for an average of 900 ms (range = 700 – 1100 ms) followed by a digit (i.e., 1, 2 or 3) for 250 ms (see Figure 1). Participants were tasked with responding as quickly as possible when certain stimuli appeared (e.g., 1 or 2; go-trials) by pressing a trigger on a game controller, and to inhibit responding when the other stimuli (e.g., 3) appeared (no-go-trials). The meaning (i.e., go or no-go) of each stimulus was counterbalanced across participants. After the digit was presented, a blank screen was shown for 450 ms per recommendations from Luck (2005) to ensure less error in the collection of ERP data. A single trial lasted, on average, 1600 ms. Each Go/No-go task condition consisted of 150 continuous trials (50 of each number; 33% inhibitory trials), leading to a total of 450 trials throughout all three self-imagery conditions. Based on research measuring the psychometric properties of the N2 and P3, 50 trials per imagery-condition was used for a reliable inhibitory response (Clayson & Larson, 2013; Rietdijk, Franken, & Thurik, 2014). Each trial condition took approximately 4 minutes, with a total Go/No-go task time of 12 minutes.

Procedure

Procedures were approved by the University's Institutional Review Board. This procedure was based on Righi, Mecacci, and Viggiano's (2009) study. After informed consent, participants completed the measures online. After completion of the measures, electrodes were attached to measure and record EEG and Electromyography (EMG). The participants completed 20 practice trials of the Go/No-go task. Next, the participant completed the first self-image manipulation and the first set of self-image manipulation checks. Next, the participant completed the first Go/No-go task and then the second set of self-image manipulation checks. The self-image manipulation, manipulation checks, and Go/No-go task procedure occurred two more times for a total of three self-image manipulations and three Go/No-go conditions. After completion of all three self-imagery conditions, participants were debriefed.

Physiological Recordings. Electroencephalography (EEG) data were collected using MP150 hardware from BIOPAC Systems. AcqKnowledge Software was used to record the EEG activity. EEG data were collected using nine electrode channels (F3, FZ, F4, C3, CZ, C4, P3, PZ, P4) at a sampling rate of 250Hz, with a band pass filter of .1 – 35Hz using Electro-Cap international Inc. electrode caps. An electrode placed on the right mastoid served as the reference for all EEG channels for data collection. Offline, all channels were re-referenced to the average of the right and left mastoid (Luck, 2007). EMG (eye-movement) was measured using a silver-chloride electrode placed on the outer canthus of the left and right eye. In addition, blinks were detected using an electrode below the left eye. Electrocardiogram data (EKG) electrodes were placed on the participant's torso using a standard 2-lead configuration (Andreassi, 2007). EKG data were analyzed using QRStool which identified heartbeats and computed the mean heart rate, heart rate variability, and respiratory sinus arrhythmia (Allen, 2002; Allen, Chambers, & Towers, 2007).

EEG data were processed using EEGLAB version 12 (Delorme & Makeig, 2004) and ERPLAB version 3 (Lopez-Calderon & Luck, 2010). The data were filtered offline using a Butterworth low-pass filter with a half-amplitude cutoff of 30Hz and a 12dB role off. EEG activity related to the stimuli was marked using digital TTL signals generated by the computer which presented the stimuli. The stimulus epoched EEG activity was epoched 200 ms before and 600 ms after the onset of the stimuli (total: 800 ms). The EEG activity within the 200 ms prior to stimulus onset was used as a baseline for ERP activity. Based on visual inspection of the data and previous research using Go-No/go tasks, the N2 was maximal at the FZ electrode cite and P3 was maximal at CZ (Falkenstein, Hoormann, & Hohnsbain, 1999). Additionally, N2 amplitude and latency was measured in a window of 240 – 320 ms after stimulus presentation whereas the P3 amplitude and latency were measured in a window of 320 – 500 ms after stimulus presentation based on previous literature (Bokura, Yamaguchi, & Kobayashi, 2001; Bruin & Wijers, 2002; Donkers, van Boxtel, 2004; Eimer, 1993; Falkenstein, Hoormann, Hohnsbein, 1999; Nakata, Arakawa, Suzuki, & Nakayama, 2016). Artifact rejection was initially completed using ICA to correct eye artifacts using automatic routines in ERPLAB. No participant had 25 percent or more trials rejected.

Analytic Strategy. The current study used a mixed method design with a between-subject factor of social anxiety (HSA, LSA) and within-subjects factors of self-image (positive, neutral, negative) and task type (go, no-go) and measured multiple outcomes (go/no-go error rates, go/no-go response latency, N2 amplitude, N2 Latency, P3 amplitude, and P3 latency). Therefore, the data were analyzed using a series of repeated measures factorial ANOVA's. Mauchley's test was used to assess sphericity, in which no violations of sphericity were observed. When examining pairwise comparisons, the Bonferroni adjustment was used when necessary to follow up significant interactions.

CHAPTER IV

RESULTS

Manipulation Check

Table 1 provides means and standard deviations for each social anxiety (SA) Group during each Imagery condition for the manipulation checks. A 2 (SA: High, Low) by 3 (Image: Pos, Neg, Neu) MANOVA was conducted for the mental images 1) accessibility, 2) vividness, 3) averseness, 4) anxiety-provocation, 5) valence 6) strength of the urge to avoid, 7) frequency of task-irrelevant thoughts, 8) ability to hold image in mind, and 9) valence of image during the task. There was a significant omnibus test for Imagery Condition, $F(18,29) = 11.388$, $p < .001$, $\eta^2 = .876$, and a marginal effect for SA Group, $F(9,38) = 2.010$, $p = .065$, $\eta^2 = .322$. There was no significant omnibus interaction, $F(18,29) = 1.400$, $p = .204$, $\eta^2 = .465$. Results suggested that the linear combination of the dependent variables significantly predicted image condition and marginally predicted SA group. Follow up analysis with Bonferroni corrections was used to determine which manipulation checks produced significant main effects. Only significant results are reported.

Results of the follow up analysis revealed a main effect of image for the accessibility of the mental images $F(2,92) = 6.003$, $p = .004$, $\eta^2 = .115$. Interpretation of simple effects indicates that the positive image ($M = 8.332$) was easier to access than the negative image ($M = 7.123$). There was a main effect of image for the averseness of the self-image, $F(2,92) = 7.027$, $p = .001$,

$\eta^2 = .133$, in which the negative image ($M = 5.055$) was more aversive than the neutral ($M = 3.812$) and positive ($M = 3.602$). Results indicated a main effect for image on anxiety level, $F(2,92) = 92.615$, $p < .001$, $\eta^2 = .668$, suggesting that the negative image ($M = 6.049$) created more anxiety than the neutral ($M = 1.246$) and positive ($M = 1.517$). There also was a main effect of social anxiety on anxiety level, $F(1,46) = 8.613$, $p = .005$, $\eta^2 = .158$, indicating that the high social anxiety group ($M = 3.613$) had more anxiety compared to the low social anxiety ($M = 2.261$) group across all image conditions. There was a main effect of image for the urge to avoid, $F(2,92) = 25.503$, $p < .001$, $\eta^2 = .357$, suggesting that the negative image ($M = 4.761$) showed a stronger urge to avoid than the neutral ($M = 2.108$) and positive image ($M = 1.693$). Results indicated a main effect of image for valence, $F(2,92) = 33.391$, $p < .001$, $\eta^2 = .421$, suggesting that the negative image ($M = 5.780$) was more negative than the neutral ($M = 3.434$) and positive image ($M = 1.843$). Additionally, the neutral image was more negative than the positive. There was a main effect of image for the valence of the image that was held during the computer task, $F(2,92) = 30.785$, $p < .001$, $\eta^2 = .401$, indicating that the negative image ($M = 5.737$) was more negative than the positive ($M = 2.243$) and neutral ($M = 3.729$). Additionally, the positive image was more positive than the neutral.

Table 1. Means, Standard Deviations, and Tests of Main Effects

	High SA Group *M(SD)*				Low SA Group *M(SD)*			Main effect of SA Group *F(p)*	Main effect of Image Condition *F(p)*
	Negative	Positive	Neutral		Negative	Positive	Neutral		
Accessibility	7.68(2.13)	8.36(2.01)	7.00(2.64)		6.56(2.71)	8.30(1.57)	8.34(1.82)	0.01(.904)	6.00(.004)
Vividness	7.36(2.23)	7.72(2.13)	6.92(2.62)		7.13(2.43)	7.95(1.77)	8.13(1.79)	0.62(.432)	1.67(.193)
Averseness	5.24(2.36)	4.16(3.41)	4.32(3.14)		4.86(2.86)	3.04(3.02)	3.30(3.03)	1.35(.250)	7.02(.003)
Anxiety	6.88(2.22)	2.12(2.87)	1.84(2.01)		5.21(2.95)	0.91(1.62)	0.65(1.22)	8.61(.005)	92.61(< .001)
Valence	5.56(2.20)	1.60(2.36)	2.52(2.48)		6.00(1.59)	2.08(2.85)	3.34(2.69)	0.38(.541)	33.39(< .001)
Urge to Avoid	5.48(2.74)	1.56(2.21)	2.52(3.12)		4.04(2.32)	1.82(2.60)	1.69(2.22)	1.69(.199)	25.50(< .001)
Frequency of Irrelevant Thoughts	3.20(2.72)	2.84(2.73)	3.52(3.07)		2.86(2.39)	3.65(3.14)	3.69(2.91)	0.10(.750)	1.09(.340)
Ability to Hold Image	3.40(2.67)	3.92(3.10)	4.12(1.98)		4.65(2.32)	4.78(2.96)	4.60(3.10)	1.67(.202)	0.57(.562)
Valence of Image During Task	6.04(2.42)	2.40(2.53)	4.24(2.40)		5.43(1.50)	2.08(2.59)	3.21(2.41)	2.17(.147)	30.78(< .001)

In addition, heart rate (HR), heart rate variability, and respiratory sinus arrhythmia were analyzed using a 2 (SA: high, low) x 4 (Image: baseline, pos, neg, neu) mixed-model factorial ANOVA to determine if the manipulation influenced physiological arousal. Due to electrodes falling off and high levels of noise, 3 individuals from the low and 4 from the high group were excluded from these analyses. Results of the HR analysis found a main effect of Image, F (3,117) = 3.981, $p = .010$, η2 = .093. Follow up analyses indicate that the negative image ($M = 78.074$) resulted in a quicker heart rate than the baseline condition ($M = 76.020$, $t(40) = 3.179$, $p = .017$). Results also revealed an interaction, $F(3,117) = 4.222$, $p = .007$, η2 = .098, such that there were no differences within the low social anxiety group; however, within the high social anxiety group the baseline ($M = 75.171$) had a lower heart rate than the negative ($M = 79.311$, $t(40) = 4.589$, $p <$ .000) , the neutral ($M = 78.281$, $t(40) = 3.025$, $p = .004$), and the positive condition ($M = 78.290$, t (40) = 3.262, $p = .002$). Results for HRV and RSA revealed no significant main effects or interactions.

Behavioral Data (Error Rates and Response Latency)

To assess whether the self-imagery manipulation or social anxiety influenced the performance of the Go/No-go task, a 2 (SA: high, low) x 3 (Image: pos, neg, neu) x 2 (Task: go, no-go) mixed-model factorial ANOVA was used for error rates and a 2 (SA: high, low) x 3 (Image: pos, neg, neu) mixed-model factorial ANOVA response latency for correct go trials. For sake of brevity, only significant effects are reported. One participant was excluded from the behavioral data analysis as they produced 100% error rates, suggesting they did not complete the task correctly.

Error rate results showed a main effect of task, $F(1,45) = 73.118$, $p < .000$, $\eta^2 = .619$. These results suggest that the no-go trials ($M = 3.491$; i.e., errors of commission) had more errors than the go trials ($M = .731$; i.e., errors of omission). Moreover, there were no significant interactions; however, there was a marginal interaction between image and task, $F(2,90) = 3.102$,

$p = .050$, $\eta^2 = .064$. Follow up analysis indicated that within the go-trials there were no differences between image conditions, but there was a difference between the Negative (M = 4.10) and Neutral ($M = 3.14$; $t(69) = 2.15$, $p = .034$) and Negative and Positive ($M = 3.21$; $t(69) = 2.15$, $p = .014$) conditions within the no/go-trials.

As for reaction time, results revealed a main effect of social anxiety, $F(1,43) = 10.313$, $p = .003$, $\eta^2 = .193$, indicating that the high social anxiety group (M = 401.152 ms) had a longer reaction time than the low social anxiety group (M = 363.044 ms). No other main effect or interaction was significant.

ERP amplitude (N2 and P3)

To assess whether the self-image manipulation or social anxiety influences neural data, multiple 2 (Task: go, no-go) x 2 (SA: high, low) x 3 (Image: pos, neg, neu) mixed-model factorial ANOVA's were used for each ERP's amplitude at the main electrode sites (N2 at FZ, and P3 at CZ). Only correct trials (i.e., correct go-trials and correct no/go-trials) were used due to the low frequency of error trials. Seven participants were list-wise excluded from the EEG analysis due to extreme scores (i.e., Z-scores > 3.29; Tabachnick and Fidell, 2007), leaving 18 in the low and 24 in the high group.

Results of the N2 revealed no main effects or interactions. Results of the P3 revealed a significant main effect of task, $F(1,40) = 28.940$, $p < .000$, $\eta^2 = .420$, suggesting that no/go trials resulted in a larger P3 ($M = 7.497$) than the go-trials ($M = 3.606$). Results also revealed a main effect of social anxiety, $F(1,40) = 5.177$, $p = .028$, $\eta^2 = .115$, suggesting that the low social anxiety group had a larger P3 ($M = 7.108$) than the high group ($M = 3.996$; see Appendix C). No other main effects or interactions were significant.

ERP Latency (N2 and P3)

To assess whether the self-image manipulation or social anxiety influences the latency of the ERP's, multiple 2 (Task: go, no-go) x 2 (SA: high, low) x 3 (Image: pos, neg, neu) mixed-model factorial ANOVA's were used. Only correct trials (i.e., correct go-trials and correct no/go-trials) were used due to the low frequency of error trials.

Results of the N2 latency revealed no main effects or interactions. Results of the P3 latency revealed a main effect of social anxiety, $F(1,25) = 5.177$, $p = .008$, $\eta^2 = .248$, suggesting that high social anxiety group had a later peak P3 ($M = 403.792$) than the low group ($M = 372.727$). No other main effects or interactions were significant.

CHAPTER V

DISCUSSION

The current study aimed to investigate how manipulations in cognitive load and threat focus influences effectiveness and efficiency within social anxiety. To explore this relationship, participants both high and low in social anxiety completed three self-imagery manipulations and three Go-No/go tasks. Based on predications from the attentional control theory, it was hypothesized that individuals with high social anxiety would show similar effectiveness (i.e., accuracy) as those in the low social anxiety group. Additionally, it was hypothesized that individuals with high social anxiety would show hindered efficiency in the Go/No-go task displayed by 1) longer inhibition response latencies to the to-be-inhibited stimuli, and 2) enhanced levels of neural activity (N2, P3) to inhibit a response. It also was hypothesized that manipulating self-imagery would differentially load working memory and present increased deficits for those with high social anxiety.

Results of the manipulation check suggest that those with high social anxiety were more anxious, in general, as a result of describing their self-images. These results were supported by heart rate data, which indicated that that the individual with high levels of social anxiety showed increased HR compared to the baseline, which was not seen in the low anxious group. Additionally, the negative self-image manipulation was indeed more aversive, negative, anxiety provoking, and held a greater urge to avoid. The negative self-image also remained more negative than the other conditions through the Go-No/go task. These results suggest that the negative self-image manipulation increased anxiety and was more negative than the other conditions as expected; however, the manipulation did not appear to differentially impact those with low and high levels of social anxiety. This is contrary to similar research on self-imagery within social anxiety. For example, Hirsch and colleagues (2003) found that negative self-imagery often resulted in increased anxiety for those with social anxiety. It is possible that the negative imagery manipulation did not induce expected levels of anxiety or were not specific to enough to idiographic social anxiety. Specifically, the negative imagery manipulation may not have resulted in the typical level of anxiety experienced within social situations. Moreover, based on physiological data, it appeared that individuals with social anxiety had increased arousal when engaging in all three manipulations. These results are contradictory to research suggesting that the negative self-image leads to increased deficits (e.g., Brozovich & Heimberg, 2013; Hirsch, Clark, Mathews, & Williams, 2003; Hirsch, Meynen, & Clark, 2004; Makkar & Grisham, 2011); however, are consistent with research suggesting increased anxiety associated with self-focused attention broadly (e.g., Bögels & Mansell, 2004; Judah, Grant, Mills, & Lechner, 2013; Woody & Rodriguez, 2000). Specifically, self-focused attention, in and of itself, increases anxiety, thus, it is possible that all image conditions led to increased self-focused attention and increased anxiety.

As predicted, results did not find a difference between high and low social anxiety for error rates, suggesting that, within this task, social anxiety does not impact task performance. These results are consistent with inhibitory research and the attentional control theory, which suggest that social anxiety may not show deficits in task effectiveness depending on tasks (Eysenck & Derakshan, 2011). It is possible that this task did not show direct deficits in effectiveness since the task did not involve the threat of social interactions, which are often areas where deficits in efficiency occur for those with social anxiety (Hirsch, Clark, Mathews, & Williams, 2003; Stopa & Jenkins, 2007). As expected and consistent with previous Go/No-go paradigms, a main effect of task was revealed, such that the inhibition trials resulted in more errors (i.e., errors of commission) than go trials (i.e., errors of omission). Additionally, results revealed a significant interaction between task and self-image type, such that the negative image condition produced more errors than the positive and neutral within the no-go trials but not in the go trials. It is possible that negative images additionally loaded working memory in the inhibition trials, thus leading to decreased ability to inhibit a response. This is consistent with previous research, indicating that negative self-images result in increased deficits in performance (Vassilopoulos & Moberly, 2013). Interestingly, this effect was not specific to social anxiety.

Conversely, efficiency results suggested that the social anxiety group was slower to respond behaviorally and showed decreased neural recruitment in the P3 and a later P3 amplitude. These results support the attention control theory (Eysenck & Derakshan, 2011), such that social anxiety may not show deficits in effectiveness, but often show deficits in efficiency. Moreover, this is apparent with slower reaction times towards correct responses, indicating potentially slower processing and responding. Furthermore, later P3 amplitude may indicate that the group high in social anxiety took longer to process the stimuli, which suggests inefficient processing. Moreover, anxiety often impacts attentional control (Eysenck & Derakshan, 2011), and the high socially anxiety group had higher levels of anxiety across all three imagery conditions, implying that the higher levels of anxiety the social anxiety group experienced may have impacted neural recruitment efficiency. Interestingly, the high social anxiety group showed a lower P3 amplitude suggesting either increased efficiency of neural recruitment to complete the task or decreased neural recruitment due to distraction or lower cognitive resources. Although possible, the P3 amplitude results are unlikely a consequence of increased efficiency due to the increased error rates and later P3 amplitude presented within social anxiety. It is more likely that individuals with social anxiety were experiencing decreased neural resources due to increased anxiety and increased self-focused attention broadly. Specifically, Eysenck and Derakshan (2011) posit that anxiety reduces available cognitive resources, thus leaving less resources to effectively complete other tasks. In this study, the high anxiety that those in the high social anxiety group reported may have loaded working memory and cognitive resources, leaving less to allocate towards the task. This likely resulted in decreased and later P3 amplitude as well as slower responses.

Contrary to hypotheses, there were no interactions with self-imagery manipulation and social anxiety. Past research indicates that negative mental images increase anxiety within those that have social anxiety (Vassilopoulos & Moberly, 2013; Vassilopoulos, Moberly & Douratsou, 2012). Moreover, this increased anxiety was hypothesized to further load cognitive resources; however, the current study did not find this effect. It is possible that self-imagery does not impact social anxiety as theory suggests, but these results may have been influence by a number of factors. For example, the effects shown in social anxiety may be due to increased self-focused attention broadly which spans across all three image conditions, thus not resulting in differential deficits. Additionally, anxiety regarding the self-images was primarily based on self-report and assumption of participant engagement in the task. It is possible that certain participants avoided anxiety provoking mental images, as cognitive avoidance is often a strategy within anxiety disorders (Akbari & Khanipour, 2018; Borkovec et al., 2004; Heimberg, Brozovich, & Rapee, 2010). Furthermore, it is possible that the imagery manipulations did not tap into the anxiety often elicited by true social situations, thereby not resulting in differential increases in anxiety. Finally, recent research suggests that negative imagery may influence individuals with and without anxiety in a similar way, resulting in the sometimes contradictory findings with imagery manipulations (Ng & Abbott, 2014; Ng & Abbott, 2016; Ng, Abbott, & Hunt, 2014).

This study is not without limitations. The current study used a convenience sample of college students, which is often a more homogeneous sample then the general population (Fabrigar et al., 1999). As discussed above, manipulation checks were used to help ensure that participants fully engaged in the manipulation; however, it is possible that participants simply failed to fully comply. Additionally, on the scale from 0 to 10, the negative self-images only received an average averseness rating of 4-5, valence rating of 5-6, and anxiousness rating of 5-6. It is clear that the negative imagery condition did not induce anxiety above minimal to moderate levels. Finally, the amplitude of the P3 may be conflated by the latency of the P3 (Luck, 2007). Specifically, the lower amplitude for the social anxiety group may be influenced by trials where the peak amplitude occurs outside of the measurement window, thus reducing the trials that show the peak amplitude of the P3. Additionally, no significant results were found with the N2. It is possible that the Go/No-go task had a larger influence on the P3 or that there was a large amount of noise within the waveform, thus only leading to effects for the largest ERP. Future investigations should use more individualistic and effective manipulations of self-imagery that lead to anxiety levels closer to that experienced in social situations.

In conclusion, this study aimed to determine whether the relationship between social anxiety and both efficiency and effectiveness was influenced by self-imagery manipulations. Consistent with the attentional control theory (Eysenck & Derakshan, 2011), those with social anxiety showed no deficits in effectiveness but did show broad deficits in efficiency. No interactions were seen with self-imagery manipulations, suggesting that the influence of different self-images may equally load cognitive resources within social anxiety. Moreover, it is possible that the effects of self-imagery are task specific. Generally, these results support the assertion that individuals with social anxiety may show ineffective processing and completion of tasks; however, further research is required to determine the influence of self-imagery.

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APPENDICES

APPENDIX A

FIGURE 1

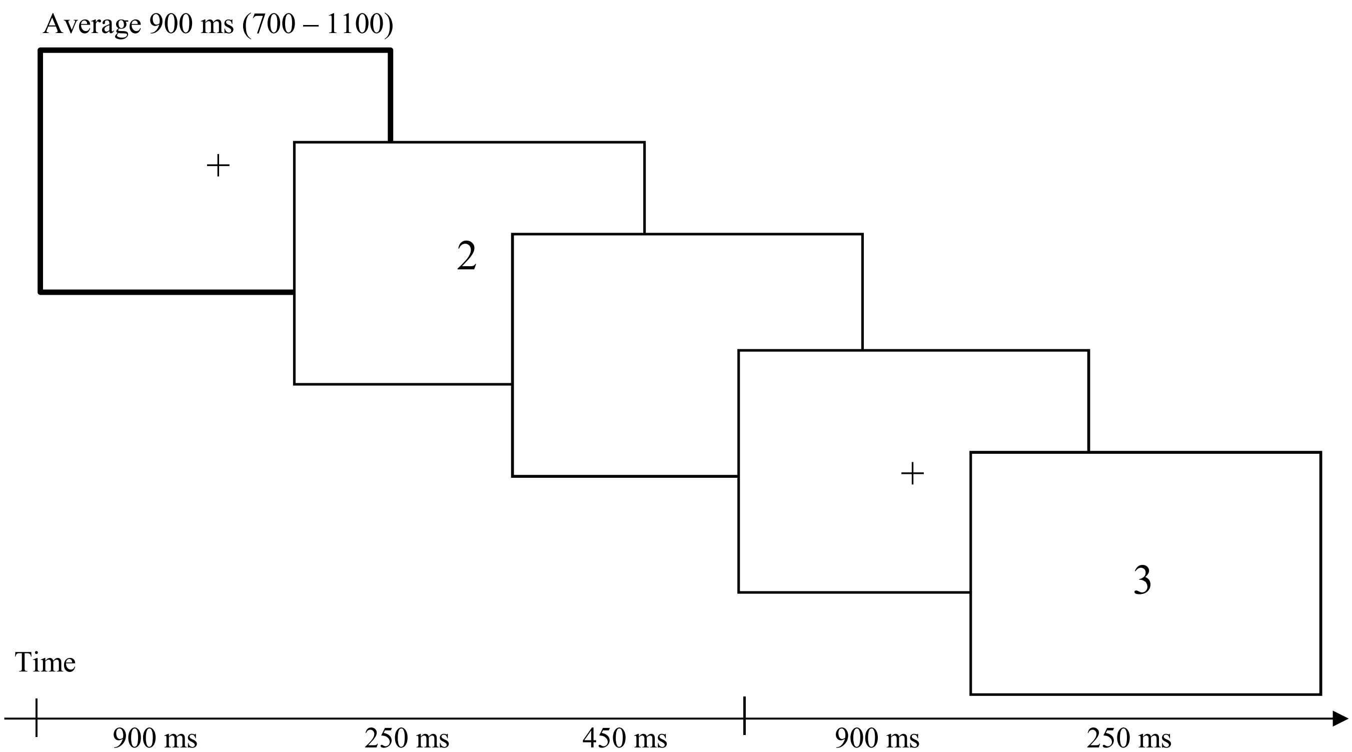

Figure 1. The Go-No-Go Task

APPENDIX B

Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998)

For each question, please circle a number to indicate the degree to which you feel the statement is characteristic or true of you. The rating scale is as follows:

0 = Not at all characteristic or true of me
1 = Slightly characteristic or true of me
2 = Moderately characteristic or true of me
3 = Very characteristic or true of me
4 = Extremely characteristic or true of me

1. I get nervous if I have to speak with someone in authority (teacher, boss, etc.)	0	1	2	3	4
2. I have difficulty making eye-contact with others.	0	1	2	3	4
3. I become tense if I have to talk about myself or my feelings.	0	1	2	3	4
4. I find difficulty mixing comfortably with the people I work with.	0	1	2	3	4
5. I find it easy to make friends of my own age.	0	1	2	3	4
6. I tense - up if I meet an acquaintance on the street.	0	1	2	3	4
7. When mixing socially, I am uncomfortable.	0	1	2	3	4
8. I feel tense if I am alone with just one person.	0	1	2	3	4
9. I am at ease meeting people at parties, etc.	0	1	2	3	4
10. I have difficulty talking with other people.	0	1	2	3	4
11. I find it easy to think of things to talk about.	0	1	2	3	4
12. I worry about expressing myself in case I appear awkward.	0	1	2	3	4
13. I find it difficult to disagree with another's point of view.	0	1	2	3	4
14. I have difficulty talking to an attractive person of the opposite sex.	0	1	2	3	4
15. I find myself worrying that I won't know what to say in social situations.	0	1	2	3	4
16. I am nervous mixing with people I don't know well.	0	1	2	3	4
17. I feel I'll say something embarrassing when talking.	0	1	2	3	4
18. When mixing in a group, I find myself worrying I will be ignored.	0	1	2	3	4
19. I am tense mixing in a group.	0	1	2	3	4
20. I am unsure whether to greet someone I know only slightly.					

APPENDIX C

FIGURE 2

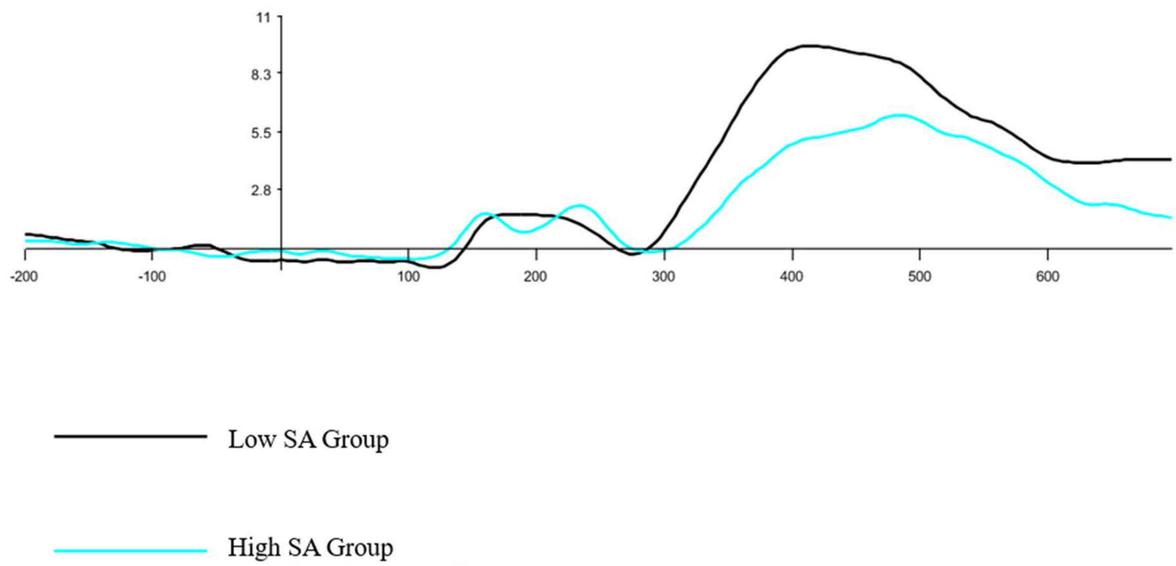

Figure 2. P3 ERP waveform at CZ electrode for High and Low social anxiety groups

VITA

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