The Effects Anxiety has on Attentional Bias and Working Memory

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The Effects Anxiety has on Attentional Bias and Working Memory

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Master of Science

By
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Abstract

Research has shown that anxiety impairs attention and working memory, especially when it comes to completing a mentally demanding cognitive task such as the emotional Stroop paradigm or the n-back task. The purpose of this study was to investigate whether state anxiety affects behavioral performance on executive function tasks. State anxiety was induced using negatively valenced images from the International Affective Picture System, while neutral images served as the control. We compared behavioral performance between individuals in the negative mood induction against those in the neutral mood induction. Trait anxiety was used as a covariate for both groups. This allowed us to determine whether state anxiety, as apposed to trait anxiety, plays a significant role in interfering with attentional control or working memory systems.
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The Effects Anxiety has on Attentional Bias and Working Memory

Anxiety is a common and natural reaction to stress and can prove to be life saving in certain life or death situations (Kessler, Chiu, Demler, & Walters, 2005). However, anxiety can also pose a problem for individuals who experience “severe” chronic anxiety. According to Kessler and colleagues (2005), approximately 18.1% of the U.S. adult population experiences this chronic level of anxiety over a 12-month time period, and 28.8% of the U.S. adult population struggle with severe anxiety over their lifetime. There are numerous anxiety disorders that are currently specified in the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5; American Psychiatric Association [APA], 2013). According to the DSM-5, specific phobia, social anxiety disorder (social phobia), and generalized anxiety disorder are the most common forms of anxiety in the U.S. (APA, 2013). With respect to suicidality, the most severe anxiety disorders include specific phobia; individuals with this diagnosis are 60% more likely to attempt suicide, and panic disorder, which also has an increased risk of suicide (APA, 2013).

The common criteria for all anxiety disorders require the feelings of fear, panic, and/or anxiety to remain prevalent for a substantial period of time (typically six months or more), as opposed to these feelings persisting in a transient state (APA, 2013). Thus, one of the main diagnostic differences between typical anxious feelings and a classification of an anxiety disorder is the duration for which the feeling is endured. At times, especially considering certain environmental contexts, it is normal for an individual to experience feelings of anxiety or worry. It has been shown in previous

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research (Sheppes, Luria, Fukuda, & Gross, 2013) that these fleeting feelings serve as a survival tactic, alerting the individual to possible danger and influencing whether to stay and “fight” the danger head on, or leave the danger for safety (“flight”). Non-anxious individuals experience normal levels of vigilance in assessing potential threats to homeostasis. Being in a state of anxiety leads to hypervigilant behavior in which threat is detected at a much lower threshold (Van Marle, Hermans, Qin, & Fernandez, 2009). Therefore, anxiety disorders, as well as individuals suffering with severe, chronic anxiety (without an anxiety disorder diagnosis) can be maladaptive and distressing. Conversely, experiencing a temporary state of anxiety is healthy and can aid in survival.

**State and Trait Anxiety**

There are two different ways that anxiety manifests: trait anxiety and state anxiety. According to Crowe, Matthews, and Walkenhorst (2007), trait anxiety can be viewed as a personality dimension, while state anxiety can be viewed as a situational dimension. In essence, trait anxiety is defined as the more stable, unchanging aspect of anxiety that is inherent in a person, while state anxiety is ever changing, depending on the current situation and environment. For example, it has been posited that trait anxiety is a result of a person’s development of specific coping mechanisms that involve regulating his/her mood to deal with life stressors (Eysenck & Derakshan, 2009). While trait anxiety implies a consistent presence of anxiety over a period of time, it does not follow that the individual is in a constant state of worry and apprehension that impairs every aspect of his/her cognitive performance (Eysenck & Derakshan, 2009). Rather, individuals with
high trait anxiety respond differently to stressful situations compared to individuals low in trait anxiety.

When discussing anxiety it is important to briefly review the similarities and differences between anxiety and stress, as they are related constructs. Much like anxiety may be present either as a state or trait, stress may be experienced either chronically or acutely. Chronic stress and acute stress are interrelated in that chronic stress regularly has an impact on acute stress. The extent to which a current stressful situation has an impact on a person’s response to the stressor is partly attributed to individual differences (Constantinou et al., 2009). One aspect of these differences includes the perceived level of chronic stress he/she has had to endure. Therefore, if a person scores relatively high on a chronic stress inventory, this could influence whether the person is subsequently more affected by an acute stressor than someone who scores lower on the same inventory (Constantinou et al., 2009).

However, anxiety and stress are still separate constructs. This is evident in the Depression Anxiety Stress Scale (DASS), which has different subscale items that relate to the different aspects of depression, anxiety, and stress (Lovibond & Lovibond, 1995). The anxiety subscale includes measures of autonomic arousal, situational anxiety, skeletal musculature effects, and subjective experience of anxious affect, while the stress subscale includes measures of difficulty relaxing, nervous arousal, easily upset/-agitated, irritable/over-reactive, and impatient (Lovibond & Lovibond, 1995). Thus, while anxiety and stress are similar, they encompass different aspects of negative affect that a person may experience.
It is possible to induce temporary anxiety (i.e., state anxiety) in an individual regardless of whether he/she is generally an anxious individual. This is referred to as sensitized anxiety and it can be induced after just one exposure to an acute stressor (Grillon, Duncko, Covington, Kopperman, & Kling, 2007). Researchers have employed various techniques to induce sensitized anxiety in participants, ranging from the anticipation of an aversive stimulus to exposure to mood states. Rhudy and Meagher (2000) told participants they would receive a painful shock, and allowed the anticipation of the shock (which never came) to generate anxiety. Participants can also be exposed to specific mood states by having them read aloud self-statements such as “I feel very anxious/worried about a future event,” or by having them imagine giving an impromptu speech in front of a crowd (Orton, Beiman, LaPointe, & Lankford, 1983). Mood states can also be induced by having participants view emotionally salient film clips or images that perpetuate the intended mood (Fales et al., 2008; Sanchez, Vazquez, Gomez, & Joormann, 2013).

One line of inquiry that remains equivocal is the degree to which trait anxiety interacts with state anxiety brought on by an acute stressor. While some researchers have shown that trait anxiety does not impact a person’s level of state anxiety (Dresler, Meriau, Heekeren, & Van der Meer, 2009), others have shown that it does (Eysenck, Derakshan, Santos, & Calvo, 2007). These conflicting findings may be due in part to the multiple ways in which individuals process emotion. Rusting (1998) discussed three different routes to emotional processing: the traditional approach, a moderation approach, and a mediation approach. The traditional approach posits that temporary mood states
and stable personality traits each have independent effects on emotional processing (Rusting, 1998). For example, someone who is not high in trait anxiety could still feel an overwhelming amount of state anxiety when placed in a situation that the individual finds highly uncomfortable (e.g. being asked to ride a roller coaster with a very steep drop). This activity may be very anxiety provoking in that moment even for someone who is not considered an “anxious” person, as heights are frequently reported as a “fear” (LoBue, 2013). The second approach, the moderation approach, Rusting suggests that personality traits may moderate the relationship between mood states and emotional processing. In other words, whether an individual processes emotional stimuli in a mood-congruent or a mood-incongruent manner would depend on his/her personality traits. Mood congruency refers to an individual retrieving pleasant thoughts and associations more easily when in a good mood, because pleasant associations have already been activated within the emotional network (Rusting, 1998). The opposite is true as well: an individual in a bad mood will more easily recall unpleasant thoughts and associations (Rusting, 1998). For example, someone who is high in trait anxiety would suffer the negative consequences of being in a state of anxiety much more so than someone low in trait anxiety, due to the nature of his/her emotional processing. Finally, the third approach, the mediation approach, suggests that the effect of an individual’s personality traits on the processing of emotional stimuli may be mediated by the individual’s current mood state (Rusting, 1998). In other words, the effects of personality trait on emotional processing may be indirect rather than direct. An example of this is that an individual’s personality (trait anxiety) may make him/her more susceptible to certain mood states (state anxiety), which
leads to mood-congruent processing of emotional stimuli when placed in an anxious state. To summarize, while mood states and personality traits have effects irrespective of each other, they also have a reciprocal relationship when combined that impacts the individual and how he/she responds to certain situations. Further research is needed to understand more clearly how trait and state anxiety affect emotional processing.

**Attentional Control Theory**

According to the attentional control theory (Eysenck et al., 2007), anxiety affects the cognitive domains of attention and memory. With respect to attention, anxiety makes it difficult to remain focused on the task at hand when stimuli are presented that are perceived as threatening. Anxiety also makes it difficult to keep information in working memory (discussed in further detail below), a short-term, dynamic memory register that allows people to manipulate information in the present. People with high trait anxiety have less “room” in this memory register to store information than people with low anxiety, which makes tasks involving working memory harder for them (Eysenck, Payne, & Derakshan, 2005). This difficulty manifests in slower reaction times in order to preserve accuracy levels. This tradeoff of reduced speed for accuracy is key to attentional control theory, and warrants further explanation.

When analyzing performance, it is important to differentiate between the concept of performance *efficiency* and that of performance *effectiveness*. Effectiveness can be referred to as response accuracy, or the number of items that are answered correctly, while efficiency encompasses the relationship between accuracy (effectiveness), the amount of effort expended, and the resources recruited to obtain the correct response
(Eysenck et al., 2007). Essentially, effectiveness takes into account more details than simply whether or not the response was accurate, such as how much mental effort the person had to put forth in order to compensate for deficiencies in other areas. Typically, as more resources are forcefully used due to task complexity and/or deficits in other areas (such as working memory capacity), efficiency deteriorates (Eysenck et al., 2007).

Anxiety typically impairs performance efficiency, not performance effectiveness (Edwards, Edwards, & Lyvers, 2015). In other words, high-anxious people can perform a task with the same level of accuracy as their low-anxious counterparts; however, it will require more effort and resources in order to accomplish this. This phenomenon manifests in the form of high-anxious individuals taking longer to respond correctly (i.e., longer response latency) on attention and memory tasks than low-anxious individuals, resulting in an overall slower reaction time.

Evidence of this speed/accuracy tradeoff in high-trait anxious individuals comes from Edwards and colleagues (2010). Their results showed that individuals higher in trait anxiety were forced to rely on other cognitive resources, besides task-related cognitive control, in order to achieve equivalent accuracy as individuals lower in trait anxiety. They concluded that these extra cognitive resources could include extra motivation or working memory capacity (Edwards, Burt, & Lip, 2010). Eysenck et al. (2007) found that when low-trait- and high-trait-anxious individuals have comparable performance effectiveness on an attention task, group differences in efficiency can be deduced from differences in response time. In this study, high-trait-anxiety performance was comparable to low-trait-anxiety performance, but with longer response latencies for the high-trait-anxious
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participants (Eysenck et al., 2007). This means that low-trait- and high-trait-anxious individuals will “get the right answer” the same amount of times, but high-trait-anxious individuals will take longer to process the “right answer,” which will be evident in the length of time it takes them to respond to the task.

Attentional Bias

Anxious individuals tend to be more distracted by threatening stimuli as opposed to neutral or positive stimuli, referred to as attentional bias (Eysenck et al., 2007). Due to anxious individuals’ hypervigilant tendencies, they have a harder time both ignoring stimuli they perceive as threatening, and disengaging from perceived threatening stimuli while performing a task (Eysenck et al., 2007). Derakshan and Koster (2010) found that high-trait-anxious, but not low-trait-anxious individuals, were slower to detect a happy face in an angry crowd. This finding exemplifies the difficulty high-anxious individuals experience when attempting to disengage from threatening stimuli (i.e., angry faces). This difficulty may be due to the fact that emotional stimuli are processed earlier in the processing stream than neutral stimuli, a phenomenon referred to as “attention capture” (Chajut, Schupak & Algom, 2010). In addition, emotional stimuli hold attention longer than do neutral stimuli, exacerbating the already difficult challenge of disengaging, referred to as a temporary freezing behavior (Chajut et al., 2010). Typically, high-trait-anxious individuals allocate their available attentional resources to the perceived threat as opposed to maintaining their attentional resources on the task at hand.

According to attentional control theory, anxiety causes this distraction to threatening stimuli because of its association with an increased influence of the stimulus-
driven (i.e., bottom-up) attentional network and a decreased influence of the goal-directed (i.e., top-down) attentional network (Eysenck et al., 2007). The stimulus-driven attentional system forces the individual to pay attention first and foremost to whichever distracting stimulus is in the environment, regardless of the task at hand. In contrast, the goal-directed attentional system forces the individual to focus attention on the task at hand, or the completion of a certain goal, regardless of what distracting stimulus is present in the environment. Anxiety stimulates activation of the stimulus-driven attentional system and inhibits activation of the goal-directed attentional system for the individual. Consequently, anxiety shifts the immediate priority to threat assessment, causing the individual to disengage from the task at hand in order to ensure the distracting stimulus is not a threat to safety. Thus, individuals high in trait anxiety have a harder time overriding the stimulus-driven attentional process (Eysenck et al., 2007).

The emotional Stroop task (e-Stroop; Watts, McKenna, Sharrock, & Trezise, 1986; Williams & Nulty, 1986) is a valid measure of attentional bias, capable of demonstrating how difficult it is for anxious individuals to inhibit task irrelevant information (De Ruiter & Brosschot, 1994). It is a variation of the Stroop color-word task (Stroop, 1935) that requires an individual to name the color of the ink in which a word is presented, ignoring the semantic meaning of the word, which in some cases is the name of another color. This response conflict from competing information slows response time (i.e., Stroop interference). In order to respond quickly and accurately, the participant must inhibit the automatic tendency to read and interpret the word’s meaning. Rather than using color-related words, the e-Stroop uses words with an emotional connotation,
including threat-related words (e.g., snake; Watts et al., 1986), positive words (e.g., happy; Bailey, Paret, Battista, & Xue, 2012), as well as neutral words (e.g., table; De Ruiter & Brosschot, 1994). Participants take longer to name the color of the ink for threat words due to an inability to ignore the semantic content (De Ruiter & Brosschot, 1994). This threat-induced response latency is referred to as e-Stroop interference, and is evident in all participants, not just those with high levels of anxiety (De Ruiter & Brosschot, 1994). However, Mogg and colleagues (1990) found that high levels of trait anxiety were positively related to the magnitude of e-Stroop interference. In other words, individuals with high-trait-anxiety are even slower than individuals low in trait anxiety to identify the color of the ink for threat words.

A similar study also found that e-Stroop interference was evident in threat-related words, as opposed to neutral or positive words, for high-trait-anxious individuals (Richards & French, 1990). Interestingly, individuals with an anxiety disorder (generalized anxiety disorder and social phobia) demonstrate e-Stroop interference to threat-related words when the words are content specific (Becker, Rinck, Margraf, & Roth, 2001). For example, instead of using random words that pertain to threat, choosing a specific category, such as a specific phobia, results in slower reaction times for high-anxious individuals participating in the e-Stroop task. Thus, high-trait-anxious individuals show particular difficulty disengaging from high threat words, while non-trait-anxious individuals do not.

Differences in how low-trait- and high-trait-anxious individuals respond to stimuli are not limited to exposure to threat and/or category-specific words. High-trait-anxious
individuals have been shown to interpret neutral or ambiguous stimuli as being more threatening (referred to as interpretation bias) than low-trait-anxious individuals (Van Bockstaele et al., 2014). Another difference between high-trait- and low-trait-anxious individuals lies in how they direct their attention to threatening stimuli. High-trait-anxious individuals tend to allocate their attention towards threatening information, whereas low-trait-anxious individuals tend to allocate their attention away from threatening information, a phenomenon known as biased attentional direction (Wilson & MacLeod, 2003). Furthermore, when the threat stimulus is perceived as having intermediate intensity, high-trait-anxious individuals will display greater attentional orientation towards it than low-trait-anxious individuals (Wilson & MacLeod, 2003). For low-trait-anxious individuals, there tends to be more of a “what was it?” response to threatening stimuli as opposed to a “what is it?” response (Bailey, Paret, Battista, & Xue, 2012). Importantly, high-trait-anxious individuals have a harder time ignoring distracting/threatening stimuli and feel the need to process the stimuli immediately to determine whether or not there is imminent danger in the present moment (“what is that?”). Conversely, low-trait-anxious individuals do not experience this dilemma. They are better able to ignore distracting/threatening stimuli in order to finish the task at hand, and process the stimuli once the task is complete (“what was that?”).

An explanation for why high-trait anxious individuals respond differently to threatening stimuli may be because of differences in the activation patterns of neural networks that process threat. The amygdala is involved in the processing and evaluation of emotional stimuli, especially fear (Ragen, Roach, & Chollak, 2016). Individuals
exposed to chronic stress have an exaggerated fear response including over-activation of the amygdala (Ragen et al., 2016). In high-trait-anxious individuals, a large proportion of amygdala activation is predicted to occur within the first 500-600 milliseconds (ms) of threatening stimulus presentation, whereas with low-trait-anxious individuals it is predicted that the amygdala comes online later in the processing stream (Frewen, Dozois, Joanisse, & Neufeld, 2008). According to Wilson and MacLeod (2003), all individuals shift focus away from very low threat (avoidance) and all individuals shift focus towards very high threat (vigilance). The difference between low-trait and high-trait anxious individuals lies in the response to intermediate threat intensity; high-trait anxious individuals experience attentional vigilance starting at lower threat intensity. However, it has been proposed that high-trait-anxious individuals view any given level of stimulus as more threatening than low-trait-anxious individuals (Wilson & MacLeod, 2003). This tendency of high-trait-anxious individuals to perceive threat in any stimulus could be explained as anxiety being associated with a lower threshold for perceiving threat, such that even moderately threatening stimuli evoke a response among anxious individuals (Bailey et al., 2012).

State anxiety, as opposed to anxiety in general, might be the cause of the e-Stroop interference of emotional words for high-anxious individuals reported above. According to Dresler and colleagues (2009), state anxiety is what biases one’s attention towards the emotionally salient stimuli. Dresler and colleagues found that trait anxiety did not have a significant effect on reaction time for high-state- or low-state-anxious individuals; instead, they found that state anxiety specifically caused the interference. These findings
are consistent with prior research concluding that state anxiety refers to how a person feels in that particular moment, and anyone can feel a state of anxiety without having to be classified as an “anxious” person. If a low-trait-anxious individual is in a state of anxiety, it is logical to assume that he/she will experience the same response latency as that of a high-trait-anxious individual. However, as mentioned previously, trait and state anxiety also have a reciprocal relationship, such that trait anxiety will inevitably impact an individual’s level of state anxiety. Thus, while low-trait-anxious individuals will display noticeably higher than normal levels of anxiety when placed in a stressful situation, their anxiety levels will not reach the same intensity as high-trait-anxious individuals exposed to the same stressor.

Overall, both trait- and state-anxiety impairs performance efficiency (i.e. accuracy plus effort) as opposed to performance effectiveness (i.e., accuracy), as evidenced by slower reaction times but comparable accuracy on cognitive tasks for individuals with high anxiety levels. Most research has focused on high levels of trait anxiety instead of state anxiety when studying this performance impairment. However, Dresler and colleagues’ study indicates that perhaps state anxiety plays a larger role in this deficiency than trait anxiety. Thus, more research is needed that is sensitive to the contribution of state anxiety, and the interrelationship between state and trait anxiety.

**Role of Working Memory in Attention**

Up until now, the emphasis has been on attentional control and how anxiety can interfere in this cognitive process. However, attention is not an isolated cognitive network. Successful performance on the e-Stroop requires cognitive control, specifically
inhibitory control. The more effectively an individual can inhibit the competing meaning of the threat word, the faster he/she can disengage and respond. Failure to inhibit distracting information results in poorer performance because this task-irrelevant information is taking up valuable space in working memory. Working memory refers to a system that is dynamic, flexible, and importantly, has limited capacity (Baddeley, 2003). Working memory is capable of maintaining important information in a temporary buffer that is continuously updated with new, relevant information (Baddeley, 2003). Previous studies have shown that working memory is partially affected by anxiety (Qin, Hermans, van Marle, Luo, & Fernandez, 2009). For example, one particular study found that high-anxious individuals (both state and trait anxiety) performed substantially worse, in regards to less capacity, on a cognitive task focusing on working memory when compared to low-anxious individuals (Crowe et al., 2007).

The ability to ignore task irrelevant stimuli and/or acknowledge task irrelevant stimuli and then refocus attention to the task at hand requires cognitive control processes including inhibition, shifting (or task switching), and updating. Each of these methods of cognitive control is an example of executive function. These functions are “supervisory” cognitive processes because they require higher-level organization and execution of complex thoughts and behaviors in completing cognitive tasks (Alvarez & Emory, 2006). Inhibition, task switching, and updating are all negatively affected by anxiety (Shackman, Sarinopoulos, Maxwell, Pizzagalli, Lavric, & Davidson, 2006). Inhibition is the ability to intentionally suppress dominant, automatic, or salient responses when necessary (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). This involves using attentional control
to inhibit interfering or task-irrelevant stimuli that disrupts focused attention (Miyake et al., 2000). Shifting/task switching is defined as the “shifting” back and forth between multiple tasks, stimuli, etc. (Miyake et al., 2000). This requires an individual to detect a task-irrelevant stimulus in the environment and reorient attention back to the task at hand as quickly as possible so as not to interrupt the performance of the task. Updating is defined as the ability to monitor and code incoming information for relevance to the task at hand, and replacing old information with new, relevant information (Miyake et al., 2000). This is important in regards to completing a mental task, as working memory has a limited capacity to hold information in the buffer at any given time. Optimal performance cannot be attained if working memory is taxed by a failure to inhibit irrelevant information, shift focus, or update task-specific goals. Even in the absence of anxiety, working memory has its limitations.

**Anxiety and working memory capacity.** One of the ways anxiety influences working memory is its negative impact on capacity. As Crowe et al. (2007) explained, working memory has a very limited capacity to begin with, and highly anxious individuals have even less available working memory capacity because they are simultaneously processing the task at hand as well as processing their anxiety. Low-anxious individuals are able to devote all available working memory capacity to the task at hand, which results in a better performance (Crowe et al., 2007).

Successful attentional control requires the ability to focus attention on the task at hand and inhibit refocusing of attention towards irrelevant stimuli. However, it has been shown that people with high levels of anxiety struggle with being able to do this,
especially if the irrelevant stimuli is perceived as threatening (Stout, Shackman, Johnson, & Larson, 2015). This manifests itself in high-trait-anxious individuals by producing distressing thoughts that are characteristic of worry and anxiety, and these thoughts are likely to be mentally rehearsed, thus competing with goal-oriented thoughts and actions (Stout et al., 2015). Furthermore, once these threatening stimuli are processed in working memory, they may continue to bias attention long after the stimuli have been removed from the environment (Stout et al., 2015). Threatening stimuli are often given priority in working memory, which enables a state of worry that persists after the threat has been removed. This makes it almost impossible for highly anxious individuals to ignore the threatening stimuli and refocus on the task at hand (Stout et al., 2015). This phenomenon is not present in low-trait-anxious individuals as it is in high-trait-anxious individuals, which supports the stimulus-driven attentional control theory that high-trait-anxious individuals experience greater difficulty ignoring a perceived threat, as they often exhibit more hypervigilant behavior. Thus, in order to determine if the effect of anxiety on attentional bias to threat is in part due to the effect of anxiety on working memory capacity, it is necessary to not only investigate state anxiety on attentional bias using e-Stroop, but also separately test the effect of state anxiety on working memory capacity.

There are several factors to consider when determining how a particular individual will perform on a given cognitive task. These factors include trait anxiety, state anxiety, and whether or not the current condition in which the individual is placed is stressful or not. Both being placed in a stressful condition and being exposed to an acute stressor, have been shown to impair working memory in much the same way as trait
anxiety (Qin et al., 2009). In one study, participants who had been placed under stress showed substantially longer response latencies than those not under stress during a task that measures working memory capacity called the n-back task (Dobbs & Rule, 1989; Gevins & Cutillo, 1993; Kirchner, 1958; Schoofs, Preu, & Wolf, 2008). The n-back task requires individuals to remember a stimulus that was presented n trials back. Most n-back paradigms include 1-back (A-A), 2-back (A-B-A), and 3-back (A-B-B-A) conditions. This is a cognitively demanding task that is difficult to perform, even for people who have no problems with trait anxiety, and who are not attempting the task in a current state of anxiety (Eysenck et al., 2005). In the Schoofs et al. (2008) study, stressed participants showed slower reaction times during the task, but the differences between the stressed participants and the non-stressed participants were no longer significant by the end of the task. This indicates that state anxiety has a negative impact on performance efficiency that dissipates over time. As evidenced by prior studies discussed thus far, it is clear that there is insufficient research that focuses on state anxiety as opposed to trait anxiety with respect to attentional bias and working memory. Thus, it is the aim of this study to test the effects of state anxiety on attentional bias by using the e-Stroop task and on working memory by using the n-back task.

Mood State. Previous studies that have used mood state manipulation prior to investigating attentional bias or working memory have shown varying results. For example, Byrne and Eysenck (1995) found an effect of state anxiety when they examined whether angry faces in a crowd would be detected more quickly for individuals in the negative mood induction group as opposed to individuals in the control group, which
received a neutral mood induction. Those in the negative mood induction group detected angry faces faster than those in the control group, however reaction times did not differ significantly between the two groups in detecting happy faces (Byrne & Eysenck, 1995). The results of this study indicated that inducing a negative mood state (i.e., state anxiety) affected the speed at which the participants detected angry faces in a crowd, indicating state anxiety does have an impact on attentional bias (Byrne & Eysenck, 1995).

Ellenbogen and colleagues (2002) found an effect of state anxiety when they had participants complete the e-Stroop task after a stress induction. Two important findings from their study were, first, that participants in the negative stressor condition were faster to shift attention away from negative words than from positive or neutral words, and second, that attentional shifts away from negative words were associated with the stress induction (Ellenbogen, Schwartzmen, Stewart, & Walker, 2002). The researchers posit that the rapid shift away from negative words may have been an adaptive response in an attempt to regulate emotional arousal (Ellenbogen et al., 2002).

Roelofs and colleagues (2007) also found an effect of state anxiety in their study that looked at stress levels via an increase in cortisol levels and selective attention to social threat. The participants were divided into either high or low responders based on their cortisol levels after the stress induction. Their results indicated that, while low responders became avoidant to threat (angry faces in a crowd), high responders became vigilant to the angry faces after the stress induction (Roelofs, Bakvis, Hermans, van Pelt, & van honk, 2007). Therefore, individuals with high cortisol levels (high stress) became more aware of the social threat than individuals with low cortisol levels (low stress).
With respect to working memory, Qin and colleagues (2009) reported significant effects of state anxiety on frontal lobe activation. In their study, they induced acute psychological stress by having participants viewing strongly aversive movie material together with a self-referencing instruction designed to induce a stressful state, and then had them complete the n-back task. The induced stress led to a decrease in working memory related activity in the brain, as evidenced through the use of functional magnetic resonance imaging (fMRI), and further supported by increased reaction time and decreased accuracy on the n-back task (Qin, Hermans, van Marle, Luo, & Fernandez, 2009).

Conversely, Ozawa and colleagues (2014) altered mood state via the International Affective Picture System (IAPS), and then had participants complete the n-back task. Their results indicated that there were no effects of emotion on n-back performance in terms of reaction time and accuracy (Ozawa, Matsuda, & Hiraki, 2014). In their study, negative pictures yielded an unpleasant emotional state, which they likened to anxiety. The researchers posited that the behavioral performance was maintained while under an unpleasant state perhaps due to the fact that the participants they employed had adequate working memory resources. The researchers credit the processing efficiency theory, mentioned previously, in which highly anxious people require greater effort in order to maintain the same level of performance as low anxious people (Ozawa et al., 2014). Therefore, the highly anxious people that participated in the study may have had a healthy brain that was able to help them compensate for the anxious state they were placed in, and perform on par with the low anxious individuals.
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Given the varying conclusions from previous studies investigating these cognitive domains, and the pattern of findings showing reaction time, but not accuracy, is affected by mood state, the aim of this study was to investigate the effect of mood state manipulation (i.e., induced state anxiety) on inhibitory control and working memory. We used the e-Stroop to test the effect on inhibitory control and the n-back to test the effect on working memory. Based on the attentional control theory, it was hypothesized that individuals who score higher on trait anxiety levels will have slower reaction times (but similar accuracy) on the e-Stroop task on threat words than individuals who score lower on trait anxiety levels. Based on the performance efficiency theory, it was hypothesized that those who score higher on trait anxiety levels will have a slower reaction time (but similar accuracy) on the n-back task than individuals who score lower on trait anxiety levels. Trait anxiety was a covariate for both analyses.

_Hypothesis 1a:_ There will be a main effect of mood state induction in that those in the negative mood state induction group will have slower reaction times, but no difference in accuracy, on the e-Stroop than those in the neutral group, independent of word type, and controlling for trait anxiety.

_Hypothesis 1b:_ There will be a main effect of word type in that threat words will demonstrate slower reaction times, but no difference in accuracy, compared to both neutral and positive words, independent of mood state induction.

_Hypothesis 1c:_ There will be an interaction between mood state induction and word type in that those in the negative mood state induction group will have slower reaction times,
but no difference in accuracy, on threat words, than those in the neutral mood state induction group, even when controlling for trait anxiety.

Hypothesis 2a: There will be a main effect of mood state induction in that those in the negative mood state induction group will have slower reaction times, but no difference in accuracy, on the n-back than those in the neutral group, independent of memory load, and controlling for trait anxiety.

Hypothesis 2b: There will be a main effect of memory load in that the 3-back (the most challenging memory load) will demonstrate slower reaction times compared to the 2-back, which will be slower than the 1-back.

Hypothesis 2c: There will be an interaction between mood state induction and memory load in that those in the negative mood state induction group will have slower reaction times, but no difference in accuracy, on the 3-back memory load than those in the neutral mood state induction group, even when controlling for trait anxiety.

General Method

Overview

In the experiments reported below, a mood induction technique was used prior to having participants perform one of the two computer-based cognitive tasks. The tasks were divided into two separate experiments to ensure that the mood state induction would last throughout the entire task. It was unclear if the mood state induction would last long enough for each participant to complete two tasks; therefore each participant completed one task.

Measures
Demographics questionnaire and inclusion criteria. To ensure participants were eligible, inclusion criteria was gauged via a questionnaire assessing whether or not the individual is over the age of 18, has no psychiatric diagnosis, was not currently on beta-blockers or other medication(s) that may impact his/her stress response, and was not currently under the influence of alcohol or illicit drugs. To obtain the demographic data of the sample, participants were asked to complete a questionnaire assessing age, gender, race, ethnicity, and years of education (see Appendix A).

Anxiety. The State-Trait Anxiety Inventory (STAI; see Appendices B and C; Spielberger, Gorssuch, Lushene, Vagg, & Jacobs, 1983) is a commonly used measure to assess anxiety. It is a 40-item self-report inventory based on a 4-point Likert scale (1 = not at all, 4 = very much so) that differentiates state and trait anxiety from anxiety-present and anxiety-absent components. Twenty items pertain to state anxiety and 20 items pertain to trait anxiety, thus participants in this study only answered the 20 items that pertain to trait anxiety. Higher scores indicate higher levels of anxiety. As mentioned previously, trait anxiety can be viewed as a personality dimension while state anxiety can be viewed as a situational dimension (Crowe et al., 2007), with both interacting with one another to ultimately determine an individual’s overall level of anxiety at any given time (Dresler et al., 2009).

In an investigation of the reliability of the STAI (Barnes, Harp, & Jung, 2002), the measures demonstrated excellent internal consistency, and the STAI Trait has evidenced excellent test-retest reliability at multiple time intervals (Gros, Antony, Simms, & McCabe, 2007). However, it has been argued that the STAI does not adequately assess
anxiety as distinct from depression due to the presence of a Depression factor (Gros et al., 2007). Therefore, in order to control for this finding, a depression assessment, the Beck Depression Inventory, was administered.

**Depression.** The Beck Depression Inventory, second version (BDI-II; see Appendix D) is a 21-item self-report measure that assesses common symptoms of depression based on a 4-point Likert scale ranging from 0 (*not at all*) to 3 (*severely*—I could barely stand it). A total score ranging from 0-63 is calculated by summing the severity ratings for all 21 items, with the higher the score indicating the higher degree of depression. The internal consistency of the BDI-II was demonstrated to be good (Beck, Steer, Ball, & Ranieri, 1996) and the 1-week test-retest reliability was shown to be high (Beck, Steer, & Brown, 1996).

**Mood State Induction.**

There were two valences of mood state induction: neutral and negative. The control group viewed a slideshow containing 36 neutral images (see Appendix F) selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). The images ranged in valence from 4 – 6 (average), and ranged in arousal from 1.4 – 4 (low; Conklin & Perkins, 2005). Each image was shown for five seconds each, with a 200 ms blank screen between each slide. The slideshow lasted three minutes.

The experimental group viewed a slideshow containing 36 negative IAPS images (see Appendix E). The images ranged in valence from 1 to 3.5 (low), and ranged in arousal from 4.5 – 7.5 (high).
Mood state manipulation check. To assess the efficacy of the mood state induction, a pilot study was conducted including 20 individuals. These individuals were first shown the neutral slideshow, and then asked to fill out the state portion of the State Trait Anxiety Inventory. Next, they were shown the negative slideshow, and asked to fill out the questionnaire again. A paired samples t test was conducted on anxiety scores for the neutral and negative images to determine if there was a significant increase in anxiety levels after the negative images. Individuals involved in the pilot testing were excluded from the experiments.

Procedure

Participants began by completing the informed consent (see Appendix G), as well as the demographic questionnaire. Participants then conducted two practice blocks for one of the two tasks, to ensure they understood the rules. Upon completing the practice blocks, participants were given the trait portion of the STAI and the BDI-II to fill out. Participants then completed one of the two tasks, outlined in detail below.

Experiment 1 – Attentional Bias

Method

Participants. A convenience sample of undergraduate students (n = 60) at the University of South Carolina Aiken, volunteered for the study by signing up through the online recruiting system SONA. For students enrolled in an introductory psychology course, course credit was awarded for their participation. No other compensation for participation was offered. See tables 1 and 2 for power analysis output, and see table 3 for demographic data.
Emotional Stroop. A variation of the e-Stroop was used consisting of threat, positive and neutral words (see Appendix F). The stimuli were presented on a Dell computer screen using E-prime 2.0 ®. The words were presented in one of three colors (red, blue, or green). For each trial, a fixation cross appeared for 500 ms then the word appeared for 1,000 ms or until a response was recorded, at which time the fixation cross reappeared. There was a random intertrial interval between 200 and 750 ms. The paradigm had two block types, threat and positive, and these blocks were counter-balanced. In the threat block, threat and neutral words were randomly presented with equal probability, and in the positive block, positive and neutral words were randomly presented with equal probability. Valenced words were matched to neutral words for length and frequency of use (Taake, Jaspers-Fayer, & Liotti, 2009). The task consisted of two blocks (1 threat and 1 positive), each consisting of 24 trials, for a total of 48 trials. Participants began with a practice block for each block type with a required accuracy of 70% to ensure they understood the rules of the task. Participants were instructed to maintain central fixation and determine the color of the ink while ignoring the meaning of each word. Participants responded by pressing one of three response keys on the keyboard, and response mapping remained on the computer screen throughout the duration of the entire task so that participants did not have to memorize each color for each key. Both speed and accuracy were emphasized. Average reaction time was calculated for each trial type and emotional block. Only reaction times for correct trials were used in reaction time analysis.
Half of the participants (n=30) were placed in the control group and half of the participants (n=30) were placed in the experimental group via random assignment. Each group viewed the corresponding image slideshow, and then completed the STAI and BDI-II questionnaires, and then the e-Stroop task.

After completing the task, participants were given the chance to ask any questions about the experiment, and were thanked for their time upon leaving.

Results

**Mood State Manipulation Check.** A pilot study was conducted prior to the experiment to assess the efficacy of the mood state induction that used negative and neutral IAPS images. A paired samples t-test was conducted on averaged STAI-S anxiety scores reported after viewing neutral then negative IAPS images to determine if there was a significant increase in anxiety levels after the negative images were shown. There was a significant increase in anxiety scores from before ($M = 1.72, SD = .55$) to after ($M = 2.52, SD = .76$) the negative images were viewed, $t(19) = 5.06, p < .001$, and represented a medium-sized effect, $r = .69$. The significant results of our pilot study enabled us to extrapolate that those subjects in the negative mood induction group, the experimental group, would experience state anxiety after viewing the negative images.

**e-Stroop Behavioral Data Analysis.** Prior to statistical analyses, data were entered into a spreadsheet, and screened for data-entry accuracy and missing values. All statistical analyses were conducted using SPSS software (version 24). Only correct responses on the tasks were used in computing the averages for reaction times on trial types for each hypothesis, and any reaction times that were greater than three standard
deviations away from the mean were thrown out, due to being outliers. Of the 60 subjects who completed the e-Stroop task, four individuals (2.4%) were excluded due to poor performance (accuracy less than 65%), for a total of 56 subjects. Two separate 3 (threat, positive, neutral words) x 2 (neutral or negative mood state induction) repeated measures analysis of covariance (ANCOVA) on reaction time and accuracy, with trait anxiety as the covariate, were conducted. Hypothesis 1a stated that there would be a main effect of mood state induction on reaction time in that those in the negative mood state induction group will have slower reaction times on the e-Stroop than those in the neutral group, independent of word type. The results show that there was a main effect of group, $F(1, 26.85) = 15.314, p < .001$, in that those in the mood state induction group were more accurate overall than those in the neutral group, independent of word type. However, reaction times for the mood state induction group were not significantly slower than reaction times for the neutral group, $F(1.5, 88.47) = 1.51, p = .307$. Therefore, these data provide no support for hypothesis 1a.

Hypothesis 1b stated that there would be a main effect of word type in that threat words would elicit slower reaction times, but no difference in accuracy, compared to both neutral and positive words, independent of mood state induction. A one-way repeated-measures ANCOVA was computed to compare accuracy for threat, neutral, and positive words. The results show that there was no difference in accuracy between the three word types, $F(2, 106) = .362, p = .697$. Furthermore, reaction times for threat words were not significantly slower than reaction times for neutral or positive words, $F(2, 100) = .064, p = .938$. These data provide no support for hypothesis 1b.
Hypothesis 1c stated that there would be an interaction between mood state induction and word type in that those in the negative mood state induction group will have slower reaction times on threat words, but no difference in accuracy, than those in the neutral mood state induction group. The results show that there was no difference in accuracy between the two groups and threat words, $F(2, 106) = 2.157, p = .121$. There was also no significant differences in reaction times on threat words for those in the negative mood state induction group compared to the reaction times on threat words for those in the neutral group, $F(2, 100) = .987, p = .376$. These data provide no support for hypothesis 1c. See tables 4 and 5 for descriptive statistics for accuracy and reaction times, respectively.

**Discussion**

While there is a lack of research focusing on state anxiety and reaction time with respect to working memory (discussed later) and attentional bias, the studies that are available tend to have mixed results. Some studies suggest state anxiety has significant impact on reaction time, while other studies suggest the opposite. The present study falls into the category of showing that state anxiety has no significant impact on reaction time.

Participants in the mood induction group responded more accurately to all word types than participants in the control group, however, there was no significant difference in reaction times between the two groups. The vast majority of research indicates that there is typically no difference in accuracy between the control group and the mood induction group, however, one study did show similar findings to the present study. Brand, Verspui, and Oving (1997) found that the least amount of errors on the Stroop
task was evident in the mood induction group as opposed to the control group. However, it is important to point out that this study did not include the emotional Stroop task, but rather the original Stroop task, as well as the mood induction group consisting of a state of depression as opposed to anxiety.

It appears that there is a discrepancy when it comes to how much of an impact anxiety has on attentional bias. One argument states that anxiety does have an impact on reaction time, in that it is slowed down. The process by which this occurs is referred to as the stimulus-driven attentional system (Eysenck et al., 2007), which is when the anxious participant is unable to maintain attention on the task at hand, due to the inability to ignore the threatening stimuli. On the other hand, some research shows that anxiety does have an impact on reaction time, but in the opposite direction, namely that it is sped up. Anxious individuals have faster reaction times on threatening stimuli than on neutral or positive stimuli, suggesting that the threatening stimuli again capture attention more so than neutral or positive stimuli. Of course, then there is the fact that anxiety can be broken down into state and trait anxiety, and this leads to even more discrepancy on which kind of anxiety impacts reaction time, and/or if there is an interaction between the two (such as described in Egloff & Hock, 2001). However, as discussed later in “Study Limitations”, there is the possibility that “state anxiety” specifically was not accurately induced in the participants in this study.

The other argument states that anxiety does not have an impact on reaction time, as evidenced by various studies, including Byrne & Eysenck (1995), which was discussed
ANXIETY AND ATTENTIONAL BIAS AND WORKING MEMORY

above. And again, anxiety can be broken down into trait and state anxiety in regards to whether one or the other (or both interacting) leads to this conclusion.

Experiment 2 – Working Memory

Method

Participants. A convenience sample of undergraduate students (n= 60) at the University of South Carolina Aiken, volunteered for the study. For students enrolled in an introductory psychology course, course credit was awarded for their participation. No other compensation for participation was offered. If students participated in the e-Stroop experiment, they were not permitted to participate in the n-back experiment because they had already seen the images once, therefore the mood state induction would not have the same impact on them if they viewed the images a second time. See table 3 for demographic data.

N-back. In this paradigm, eight letters (B, F, K, H, M, Q, R, X; Kane, Conway, Miura, & Colflesh, 2007) were presented on the same Dell computer screen as Experiment 1, using Presentation ®. Each letter was displayed for 400 ms, followed by 2,000 ms interstimulus interval during which time the screen was blank. Participants were asked to respond yes or no to items that appear 1-back, 2-back, or 3-back. The blocks were not counter-balanced. A yes response meant that the current item matches the item n back. Participants clicked the left button of the mouse to signify that yes the item currently on the screen matches the item n back. Participants began with a practice block for each of the three n-back types (1-back, 2-back, and 3-back), with a required accuracy of 70% to ensure they understood the task rules. Next, participants completed three
experimental blocks of 48 trials each. One block consisted entirely of 1-back trials, one entirely of 2-back trials, and one of 3-back trials. Each block was presented a sequence of 48 letters, with each of the eight possible letters appearing six times within the sequence. Participants were asked to respond as quickly and accurately as possible. The participant was able to begin the next experimental block when he/she was ready via pressing the left button of the mouse.

Results

N-back Behavioral Data Analysis. Prior to statistical analyses, data were entered into a spreadsheet, and screened for data-entry accuracy and missing values. All statistical analyses were conducted using SPSS software (version 24). “Correct rejections” and “misses” (errors of omission, or not responding to a target) were not used in analyses, as these would not provide a reaction time since they do not require a physical response by the participant. “False alarm” (errors of omission, or responding for non-targets) reaction times were not used in analyses either, as these are incorrect responses, and only correct responses were used in computing the averages for reaction times on trial types for each hypothesis. Reaction times for hits below 100 ms were not used in analyses, as this quick of a response is often a “knee-jerk” reaction, as opposed to a purposeful response by the participant. Two separate 3 (1-back, 2-back, 3-back) x 2 (neutral or negative mood state induction) repeated measures analysis of covariance (ANCOVA) on reaction time and accuracy, with trait anxiety as the covariate, was conducted. Of the 60 subjects that completed the N-back, 5 individuals were excluded due to task non-compliance (i.e., subjects not responding according to directions).
Hypothesis 2a stated that there would be a main effect of mood state induction in that those in the negative mood state induction group would have slower reaction times, but no difference in accuracy, on the n-back than those in the neutral group, independent of memory load, and controlling for trait anxiety. An ANCOVA was computed to compare the accuracy for those in the negative mood state induction group to those in the neutral group. The results show that there is no significant difference in accuracy between the two groups, $F(1, 7917) = .045, p = .832$. A one-way repeated-measures ANCOVA was computed to compare the reaction times for those in the negative mood state induction group to those in the neutral group. The results show that the reaction times for those in the negative mood state induction group were significantly faster than reaction times for those in the neutral group, $F(1, 1078) = 11.97, p = .001$. These data provide no support for hypothesis 2a, and in fact show the complete opposite of what was being hypothesized.

Hypothesis 2b stated that there would be a main effect of memory load in that the 3-back (the most challenging memory load) would demonstrate slower reaction times compared to the 2-back, which will be slower than the 1-back. A one-way repeated measures ANOVA was computed to compare the reaction times for all three memory loads. The results indicated that there was a significant difference in the reaction times for the memory loads, $F(2, 1078) = 11.72, p < .001$. Bonferroni post-hoc analysis indicated that the 1-back is significantly faster than both the 2-back ($p = .001$) and the 3-back ($p < .001$). These data provide support for hypothesis 2b.
Hypothesis 2c stated that there would be an interaction between mood state induction and memory load in that those in the negative mood state induction group would have slower reaction times, but no difference in accuracy, on the 3-back memory load than those in the neutral mood state induction group, even when controlling for trait anxiety. One subject was excluded for getting a “below chance” average on accuracy. A repeated measures ANCOVA was conducted to compare accuracy on the 3-back memory load between the two groups. The results indicated that there was no interaction between group and load, \( F(2, 104) = 1.854, p = .162 \). A repeated measures ANCOVA was conducted to compare the reaction times on the 3-back memory load between the two groups. The results indicated that there was not a significant difference in the reaction times between the two groups on the varying memory loads, \( F(2, 94) = 1.385, p = .255 \). These data provide no support for hypothesis 2c. See tables 6 and 7 for descriptive statistics for accuracy and reaction times, respectively.

**Discussion**

For the most part, previous studies have shown that anxiety (trait anxiety in particular) negatively impacts working memory; there is not much research suggesting that trait anxiety does not impact working memory. Furthermore, there is not a lot of research that focuses on state anxiety in regards to working memory. Thus, this study is in the minority with its’ findings. However, it does suggest that state anxiety does not have a significant impact on working memory.

There was a significant difference in reaction times between the 1-back memory load and the 2- and 3-back memory loads, in that reaction times on the 1-back memory
load were significantly faster than the other two memory loads. This finding was not hypothesized, however it does suggest that the 2- and 3-back memory loads were significantly harder than the 1-back memory load.

There was also a significant difference in reaction times between the mood induction group and the control group, just not in the direction that was expected. Instead of participants in the mood induction group being slower, they were actually faster than the control group. Patel et al. (2015) found somewhat similar results, however the significant difference in reaction times was evident only on the 3-back memory load, not the 2- or 1-back memory loads. Participants in the mood induction group demonstrated faster reaction times on the 3-back memory load, than participants in the control group (Patel et al., 2015). The researchers induced a state of anxiety via an “aversive loud scream” intended to be “threatening” to the individual, and then measured this reaction via eyeblink startle (Patel et al., 2015). However, results from this study also indicated a difference in accuracy between the two groups as well (lower accuracy for the mood induction group), which was not evident in the present study. Thus, while most research suggests that an induced state of anxiety will lead to slower reaction times on working memory tasks, there are some studies that find the opposite of this finding, indicating varying results on this topic in the field as a whole.

General Discussion

It is worth discussing the varying results between the e-Stroop task and the \( n \)-back task. The e-Stroop task contains an emotional element to it, while the \( n \)-back task does not. This might explain why the mood induction did not negatively impact the reaction
times on the $n$-back task, but does impact the accuracy rates on the e-Stroop. As mentioned previously, the participants in the mood induction group responded more accurately to all word types than the control group. This suggests that the negative emotional content of the words did in fact have some sort of an impact on the participants’ performance. Thus, while “state anxiety” itself may not have been induced, it appears that some sort of negative emotional state was induced, which then had an impact on the participants’ performance. Perhaps this negative emotional state was also induced in those that completed the $n$-back task, but since there is no negative emotional content in the task, we do not see a significant decrease in reaction times.

Another possible explanation for the unexpected results is the “Yerkes-Dodson law” (Teigen, 1994).Originally discovered by two researchers, Yerkes and Dodson, in 1908, the law generally states that there is an optimal level of “arousal” for an optimal performance, and that it is possible for an individual to be “over-aroused,” which leads to a decline in performance (Teigen, 1994). Thus, since the paired samples t-test that was conducted on the pilot study data showed that a negative mood state was induced, it is possible that this actually led to a state of “over-arousal” in participants, leading to the uncommon performance.

**Study Limitations**

The present study had numerous limitations that warrant discussion. The first limitation involves the mood state induction. Although the paired samples $t$-test that was conducted on the data received from the pilot study shows that there was a significant decrease in mood state, there is still a possibility that “state anxiety” was not actually
induced in the participants. The criteria used in selecting pictures for the negative group was based on a previous study that involved inducing a “negative mood state” (Conklin & Perkins, 2005), in which the researchers used images ranging in valence from 1 to 3.5 (which is considered low), and range in arousal from 4.5 to 7.5 (which is considered high). It could be that, while the slideshow induced a “negative mood state,” this differs from “state anxiety” in important ways, especially in regards to reaction time to negative (anxious) words.

Ozawa and colleagues (2014) used images from the IAPS to induce a negative mood state as well, and their results indicated that these pictures induced an “unpleasant emotional state.” The authors concluded that this “unpleasant emotional state” is presumably similar to anxiety (Ozawa, Matsuda, & Hiraki, 2014). Therefore, being “similar” to anxiety does not mean that a feeling of anxiety was actually induced. This difference might be critically important in future studies focusing specifically on “state anxiety.” Utilizing a mood induction scenario that focuses specifically on state anxiety as opposed to a more generalized negative mood state might yield more significant differences in reaction times.

Lastly, when using pictures to induce state anxiety, ensuring the pictures match the threat words that are used in the e-Stroop task may prove useful in seeing the kind of results that were hypothesized. For example, focusing on one specific type of anxious pictures (i.e., snakes) and then having the emotional words correspond to snakes might heighten the state anxiety that was induced, which in turn might lead to a significant
difference in reaction times. In this study, the pictures did not specifically match the words shown in the e-Stroop, which could be considered a limitation.

In regards to whether or not state anxiety was actually induced, another problem may be that the STAI that was utilized is not an accurate measure for state anxiety in particular. Past research (Gros et al., 2007) has indicated that the STAI may not assess anxiety as distinct from depression, thus the BDI-II was utilized in the present study to account for this possibility. A Pearson correlation analysis between the STAI and BDI-II scores revealed that these two are in fact correlated, \( r = .79, p < .001 \). Therefore, this study suggests that a more adequate measure than the STAI should be used when gauging state and/or trait anxiety levels.

Another limitation involves the number of trials for both tasks. In this study, the e-Stroop task was comprised of two blocks (one threat and one positive), each consisting of 24 trials, for a total of 48 trials. Having more trials would have yielded more reaction time data to be analyzed, which would have made the analyses much more powerful (Taake, Jaspers-Fayer, & Liotti, 2009). For example, Taake, Jaspers-Fayer, and Liotti (2009) had six blocks (three threat and three positive), each consisting of 120 trials, and order of presentation was counterbalanced across participants. The n-back task in this study was made up of three experimental blocks (1-back, 2-back, and 3-back), each comprised of 48 trials. In Kane et al. (2007), eight experimental blocks were used (48 trials per block), with four blocks per memory load (they only looked at 2 and 3-back memory loads). Thus, on top of the smaller number of trials, this study also had only one block per memory load, while having numerous blocks per memory load may have
yielded more powerful results as well. Finally, in Kane et al. (2007), the order of memory loads that were presented were counter-balanced, such that the 2 and 3-back presentations were alternating, while this study had each participant complete the 1, 2 and 3-back memory loads in the same order.

Overall, this study did not add evidence to the viewpoint that state anxiety impairs working memory or attentional bias. Participants that completed the n-back task after the mood state induction did not show significantly slower reaction times than the participants that were in the control group, and in fact showed faster reaction times. The greatest difference in reaction times was between the 1-back memory load when compared to the 2- and 3-back memory loads, and this finding includes all participants, not just those in the mood state induction group. Thus, this finding does not appear to involve the negative mood state induction, and has more to do with the difficulty of the task.

Participants that completed the e-Stroop task after the mood state induction did not show significantly slower reaction times on any of the words than the participants that were in the control group. However, the accuracy rates for those in the mood state induction group were significantly higher on all word types than those in the control group. This suggests that, while state anxiety may not have been induced via the mood induction, some sort of negative mood was induced. This negative mood state may have led to the participants being more hypervigilant overall during the task. Thus, it is reasonable to assume that if another form of mood state induction was employed that
actually induces state anxiety as opposed to a more general negative feeling, that the participants would have had the outcomes that were hypothesized.

However, another interesting result is that, if a negative mood state was induced, this led to the participants becoming more vigilant, suggesting that this negative mood state did interfere with attentional bias, but not in the way that was expected. Instead of the mood state causing the participants to become distracted so much so that they cannot respond as quickly, the mood state caused the participants to focus even more so on the task, leading to more accurate responses. This finding could be explained by the goal-directed attentional system. Perhaps the negative mood state that was induced falls into the goal-directed attentional system as opposed to the stimulus-driven attentional system, and thus the participants were able to continue to focus on the task at hand even with the distractive stimuli. Future studies could examine this finding in depth in order to see what kind of negative mood states lead to more hypervigilant tendencies and/or which negative mood states, such as state anxiety, lead to the participants becoming distracted.
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References


*Neuroscience, 4*, 829-839. doi: 10.1038/nrn1201.


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http://doi.org/10.1016/j.cpr.2007.05.006


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LoBue, V. (2013). What are we so afraid of? How early attention shapes our most common fears. *Child Development Perspectives, 7*, 38-42.

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Depression and Anxiety Inventories. *Behavior Research and Therapy*, 33, 335-343. https://doi.org/10.1016/0005-7967(94)00075-U


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### Table 1

*Power Analysis Input for an a-priori Repeated Measures F Test*

<p>| | |</p>
<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Effect size f</td>
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</tr>
<tr>
<td>( \alpha ) err prob</td>
<td>0.05</td>
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<tr>
<td>Power (1–( \beta ) err prob)</td>
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<td>Number of measurements</td>
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<tr>
<td>Corr among rep measures</td>
<td>0.25</td>
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<td>Nonsphericity correction ( \varepsilon )</td>
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Table 2

*Power Analysis Output for an a-priori Repeated Measures F Test*

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<td>Noncentrality parameter $\lambda$</td>
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<tr>
<td>Denominator df</td>
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<td>Total sample size</td>
<td>58</td>
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<tr>
<td>Actual power</td>
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Table 3

**Summary (Means & Standard Deviations or Frequencies) for Demographic Characteristics and Psychological Assessments**

<table>
<thead>
<tr>
<th></th>
<th>e-Stroop ((n = 56))</th>
<th>N-back ((n = 56))</th>
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</thead>
<tbody>
<tr>
<td><strong>Demographic Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>38/18</td>
<td>28/27</td>
</tr>
<tr>
<td>Age</td>
<td>20.26 (5.87)</td>
<td>19.42 (1.83)</td>
</tr>
<tr>
<td>Education</td>
<td>12.21 (.65)</td>
<td>12.13 (.32)</td>
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<tr>
<td><strong>Psychological Assessments</strong></td>
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<td></td>
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<tr>
<td>STAI</td>
<td>40.09 (10.67)</td>
<td>39.49 (8.51)</td>
</tr>
<tr>
<td>BDI-II</td>
<td>12.08 (7.85)</td>
<td>11.11 (7.97)</td>
</tr>
</tbody>
</table>

*Note. STAI = State Trait Anxiety Inventory; BDI-II = Beck Depression Inventory, 2nd edition*
Table 4

*Descriptive Statistics for Accuracy for Correct Trials for e-Stroop by Word Type and by Group*

<table>
<thead>
<tr>
<th>Word Valence</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
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<td>.92</td>
<td>.19</td>
<td>28</td>
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<td></td>
<td>2</td>
<td>.94</td>
<td>.05</td>
<td>28</td>
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<td>56</td>
</tr>
<tr>
<td>positive</td>
<td>1</td>
<td>.90</td>
<td>.19</td>
<td>28</td>
</tr>
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<td></td>
<td>2</td>
<td>.95</td>
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<td>.93</td>
<td>.15</td>
<td>56</td>
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<tr>
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<td>.90</td>
<td>.19</td>
<td>28</td>
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<td></td>
<td>2</td>
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<td>Total</td>
<td>.94</td>
<td>.14</td>
<td>56</td>
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*Note.* Group 1 is the control group and group 2 is the mood induction group.

*Note.* SD = Standard Deviation.

N = Total number of participants.
Table 5

*Descriptive Statistics for Reaction Times for Correct Trials for e-Stroop by Word Type and by Group*

<table>
<thead>
<tr>
<th>Word Valence</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
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<td></td>
<td>Total</td>
<td>569.98</td>
<td>87.12</td>
<td>53</td>
</tr>
<tr>
<td>positive</td>
<td>1</td>
<td>579.78</td>
<td>102.88</td>
<td>26</td>
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<td></td>
<td>2</td>
<td>569.80</td>
<td>104.14</td>
<td>27</td>
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<td></td>
<td>Total</td>
<td>574.70</td>
<td>102.65</td>
<td>53</td>
</tr>
<tr>
<td>threat</td>
<td>1</td>
<td>558.47</td>
<td>88.38</td>
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<td></td>
<td>2</td>
<td>570.52</td>
<td>80.62</td>
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<td>564.61</td>
<td>83.92</td>
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</tr>
</tbody>
</table>

*Note.* Group 1 is the control group and group 2 is the mood induction group.

*Note.* SD = Standard Deviation.

N = Total number of participants.
Table 6

Descriptive Statistics for Accuracy for Correct Trials for N back by Memory Load and by Group

<table>
<thead>
<tr>
<th>Memory Load</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>.90</td>
<td>.15</td>
<td>26</td>
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<tr>
<td></td>
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<td>55</td>
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<td>Total</td>
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<td>.12</td>
<td>55</td>
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</table>

Note. Group 1 is the control group and group 2 is the mood induction group.

Note. SD = Standard Deviation.

N = Total number of participants.
Table 7

*Descriptive Statistics for Reaction Times for Correct Trials for N back by Memory Load and by Group*

<table>
<thead>
<tr>
<th>Memory Load</th>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
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<td>2</td>
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</tbody>
</table>

*Note.* Group 1 is the control group and group 2 is the mood induction group.  
*Note.* SD = Standard Deviation.  
N = Total number of participants.
Appendix A

Demographic Questionnaire

Subject ID: _____________________  Age: ___

Gender:  □ Male  □ Female  □ Transgender

Racial/Ethnic identification:  □ American Indian  □ Hispanic or Latino/a
                                  □ Asian  □ Pacific Islander
                                  □ Black or African American  □ White or Caucasian
                                  □ Other

Highest level of education completed: ____________

Do you currently have a psychiatric diagnosis? (Such as ADHD, depression, or an anxiety disorder):  □ Yes  □ No

Please list any medication(s) you are currently taking:
__________________________________________________

__________________________________________________

Are you currently under the influence of alcohol and/or illicit drugs?:  □ Yes  □ No

If yes, how long (in hours) has it been since you used either?:  ____
### Appendix B

State-Trait Anxiety Inventory – State

**SELF-EVALUATION QUESTIONNAIRE: STAI Form Y-1**

Please provide the following information:

Name________________________ Date__________ S________

Age______________ Gender (Circle)  M  F  T________

**DIRECTIONS:**

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

- **1.** I feel calm…………………………………………………………………………………………………………………………1 2 3 4
- **2.** I feel secure……………………………………………………………………………………………………………………1 2 3 4
- **3.** I am tense…………………………………………………………………………………………………………………………1 2 3 4
- **4.** I feel strained……………………………………………………………………………………………………………………1 2 3 4
- **5.** I feel at ease…………………………………………………………………………………………………………………………1 2 3 4
- **6.** I feel upset…………………………………………………………………………………………………………………………1 2 3 4
- **7.** I am presently worrying over possible misfortunes…………………………………………………………………………1 2 3 4
- **8.** I feel satisfied…………………………………………………………………………………………………………………………1 2 3 4
- **9.** I feel frightened……………………………………………………………………………………………………………………1 2 3 4
- **10.** I feel comfortable………………………………………………………………………………………………………………1 2 3 4
- **11.** I feel self-confident………………………………………………………………………………………………………………1 2 3 4
- **12.** I feel nervous…………………………………………………………………………………………………………………………1 2 3 4
- **13.** I am jittery…………………………………………………………………………………………………………………………1 2 3 4
- **14.** I feel indecisive…………………………………………………………………………………………………………………………1 2 3 4
- **15.** I am relaxed…………………………………………………………………………………………………………………………1 2 3 4
- **16.** I feel content…………………………………………………………………………………………………………………………1 2 3 4
- **17.** I am worried…………………………………………………………………………………………………………………………1 2 3 4
- **18.** I feel confused…………………………………………………………………………………………………………………………1 2 3 4
- **19.** I feel steady…………………………………………………………………………………………………………………………1 2 3 4
- **20.** I feel pleasant…………………………………………………………………………………………………………………………1 2 3 4

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STAIP-AD Test Form Y
www.mindgarden.com
Appendix C

State-Trait Anxiety Inventory – Trait

SELF-EVALUATION QUESTIONNAIRE
STAI Form Y-2

Name ___________________________ Date ________________

DIRECTIONS
A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

21. I feel pleasant .................................................. 1 2 3 4

22. I feel nervous and restless ..................................... 1 2 3 4

23. I feel satisfied with myself ...................................... 1 2 3 4

24. I wish I could be as happy as others seem to be .......... 1 2 3 4

25. I feel like a failure ................................................ 1 2 3 4

26. I feel rested ...................................................... 1 2 3 4

27. I am "calm, cool, and collected" ........................... 1 2 3 4

28. I feel that difficulties are piling up so that I cannot overcome them ... 1 2 3 4

29. I worry too much over something that really doesn't matter .... 1 2 3 4

30. I am happy ........................................................ 1 2 3 4

31. I have disturbing thoughts ..................................... 1 2 3 4

32. I lack self-confidence ............................................ 1 2 3 4

33. I feel secure ...................................................... 1 2 3 4

34. I make decisions easily ......................................... 1 2 3 4

35. I feel inadequate ................................................ 1 2 3 4

36. I am content ..................................................... 1 2 3 4

37. Some unimportant thought runs through my mind and bothers me ... 1 2 3 4

38. I take disappointments so keenly that I can’t put them out of my mind ... 1 2 3 4

39. I am a steady person ............................................ 1 2 3 4

40. I get in a state of tension or turmoil as I think over my recent concerns and interests .................................................. 1 2 3 4
# Appendix D

**Beck Depression Inventory-II**

<table>
<thead>
<tr>
<th>Name</th>
<th>Marital Status</th>
<th>Age</th>
<th>Sex</th>
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</thead>
<tbody>
<tr>
<td>Occupation</td>
<td>Education</td>
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<td></td>
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</tbody>
</table>

**Instructions:** This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

### 1. Sadness
- 0 I do not feel sad.
- 1 I feel sad much of the time.
- 2 I am sad all the time.
- 3 I am so sad or unhappy that I can’t stand it.

### 2. Pessimism
- 0 I am not discouraged about my future.
- 1 I feel more discouraged about my future than I used to be.
- 2 I do not expect things to work out for me.
- 3 I feel my future is hopeless and will only get worse.

### 3. Past Failure
- 0 I do not feel like a failure.
- 1 I have failed more than I should have.
- 2 As I look back, I see a lot of failures.
- 3 I feel I am a total failure as a person.

### 4. Loss of Pleasure
- 0 I get as much pleasure as I ever did from the things I enjoy.
- 1 I don’t enjoy things as much as I used to.
- 2 I get very little pleasure from the things I used to enjoy.
- 3 I can’t get any pleasure from the things I used to enjoy.

### 5. Guilty Feelings
- 0 I don’t feel particularly guilty.
- 1 I feel guilty over many things I have done or should have done.
- 2 I feel quite guilty most of the time.
- 3 I feel guilty all of the time.

### 6. Punishment Feelings
- 0 I don’t feel I am being punished.
- 1 I feel I may be punished.
- 2 I expect to be punished.
- 3 I feel I am being punished.

### 7. Self-Dislike
- 0 I feel the same about myself as ever.
- 1 I have lost confidence in myself.
- 2 I am disappointed in myself.
- 3 I dislike myself.

### 8. Self-Criticalness
- 0 I don’t criticize or blame myself more than usual.
- 1 I am more critical of myself than I used to be.
- 2 I criticize myself for all of my faults.
- 3 I blame myself for everything bad that happens.

### 9. Suicidal Thoughts or Wishes
- 0 I don’t have any thoughts of killing myself.
- 1 I have thoughts of killing myself, but I would not carry them out.
- 2 I would like to kill myself.
- 3 I would kill myself if I had the chance.

### 10. Crying
- 0 I don’t cry any more than I used to.
- 1 I cry more than I used to.
- 2 I cry over every little thing.
- 3 I feel like crying, but I can’t.
### ANXIETY AND ATTENTIONAL BIAS AND WORKING MEMORY

#### 11. Agitation
0 I am no more restless or wound up than usual.
1 I feel more restless or wound up than usual.
2 I am so restless or agitated that it’s hard to stay still.
3 I am so restless or agitated that I have to keep moving or doing something.

#### 12. Loss of Interest
0 I have not lost interest in other people or activities.
1 I am less interested in other people or things than before.
2 I have lost most of my interest in other people or things.
3 It’s hard to get interested in anything.

#### 13. Indecisiveness
0 I make decisions as well as ever.
1 I find it more difficult to make decisions than usual.
2 I have much greater difficulty in making decisions than I used to.
3 I have trouble making any decisions.

#### 14. Worthlessness
0 I do not feel I am worthless.
1 I don’t consider myself as worthwhile and useful as I used to.
2 I feel more worthless as compared to other people.
3 I feel utterly worthless.

#### 15. Loss of Energy
0 I have as much energy as ever.
1 I have less energy than I used to have.
2 I don’t have enough energy to do very much.
3 I don’t have enough energy to do anything.

#### 16. Changes in Sleeping Pattern
0 I have not experienced any change in my sleeping pattern.
1a I sleep somewhat more than usual.
1b I sleep somewhat less than usual.
2a I sleep a lot more than usual.
2b I sleep a lot less than usual.
3a I sleep most of the day.
3b I wake up 1-2 hours early and can’t get back to sleep.

#### 17. Irritability
0 I am no more irritable than usual.
1 I am more irritable than usual.
2 I am much more irritable than usual.
3 I am irritable all the time.

#### 18. Changes in Appetite
0 I have not experienced any change in my appetite.
1a My appetite is somewhat less than usual.
1b My appetite is somewhat greater than usual.
2a My appetite is much less than before.
2b My appetite is much greater than usual.
3a I have no appetite at all.
3b I crave food all the time.

#### 19. Concentration Difficulty
0 I can concentrate as well as ever.
1 I can’t concentrate as well as usual.
2 It’s hard to keep my mind on anything for very long.
3 I find I can’t concentrate on anything.

#### 20. Tiredness or Fatigue
0 I am no more tired or fatigued than usual.
1 I get more tired or fatigued more easily than usual.
2 I am too tired or fatigued to do a lot of the things I used to do.
3 I am too tired or fatigued to do most of the things I used to do.

#### 21. Loss of Interest in Sex
0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I am much less interested in sex now.
3 I have lost interest in sex completely.

---

**NOTICE:** This form is printed with blue and black ink. If your copy does not appear this way, it has been photocopied in violation of copyright laws.
Appendix E

International Affective Picture System Slides Used in Each Mood State Induction Condition

Negative

\[ N = 36 \]

\[ 1050, 1275, 1525, 2301, 2691, 2692, 2751, 2811, 3216, 4621, 5971, 6020, 6220, 6300, 6360, 6370, 6821, 6834, 7135, 7136, 7380, 8485, 9002, 9102, 9300, 9341, 9417, 9470, 9620, 9621, 9800, 9831, 9900, 9908, 9930, 9941. \]

Neutral

\[ N = 36 \]

\[ 2191, 2393, 2411, 2579, 2593, 2880, 2980, 5040, 5471, 5520, 5740, 6150, 7000, 7001, 7002, 7003, 7004, 7009, 7010, 7012, 7017, 7026, 7032, 7039, 7052, 7059, 7061, 7090, 7130, 7140, 7150, 7175, 7185, 7945, 7547. \]
Appendix F

Emotional Stroop Words

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<th>Neutral</th>
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<tr>
<td>Asthma</td>
<td>Humor</td>
<td>Helmet</td>
</tr>
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<td>Collapse</td>
<td>Fairness</td>
<td>Township</td>
</tr>
<tr>
<td>Stress</td>
<td>Energy</td>
<td>Season</td>
</tr>
<tr>
<td>Panic</td>
<td>Honey</td>
<td>Slope</td>
</tr>
<tr>
<td>Sweat</td>
<td>Glory</td>
<td>Clock</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Comfort</td>
<td>Journal</td>
</tr>
<tr>
<td>Dizzy</td>
<td>Super</td>
<td>Tenth</td>
</tr>
<tr>
<td>Suffering</td>
<td>Desirable</td>
<td>Automatic</td>
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<tr>
<td>Seizure</td>
<td>Ecstasy</td>
<td>Cyclist</td>
</tr>
<tr>
<td>Stroke</td>
<td>Flower</td>
<td>String</td>
</tr>
<tr>
<td>Ulcer</td>
<td>Shine</td>
<td>Olive</td>
</tr>
<tr>
<td>Worry</td>
<td>Smile</td>
<td>Grass</td>
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</tbody>
</table>
Informed Consent

The Effects of Mood State on Executive Function
Breana McSwain, B.S.

PURPOSE AND BACKGROUND:
You are being asked to volunteer for a research study conducted by Breana McSwain. I am a graduate student in the Psychology Department at the University of South Carolina. This research is sponsored by the University of South Carolina. The purpose of this study is to investigate the effects mood state has on executive function. You are being asked to participate in this study because you are an undergraduate student. This study is being done at one site and will involve approximately 120 volunteers. This form explains what you will be asked to do if you decide to participate in this study. Please read it carefully and feel free to ask questions before you make a decision about participating.

PROCEDURE:
If you agree to be in this study, the following will happen:
1. You will be asked to complete a demographic questionnaire and self-report measures.
2. You will be asked to view a slideshow, which may contain negative images.
3. You will be asked to perform a series of computer based executive function and thinking tasks.
4. You will be debriefed at the conclusion of the experiment.

DURATION:
Participation in the study will take one visit. This study visit will last about one hour.

RISKS/DISCOMFORTS:
Loss of Confidentiality: There is a risk of a breach of confidentiality, despite the steps that will be taken to protect your identity.
Uncomfortable mood state: There is a risk of the negative images that may be shown inducing a negative mood state due to their content. This discomfort will subside by the end of the experiment.

BENEFITS:
Taking part in this study is not likely to benefit you personally. However, this research may help us understand exactly how much of an impact mood state has on executive function.

**COSTS:**
There will be no costs to you for participating in this study.

**PAYMENT TO PARTICIPANTS:**
You will not be paid for participating in this study.

**USC STUDENT PARTICIPATION:**
Participation in this study is voluntary. You are free not to participate, or to stop participating at any time, for any reason, without negative consequences. Your participation, non-participation, and/or withdrawal will not affect your grades or your relationship with your professors, college(s), or the University of South Carolina. If extra credit or research credit is required for a course, other alternative means for obtaining research credits or extra credit is available, and you may discuss these options with your instructor. In the event that you do withdraw from the study, please email Breana McSwain.

**CONFIDENTIALITY OF RECORDS:**
Any information that is obtained in connection with this study will remain confidential and will be disclosed only with your express written permission, unless required by law. The information will be securely stored in locked files and on password protected computers. The results of this study may be published or presented at seminars, but the report will not include your name or other identifying information about you.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study I may contact Breana McSwain at mcswainl@usca.edu or Alexandra Roach at alexandraro@usca.edu or (803) 641-3217.
If I have any questions, problems, or concerns, desire further information, or wish to offer input, I may contact Lisa Marie Johnson, IRB Manager, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-7095 or email: LisaJ@mailbox.sc.edu. This includes any questions about my rights as a research subject in this study.

I agree to participate in this study. I have been given a copy of this form for my own records.

If you wish to participate, you should sign below.

<table>
<thead>
<tr>
<th>Signature of Person Obtaining Consent</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature of Participant</td>
<td>Date</td>
</tr>
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