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EFFECTS OF ANXIETY AND WORKING MEMORY CAPACITY ON PERFORMANCE IN THE EMOTIONAL STROOP TASK

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EFFECTS OF ANXIETY AND WORKING MEMORY CAPACITY ON PERFORMANCE IN THE EMOTIONAL STROOP TASK

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Psychological Science

---

by

Gia Macias

September 2019

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ABSTRACT

Emotional Stroop task results have been shown to be inconsistent throughout the literature due to a multitude of factors including both stimulus and population factors. There are also several theories to explain the emotional Stroop effects, including the attentional control theory (Eysenck et al., 2007). This theory states that anxiety consumes attentional and memory resources, resulting in impairment in executive functions, and thus cognitive performance is lowered. Recently, Owens et al. (2014) reported that the effects of anxiety on cognitive performance might be moderated by working memory capacity (WMC). The present study explored whether Owens et al.'s (2014) paradigm fit the Stroop data. It also explored the role that WMC had in recognition memory for emotional and neutral words. Processing efficiency during the Stroop task and anxiety was expected to show a positive relationship for High WMC and a negative relationship for Low WMC. Furthermore, memory for emotional words were expected to be better for Low WMC due to longer processing times for emotional words. The results showed that WMC did not improve the model for both the emotional Stroop and the surprise recognition memory task, thereby contradicting Owens et al.'s (2014) proposed paradigm. Furthermore, an increase of anxiety scores showed a decrease in memory for emotional words but only for Low WMC.

Keywords: Stroop, attentional control theory, anxiety, working memory capacity

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CHAPTER ONE

INTRODUCTION

Emotional Stroop Task

Negative emotion's influence on cognitive performance has been broadly researched for decades. It is important to unveil the underlying mechanisms for how anxiety negatively influences our ability to perform a cognitive task so that clinical practitioners and educators may implement appropriate interventions. Furthermore, it has been shown that anxiety negatively affects students' performance in the classroom (Scrimin et al., 2014). The combined factors of threatening information and anxiety's influence on cognitive performance may persist beyond childhood and into adulthood, critically affecting performance in the academic or work place; this results in a long-term need to recruit more cognitive resources in order to perform as well as someone who does not have anxiety. Emotional Stroop tasks have been widely used to investigate effects of emotion on cognitive performance. However, results are still mixed as there are so many factors affecting performance of emotional Stroop tasks. They would include subject factors such as participant populations and working memory capacity, and stimulus factors such as automaticity and valence of stimuli, and their interactions.

In order to investigate effects of interfering information on task performance, a Stroop task has been widely utilized (MacLeod, 1991; Stroop, 1935). In a standard Stroop task, participants are instructed to respond to the ink color of a color word, with congruent and incongruent conditions. In the congruent condition, the color of the ink is the same as the color word (e.g., ink color is “red” and the word is “RED”), whereas in the incongruent condition, the ink color and color word are different from each other (e.g., ink color “red” and the word is “YELLOW”). Participants are instructed to ignore the word itself and to focus on responding to the ink color of the word, however, participants have difficulty responding efficiently when presented with an incongruent trial which results in longer reaction times (RTs). The difference in RTs between the congruent and incongruent conditions is termed the Stroop effect.

The Stroop task has been modified to include negative or emotional information (emotional Stroop task), such as threat words, to study their effects on multiple aspects of cognition including memory, attention, and executive functions (e.g., Macleod et al., 1991; Pfaf et al., 2010; Williams et al, 1996; Yiend, 2010). The emotional Stroop task typically shows that color naming RTs are significantly longer for negative words than for neutral words, termed the emotional Stroop effect (e.g., McKenna, 1995; Pratto and John 1991). This occurs because negative words capture participants’ attention, causing a slowed response to color naming. However, throughout the literature this effect has not produced consistent results (e.g., Phaf et al., 2010; Williams et al, 1996; Yiend, 2010). Some researchers have suggested that there may be two types of effects in the emotional Stroop effect, a fast effect and a slow effect. For example, Pratto and John (1991) investigated the fast effect in an emotional Stroop task consisting of words that are related to desirable and undesirable traits (e.g., "honest" vs. "sadistic"). They hypothesized longer RTs for undesirable words than for desirable words. The results from their study showed that their negatively valenced stimuli grabbed attention in an automatic fashion, resulting in longer RTs for that stimuli within a trial. This suggests that the emotional Stroop effect has an automatic mechanism, where attention is automatically captured by an undesirable trait (i.e. the fast effect).

McKenna and Sharma (2004) investigated a slow effect, which is an inter-trial effect. The slow effect refers to longer RTs for neutral words following emotional words compared to neutral words following neutral words. They claimed that it is a delayed disengagement from emotional stimuli that causes longer RTs to neutral stimuli that follow emotional stimuli. McKenna and Sharma (2004) manipulated positions of words in two sequence types: emotional and neutral. Position 1 consisted of either an emotional or a neutral word, while positions 2-7 always consisted of neutral words. The fast effect would be obtained as longer RTs for the emotional words than for the neutral words at position 1. The slow effect would be observed as longer RTs for the neutral words at position 2 following emotional words than for the neutral words following neutral words. They did find the slow effect in the emotional sequence, but only on the neutral word at position 2; the slow effect then dissipated over the next five positions in the sequence. There was no difference between the emotional or neutral word held in the first position of the two sequences. In other words, there was no fast effect observed. McKenna and Sharma (2004) suggest that the slow effect is due to the inability to disengage attention from an emotional stimulus, causing a carryover effect on to the subsequent neutral stimulus. Furthermore, they show that the emotional Stroop effect is not automatic, as previously suggested by Pratto and John (1991). However, neither McKenna and Sharma (2004) nor Pratto and John (1991) measured anxiety levels, and thus individual differences could not be distinguished to understand whose cognitive performance is most affected by emotional stimuli.

In summary, some researchers claim that the emotional Stroop effect is due to an automatic capture of attention by emotional stimuli (e.g., MacLeod & Matthews, 1988; Williams, Mathews, MacLeod, 1996). Others claim that the emotional Stroop effect can be accounted for with a slowed disengagement from emotional stimuli (McKenna & Sharma, 2004). In this case, the fast effect may not be obtained, and instead the slow effect of emotional information processing may appear on the successive trial.

CHAPTER TWO

FACTORS AFFECTING THE EMOTIONAL STROOP RESULTS

The history of mixed results in the emotional Stroop tasks can be attributed to a variety of factors in the studies. For example, stimulus factors (e.g., proportion of different types of stimuli and format of presentation) and subject factors (e.g., subclinical compared to clinical population and working memory capacity (WMC)) could be involved.

Stimulus Factors

Proportion of Stimuli

One factor that may affect Stroop performance is proportion of interfering trials (e.g., threat words, incongruent trials). Participants may be anticipating information, which causes an interruption in maintaining their attention towards the goal of a task (e.g., in a Stroop task: color naming); this may occur when the distracting information is disproportional to the relevant information in a given task. For example, in a Stroop task that was modified by Tzelgov et al. (1992), incongruent trials were presented more frequently than congruent trials. Participants began to anticipate incongruent trials; thus they were able to ignore the irrelevant information and focus on the task goal of responding to colors of words. Furthermore, when incongruent trials were rarely presented, participants did not have any reason to expect incongruent trials to appear, and therefore RTs for incongruent trials increased resulting in a larger Stroop effect. Tzelgov et al. (1992) showed that, as participants were exposed to more incongruent trials, the incongruent trials interfered less with their goal of responding to the colors of the words, thus decreasing the Stroop effect. Their results suggest that participants became desensitized to incongruency after repeated presentation; in other words, they became less sensitive to the incongruent trials interference, and thus did not produce the Stroop effect. Additionally, as the proportion for incongruent trials decreased, participants did not have any reason to expect the incongruent information; when incongruent trials were seldomly presented it slowed their color-naming responses, resulting in an increase of the Stroop effect.

Format of Presentation

One method of presentation that is shown in the Stroop literature is the manipulation of frequency of words (MacKay et al., 2004; Sharma, 2016). In MacKay et al. (2004), a taboo Stroop task was used to investigate whether participants would be able to maintain color-naming (goal-directed) behavior once they are presented with taboo words. They expected to find increased RTs between the first and second half of trials due to an increased attention drawn toward taboo stimuli over time; each half of the trials consisted of equal presentation for taboo and neutral words. Contradictory to their hypothesis, they found that RTs for taboo words actually decreased over trials. MacKay et al. state that this may be due to habituation to information that is repeatedly presented, causing participants to get used to that information and increasing ability to ignore it. MacKay et al. (2004) then manipulated frequency of words in each half of trials: the first half consisted of 10 out of the 20 taboo and neutral words, and the second half presented the other 10 taboo and neutral words to test whether habituation occurs for all taboo words over time, as opposed to habituation to a single taboo word being presented multiple times. MacKay et al. found that the Stroop effect occurred in both halves of the trials, which meant that when a specific word was novel it caused the Stroop effect to occur, and not just the overall valence of taboo words. Lastly, they gave a surprise memory task at the end and participants had better memory for emotional words then neutral words; this supports the assumption that emotional words capture attention.

Sharma (2016) also investigated effects of stimulus repetition using the first and second half of trials, as well as within-block manipulations. Sharma (2016) manipulated presentation of studied words (SW) and unstudied words (UW) and block-type order (presented with either mixed block of both SW and UW followed by a block of pure UW, or pure then mixed). Both SW and UW were neutral words (e.g., “body” and “running”). Participants studied a list of words and were informed that they would be given a recognition memory task following the Stroop task. Sharma (2016) suggested that implementing the studying of words by reading those causes participants to also read words in a following Stroop task which would increase RTs for the SW in the Stroop task. Sharma (2016) hypothesized that if proactive control was high then there should be no difference in RTs for studied and unstudied words. Proactive control is the ability to prepare oneself to respond to future information with a goal in mind. Furthermore, Sharma hypothesized that if SW interferes with the goal of color naming then RTs will increase when a SW immediately follows a SW (i.e., SW-SW), compared to when it follows an UW (i.e., UW-SW). Sharma hypothesized that this effect would occur because studied words should prime participants to be influenced by the presentation of studied words in a Stroop task; this should occur because the act of studying and reading words causes participants to read words in a subsequent task, even if they are instructed to ignore the words in the task.

Sharma (2016) found that, regardless of whether the mixed block was presented first or second, RTs were longer for a SW when it followed a SW than if it followed an UW. Sharma suggested that this may have occurred because the act of studying words weakens proactive control either due to activating reading habits during the study phase, or due to a capture of attention for previously studied words. Regarding the first and second halves in the mixed block, the results showed that during the second half RTs for SW were longer than UW, regardless of block order; this finding was not found for the first half of the block, as there were no differences between SW and UW. Lastly, findings and interpretations for memory differences of SW compared to UW were not included in Sharma’s (2016) results. Furthermore, RTs did not differ for the mixed or pure blocks when they were presented second. Sharma explains that this finding is a result of repeated presentation of studied words reducing their influence on color naming.

Subject Factors

Working Memory Capacity

Working memory is utilized to store information in one's mind and keep that information readily available so that it can be manipulated to produce a response (Oberauer et al., 2018). A participant's working memory capacity (WMC) can be measured with various complex span tasks such as the operation span task (Turner & Engle, 1989) and the reading span task (Daneman & Carpenter, 1980), and has been utilized to investigate how individual differences of WMC affects cognitive performance (Engle, 2018).

In the reading span tasks, created by Daneman and Carpenter (1980), a trial consists of a sentence and a memory item. Participants are instructed to read sentences and to remember the last word of each sentence. After a number of trials, participants are asked to recall the last words they remembered. Turner and Engle (1989) introduced an operation span task, in which participants were instructed to solve math a problem and to remember a letter. After a number of trials (typically between 2 and 7), participants were asked to recall the letters in the exact order. In essence, solving mathematical problems served as a distractor task; the distractor task was utilized to interfere with participant's memory of the goal-relevant information (i.e., the to-be-remembered words or digits).

Span tasks involve WM and attentional resources. Attentional control is an important component of WMC because participants must maintain attention towards the goal of the task, while ignoring distracting information (Engle, 2018). Therefore, participants who are performing tasks that consist of interfering information, such as complex span and Stroop tasks, must exert their attentional resources towards the goals of the task and disallow other information from distracting them from performing the task well. These mechanisms of WMC and attention has been investigated in various cognitive tasks, including the Stroop task.

Kane & Engle (2003) investigated effects of individual differences in WMC (High Span group: top 25% and Low span group: bottom 25%) on performance in a Stroop task by manipulating proportion of neutral (e.g., a random sequence of letters such as JYWK), congruent, and incongruent words. One block consisted of 75% of congruent trials: 216 words were congruent, 36 were incongruent words, and 36 were neutral (36 of each word type were used for analyses). The other block consisted of 0% of congruent trials: 252 words were incongruent, 36 were neutral (36 incongruent and 36 neutral words were used for analyses). For their analyses, Kane and Engle (2003) calculated interference and facilitation scores. If results show interference effects, then it is because participants are not able to maintain the goal of color naming and instead respond to the word of the color; this is calculated by contrasting incongruent and neutral trials. Facilitation effects occur when participants respond faster to congruent trials than neutral trials. This allowed for inference of their results because in the 0% congruent condition Stroop effects could not be analyzed because there was an absence of congruent trials to contrast with incongruent trials.

Kane and Engle (2003) hypothesized that the 75% congruent block will have a larger interference effect than the 0% block because when incongruent trials are rarely presented, participants do not continuously maintain goal-directed behavior (i.e., ignoring the word and respond to the color of the word). Therefore, when an incongruent trial is presented, participants need to recruit working memory resources to remember that they are instructed to ignore the meaning of the word and respond to the color of the word. Kane and Engle (2003) also hypothesized that low WMC individuals would show larger facilitation effects than high WMC individuals because low WMC individual do not have the working memory resources to maintain the goal of ignoring the meaning of the word in the 75% congruent block where incongruent trials are rarely presented. Kane and Engle (2003) state that when low WMC individuals begin to read the word it allows them to respond to the congruent trials quicker than neutral trials.

Kane and Engle (2003) found that the interference effect was significant and was shown to be larger in the 75% congruent block for both RTs and accuracy rates. This suggests that participants were not maintaining the goal of color naming in their memory, which allowed incongruent trials to cause delay responses for color naming. WMC differences did not play a role in creating the interference effect for RTs, but low WMC individuals had larger interference effects for accuracy rates in the 75% congruent block. The facilitation effect was also found to be significant for RTs, and it was larger for low WMC than high WMC individuals in the 75% block. Facilitation effects were not evident in accuracy rates. Kane and Engle (2003) also found that when there is a higher proportion of incongruent trials than congruent or neutral trials, goal-maintenance is optimal because of repeated presentation of incongruent trials, which causes individuals to become desensitized to the incongruent trials. These findings are similar to Tzelgov et al.'s (1992) experiment, as both experiments showed habitual responses when proportions of incongruent trials were higher than both congruent and neutral trials.

Population

The mixed results in the emotional Stroop literature may be due to the recruitment of a non-clinical population (e.g., McKenna & Sharma, 2004). However, some studies recruited clinical samples (e.g., those diagnosed with generalized anxiety disorder, or GAD). Mogg et al. (1989) found that participants with GAD were significantly more affected by negative words if they were related to the physical body (e.g., illness) than a non-clinical sample. This poses as a problem, as Yu (2018) stated that larger Stroop effects are shown in a group of GAD individuals than for a sub-clinical high-trait anxious group that is considered to be healthy, although anxiety is still high. Furthermore, Yu found that the high-trait anxious and the GAD group differed in Stroop performance: high-trait anxious individuals showed better cognitive control with higher accuracy rates than GAD individuals. Williams, Mathews and MacLeod (1996) and Watts, McKenna, Sharrock, and Trezise (1986) sought to decipher the differences in Stroop performance between clinical and subclinical participants.

Williams et al. (1996) suggested that clinical populations are generally affected by emotional information, whereas nonclinical populations are only affected by emotional information if that information relates to them (e.g., the word “fail” when a student is about to take a test). Watts et al. (1986) hypothesized that the Stroop effect may also be dependent upon a specific word category-type for a particular group of participants; for example, words that are semantically related to the spiders would produce a greater Stroop effect for participants with spider-phobia than words that have no such significance (e.g., emotional words: fail). Consistent with their hypothesis, they found RT differences between spider phobic and non-spider phobic participants in their spider Stroop task, providing evidence for the Stroop effect for only spider-phobic participants. This suggests that there are different cognitive mechanisms involved in responses to negative information for GAD and high-trait anxious participants, and researchers should not generalize their findings with high-anxious population to the GAD population.

Kalanthroff et al. (2015) utilized an emotional Stroop task to investigate how threatening stimuli (emotional pictures) affects proactive control in individuals who either have high or low anxiety. In a trial sequence, either an emotional or neutral picture was presented prior to a Stroop stimulus that consisted of either a color or neutral word. Kalanthroff et al. (2015) found that low anxious participants were not affected by the emotional picture; however, high anxious participants showed longer RTs on the Stroop trial that was preceded with threatening pictures. These results provide evidence that proactive control is negatively affected by emotional pictures for participants with high anxiety, but not for low anxiety participants.

Furthermore, the population that is recruited may account for some of the variability in the emotional Stroop literature. If the non-clinical population is more susceptible to the emotional Stroop effect when the word stimuli are related to their current worries, then utilizing a Stroop task with words that do not relate to their current worries will not result in an emotional Stroop effect. As outlined here, there are many explanations for why emotional Stroop results are mixed in the literature. These factors include proportion of stimuli, method of presentation, accounting for WMC scores and the type of participants that are recruited. When these factors are taken into account, researchers may be able to explain some of the variability in the literature.

CHAPTER THREE

THEORIES OF EFFECTS OF ANXIETY ON COGNITIVE PERFORMANCE

Attentional Control Theory

The importance of understanding anxiety's interaction with cognitive functions must be explored in order to better understand how people interact with their environment. Eysenck and colleagues established a theory in 2007 and termed it Attentional Control Theory (ACT) which contains powerful claims of how anxiety impairs cognitive performance (Eysenck et al., 2007). One such claim states that anxious moods can cause detrimental effects on our executive functions; more specifically, anxious moods hinder our ability to maintain attention towards a goal. According to Eysenck, worry consumes attentional resources, resulting in impairment in executive functions, which results in weaker top-down processing, which results in more bottom-up processing; thus, worry is the main component of anxiety that is consuming attentional resources. When we have the cognitive resources to inhibit task-irrelevant information, such as threat words, top-down processing is considered stronger than bottom-up processing. Furthermore, when top-down processing is weakened, thus enhancing bottom-up processing threat information may capture attention.

Another claim in Eysenck et al.'s (2007) ACT states that anxiety negatively affects multiple functions of the central executive. These functions include the abilities to shift between tasks and inhibit irrelevant information. The shifting function is utilized to switch between task types (e.g., a subtraction task followed by an addition task) or task instructions (e.g., in a standard Stroop task, either name color of word or responding to the color word). Disengaging is one component of the shifting function and is the ability to direct one's attention away from task-irrelevant information; this is necessary to utilize when an irrelevant stimulus is presented and then disappears, otherwise it continues to affect the participant's performance on a subsequent stimulus. Inhibition, in this context, refers to the ability to inhibit irrelevant information in the presence of relevant information. ACT also claims that anxiety drives a participant's attention to negative information regardless of its relevance, affecting their ability to perform efficiently in tasks that consist of stimuli that interferes with goals of the task. This is especially evident in participants with anxiety when they are exposed to threat-related information.

ACT distinguishes between processing effectiveness and efficiency. It states that performance effectiveness refers to the correct performance on a cognitive task (e.g., accuracy). Processing efficiency refers to the relationship between effectiveness of performance and the resources needed to perform the task. Furthermore, it can be measured and evaluated by dividing accuracy by reaction times, creating an efficiency coefficient score (Edwards et al., 2015). The efficiency coefficient score allows the researcher to infer the relationship between the ability to perform accurately on a task, and the ability to perform a task quickly, and compare them among different levels of anxiety. ACT states that anxiety impairs processing efficiency to a greater extent than performance effectiveness. This is evident when participants with high anxiety have high accuracy rates, yet their RTs are longer in the presence of task irrelevant information, providing support for the idea that anxious individuals must recruit and exert more cognitive resources, and thus are not performing as efficiently.

Attentional Bias

When a participant has a high level of anxiety, it will drive their attention towards negative stimuli even if they are task-irrelevant, (Eysenck & Calvo, 1992; Eysenck et al., 2007), which results in decreased performance on various cognitive tasks (Fox et al., 2001). A delayed disengagement is also believed to be a component of attentional bias; a delayed disengagement has been evident as an intertrial effect, such as the slow effect in the emotional Stroop task (McKenna et al., 2004). For example, once a participant's attention is biased toward a threat, a neutral stimulus that immediately follows it will also show longer RTs. In essence, when a threatening stimulus is presented, participants will have difficulty disengaging their attention away from the threat stimulus and toward neutral stimulus, causing longer RTs to respond in a cognitive task.

CHAPTER FOUR

A NEWLY PROPOSED PARADIGM

As we discussed in the previous sections, recent studies reported mixed results in the emotional Stroop research. In some studies, researchers found significant differences between individuals with high and low anxiety; however, other studies didn't find the same patterns. These results suggest that there are complex interactions between emotion and attention. Owens et al. (2014) sought to reveal how WMC moderates the interaction between anxiety levels and cognitive performance. They measured WMC and trait anxiety levels, then utilized two cognitive tasks that tested general academic skills (e.g., math computation) and abstract reasoning. They found that anxiety did not affect academic performance overall, but that WMC did affect performance. Furthermore, they found a significant positive correlation between anxiety and cognitive performance for the high WMC group, and a significant negative correlation between anxiety and performance for the low WMC group. Owens et al.'s results suggest that high WMC individual's cognitive performance was better when anxiety levels were high. However, low WMC individuals showed the opposite effect: cognitive performance was worse as anxiety increased. This effect should occur because high WMC individuals become increasingly motivated to perform well as their anxiety increases, and they have the resources to act upon that motivation; however, when anxiety increases for low WMC individuals, they do not have the resources to act upon this motivation. The motivation to perform well may come from the desire to avoid negative evaluation (Owens et al., 2014). Owens et al.'s (2014) manipulation and method of analysis may be a solution to the varied results in the Stroop literature, as it accounts for WMC and differences along anxiety scores. Furthermore, Owens et al.'s (2014) ideas coincide with Eysenck et al.'s (2007) ACT that anxiety consumes executive resources. However, a higher WMC may allow high anxious individuals to have comparable performance, just as low anxious individuals do; this should occur because higher WMC will allow participants to actively maintain task goals in their memory, even in the presence of threat words and anxiety levels.

CHAPTER FIVE

EMOTIONAL STROOP EXPERIMENT

The experiments, models, and theories outlined above still leads to an important question that has not yet been flawlessly answered: How can we explain the effect of emotion, WMC, and negative information on cognitive performance? As outlined, the emotional Stroop literature's results are not consistent, and as such, we must consider different factors that play a role in the emotional Stroop effect. These factors are both stimulus and subject based.

The present study will investigate how WMC moderates the relationship between anxiety and cognitive performance in an emotional Stroop task. It will also investigate how anxiety and WMC affect memory of threat words with a word recognition task. Lastly, if repeated presentation of threat words causes participants to become desensitized by their meaning, then the second half of trials should show an increase in processing efficiency, resulting in better performance of color naming. Owens et al.'s (2014) findings support the ACT because it follows the theory that anxiety affects cognitive performance by consuming attentional and working memory executive resources. Therefore, the current experiment has the following hypotheses:

1. Anxiety's effects on cognitive performance will be dependent upon working memory capacity:

   a. A positive correlation between anxiety and processing coefficient scores will be seen for high WMC individuals: as anxiety increases, processing efficiency increases.
   b. A negative correlation between anxiety and processing coefficient scores will be seen for low WMC individuals: as anxiety increases, processing efficiency decreases.
2. Responses during the second half of trials will have better processing efficiency because repeated presentation of threat words will cause participants to become desensitized to their influence on color naming.
   a. High WMC individuals will not differ between either half because they have the resources to maintain the goal in mind of ignoring the words. During the second half, low WMC will become desensitized by the stimuli after repeated presentation, thus they should show shorter RTS during the second half of trials than the first half of trials.
3. There will be better recognition memory for threat words than for neutral words in the low WMC group because threat words will bias their attention, causing longer RTs, thus allowing more time to encode the words. However, this will not be the case for high WMC: high WMC individuals are expected to not have any differences between threat and neutral words because the words were not encoded, as they have the resources to maintain the goal in mind of ignoring the words.

Method

I recruited a total of 124 participants. Participants were a minimum of 18 years old and had to have normal to corrected vision without color blindness. Participants were to be proficient in English (a minimum of 4 on a 1-5 rating scale), as the words in the Stroop task were shown in English. Ten participants were excluded due to one or both of the following reasons: English proficiency below 4 (N = 6); missing data (N = 4). This resulted in a total of 114 participants.

Experimental Design

The experiment is a 2 (Emotional vs. Neutral stimuli) X 3 (High vs. Middle vs. Low WMC) X 2 (First vs. Second half of blocks) mixed design, where stimuli-type and first and second half of blocks are within-subjects factors and WMC is a between-subjects factor. Anxiety were analyzed as a continuous variable.

Stimulus and Materials

Anxiety Measurement

Anxiety scores were recorded with the State-Trait Inventory of Cognitive and Somatic Anxiety (STICSA, Gros et al., 2007). This measurement consists of 21 items that collect scores of both cognitive and somatic anxieties (see Appendix A).

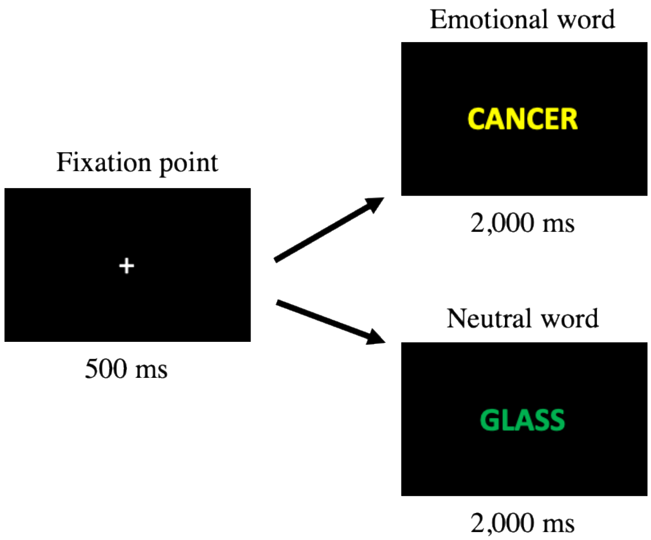
Working Memory Span Task

Working memory capacity were measured with three span tasks: Operation Span, Reading Span, and Symmetry Span (Oswald et al., 2015). Operation span and Reading span tasks are automated versions (Unsworth et al., 2005) that are essentially the same as the ones described before. Instructions for the symmetry span task (Unsworth, Brewer, & Spillers, 2009) are to remember locations of squares highlighted in red in a grid of squares while making decisions about whether or not a pattern is symmetrical; after a number of trials, participants were asked to recall the location of squares in the exact sequence that they were presented with.

Emotional Stroop Task

Participants performed an emotional Stroop task that consisted of 30 practice trials where participants practiced responding to four different colors of stimuli: blue, green, yellow, and red. The stimuli in the first half of the practice trials were a square patch of color. In the second half of the practice trials, participants responded to neutral words that were not included in the main blocks. Following the practice trials participants began the main trials in the task. The main task consisted of two blocks, each block consisting of 80 trials for a total of 160 trials, (See Figure 1 for a preview of the emotional Stroop task). Lastly, to assess participant's level of efficiency during the emotional Stroop task, a processing efficiency coefficient will be calculated (ACC divided by RT multiplied by 1000) as introduced by Edwards et al. (2015).

Figure 1. Example of the emotional Stroop task.



Memory Task

A surprise recognition memory task was given to participants to test their memory for the words that were shown in the emotional Stroop task. They were presented with 40 words: 20 words that were shown in the emotional Stroop task, and 20 words that were not previously shown during the experiment. Each of the 20 new words consisted of 10 emotional words and 10 neutral words; syllables and letters were matched to be similar to the old Stroop words.

Procedure

The experiment took place in a computer lab setting with the capacity of 12 participants per session. The span tasks, emotional Stroop task, and questionnaires were conducted utilizing E-Prime 3.0. A monitor and a mouse were utilized for this experiment. Once consent was given, participants first performed the Span tasks. Second, they performed the emotional Stroop task (See Figure 1). Third, a surprise word recognition task was given. During the recognition task, the words appeared on the screen one at a time and participants were asked to make dichotomous decisions of whether they remember the word being in the Stroop task or not (i.e., Yes and No responses). Prior to leaving, a demographic survey and STICSA survey were completed.

Results

Outliers were inspected using Cook's, Leverage, and Mahalanobis distances that were saved by running a simple linear regression analysis with the continuous variables: processing efficiency as the dependent variable and STICSA as the predictor variable. The data was then included in the analyses if their distance scores were less than the respective cut off points: Mahalanobis = 10.83; Cook's distance = 0.0385; Leverage = 0.0351. Seven participants had scores greater than Cook's distance, Leverage, or Mahalanobis distances cut off scores, resulting in a final total of 107 participants for the analyses. Assumptions for additivity and normality were also inspected and were met.

Efficiency coefficients were computed with the following formula for the three WM groups: Accuracy rates divided by reaction times, multiplied by 1,000 (Edwards et al., 2015). Participants' STICSA scores were calculated by summing the total number of responses. The OSPAN and RSPAN scores were calculated by dividing each participant's score by 30 (total number of trials); the SSPAN score was calculated by dividing each participant's score by 24. Composite scores for OSPAN, RSPAN, and SSPAN were calculated by averaging all three scores (as suggested by Oswald et al., 2015. Participants were then divided into three groups: the top 33% (N = 36), the middle 33% (N = 35), and the bottom 33% for WMC scores (N = 36; HWMC, MWMC, LWMC, respectively). For an overview (e.g., averages of WMC, RTs, PE, ACC) see Table 1.

Table 1. Descriptive statistics for the emotional Stroop task data.

			RT				**ACC**				**PE**			
			Blk 1		**Blk 2**		**Blk 1**		**Blk 2**		**Blk 1**		**Blk 2**	
	WMC	**STICSA**	**E**	**N**	**E**	**N**	**E**	**N**	**E**	**N**	**E**	**N**	**E**	**N**
HWMC (N = 36)														
Mean	0.83	41	702	721	736	741	0.96	0.96	0.95	0.95	1.37	1.37	1.32	1.32
Std. Dev.	0.06	10	126	119	122	121	0.04	0.05	0.05	0.05	0.24	0.23	0.23	0.24
MWMC (N = 35)														
Mean	0.65	41	685	710	710	710	0.97	0.97	0.96	0.96	1.44	1.40	1.37	1.38
Std. Dev.	0.04	9	94	124	106	93	0.03	0.03	0.03	0.04	0.19	0.24	0.21	0.19
LWMC (N = 36)														
Mean	0.47	37	724	723	770	760	0.94	0.95	0.92	0.92	1.32	1.33	1.22	1.24
Std. Dev.	0.07	10	99	99	116	103	0.06	0.06	0.09	0.09	0.22	0.21	0.24	0.23

A correlation analysis for all factors was conducted for the variables shown in Table 1, and the results are shown in Table 2. There was a small significant correlation between STICSA and WMC scores (r(105) = 0.21, p =

0.03). Although this is a correlation that is considered small, collinearity between the two predictors may affect the interpretations of the b values such that they are not considered as precise to each predictor's effect.

Table 2. Correlations matrix.

Measure	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00
1. WMC group	1.00										
2. STICSA	0.15	1.00									
3. WMC Score	.929**	.205*	1.00								
4. SSPAN	-0.02	-0.06	-0.01	1.00							
5. RSPAN	0.11	-0.01	0.11	.303**	1.00						
6. OSPAN	0.03	-0.10	0.04	.395**	.613**	1.00					
7. Stroop RT	-0.06	0.02	-0.09	0.11	0.15	0.05	1.00				
8. Stroop ACC	.228*	0.10	.279**	-0.09	-0.06	-0.13	-.195*	1.00			
9. Stroop Processing Efficiency	0.13	-0.01	0.17	-0.12	-0.19*	-0.10	-0.95**	.44**	1.00		
10. Recognition Task ACC	0.14	0.18	0.16	-.217*	0.06	0.01	0.03	.230*	0.01	1.00	
11. Recognition Task RT	0.11	0.03	0.13	0.00	0.09	0.05	0.13	0.11	-0.09	.202*	1.00

** Correlation is significant at the 0.01 level (2-tailed).

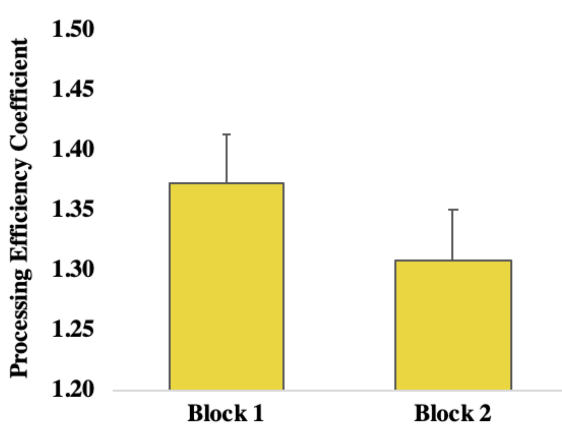
* Correlation is significant at the 0.05 level (2-tailed).

Emotional Stroop Task

Reaction times and ACC (shown in Table 2) were submitted to a 3-way ANOVA for the emotional Stroop task, 2 (Stimuli: Emotional vs. Neutral word) X 2 (Block: First vs. Second Block) X 3 WMC (Low vs. Middle vs. High), for processing efficiency, RTs, and ACC to inspect whether the emotional Stroop effect was present.

Processing Efficiency. A main effect of Block was significant, $F(1,104) = 28.82$, $p < 0.001$, $\eta 2 = 0.23$, where participants were more efficient during the first block than during the second block (See Figure 2). There was also a marginal significant difference between WMC groups ($F(2,104) = 2.89$, $p = 0.06$, $\eta 2 = 0.05$), where MWMC was more efficient than the other two groups, and HWMC was more efficient than LWMC. No other effect reached statistical significance. Block and WMC interaction did not reach significance, $F(2,104) = 1.74$, $p = 0.18$, $\eta 2 = 0.03$. A main effect of Stimulus was not significant, $F(1,104) = 0.01$, $p = 0.92$, $\eta 2 < 0.001$. An interaction for Stimuli and WMC was not significant, $F(2,104) = 1.90$, $p = 0.15$, $\eta 2 = 0.04$. An interaction between Stimuli and Block was not significant, $F(1,104) = 0.94$, $p = 0.33$, $\eta 2 = 0.01$. A three-way interaction between Stimuli, Block, and WMC was not significant, $F(2,104) = 0.62$, $p = 0.54$, $\eta 2 = 0.01$.

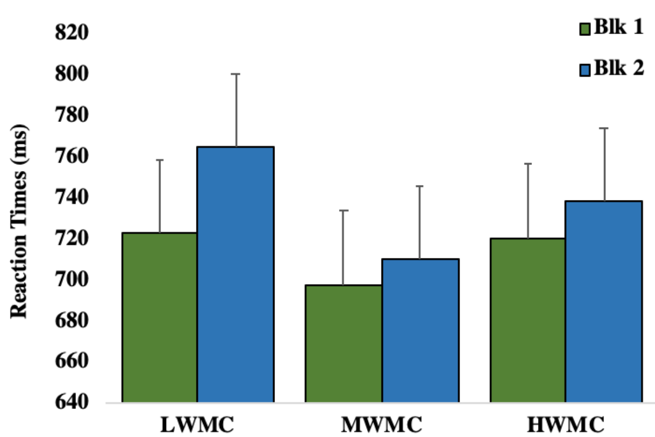
Figure 2. Main effect of Block in the emotional Stroop task.



Note: Shown are 95% confidence intervals.

Reaction Times. The main effect of Stimuli was not significant, $F(1,104) = 1.01$, $p = 0.32$, $\eta 2 = 0.01$. The interaction between Stimuli and WMC was not significant, $F(2,104) = 2.26$, $p = 0.11$, $\eta 2 = 0.04$. There was a main effect of Block, $F(1,104) = 23.99$, $p < 0.002$, $\eta 2 = 0.19$, where the second block took longer to respond to than the first block; this main effect was qualified by an interaction between Block and WMC, $F(2,104) = 3.45$, $p = 0.04$, $\eta 2 = 0.06$ (Figure 3). This interaction showed that the RT difference between Block 1 and 2 was significant for LWMC, but no difference between the two blocks for HWMC and MWMC groups. The interaction between Stimuli and Block was not significant, $F(1,104) = 1.96$, $p = 0.17$, $\eta 2 = 0.02$). The three-way interaction between Stimuli, Block, and WMC was not significant, $F(2,104) = 1.39$, $p = 0.26$, $\eta 2 = 0.03$. Lastly, WMC was not significant, $F(2,104) = 1.33$, $p = 0.27$, $\eta 2 = 0.03$.

Figure 3. Interaction between Block and WMC.



Note: Shown are 95% confidence intervals.

Accuracy Rates. There was a main effect of Block, $F(1,104) = 6.19$, $p = 0.01$, $\eta 2 = 0.06$, where participants were more accurate during the first block than the second block. The main effect of Stimulus was not significant, $F(1,104) = 2.03$, $p = 0.16$, $\eta 2 = 0.02$. There was a main effect of WMC, $F(2,104) = 5.84$, $p = 0.004$, $\eta 2 = 0.10$, where LWMC was less accurate than both MWMC and HWMC; all other groups were not statistically significant from one another. The interaction between Stimulus and WMC was not significant, $F(2,104) = 0.15$, $p = 0.16$, $\eta 2 = 0.003$. The interaction between Block and WMC was not significant, $F(2,104) = 0.20$, $p = 0.82$, $\eta 2 = 0.004$. The Stimulus and Block interaction was not significant, $F(1,104) = 0.04$, $p = 0.84$, $\eta 2 < .001$. Lastly, the three-way interaction between Stimulus, Block, and WMC was not significant, $F(2,104) = 0.22$, $p = 0.81$, $\eta 2 = 0.004$.

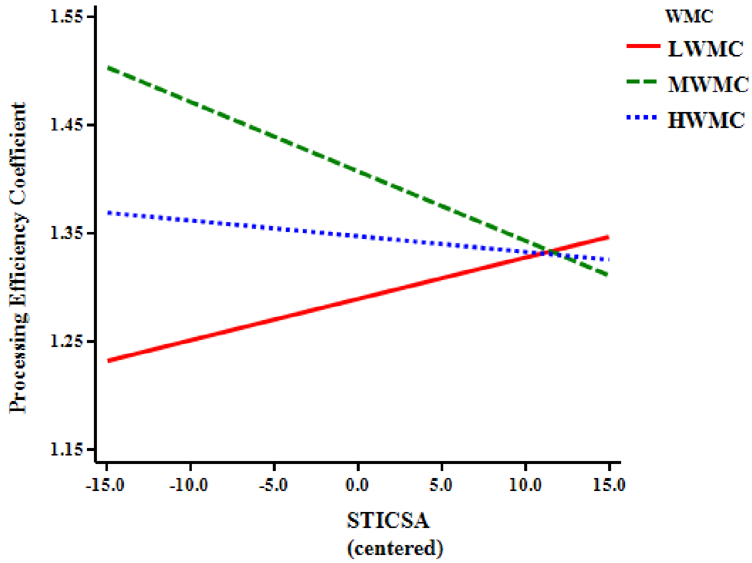
Regression Analysis. To test whether WMC would explain more variance in a model consisting of anxiety as the predictor, a regression analysis was conducted by utilizing Process for SPSS (created by Andrew F. Hayes) where PE was entered as the dependent variable, STICSA was entered as the independent variable, and WMC (LWMC, MWMC, and HWMC) was entered as the moderating variable (Table 3). By entering WMC it did not improve the model, *R2 change* = 0.04, $p = 0.13$. The overall model was marginally significant, $F(5,101) = 2.03$, $R2 = 0.09$, $p = 0.08$. There was a significant difference between MWMC and LWMC, $b = 0.118$, $t = 2.35$, $p = 0.02$ where the mean efficiency coefficient for MWMC ($M = 1.40$) was higher than that for LWMC

(*M* = 1.28). The slope for MWMC was marginally significant, *b* = -0.006, *t*(101) = -1.69, *p* = 0.09, where STICSA predicted a decrease in processing efficiency scores by -0.006 points (See Figure 4). As anxiety increased for MWMC, their processing efficiency decreased.

Table 3. Hierarchical regression results for the emotional Stroop task.

Hierarchical Regression: Processing Efficiency						
Variable	***b***	***t***	***F***	***R***	R^2	ΔR^2
Model 1			2.03	0.30	0.09	
STICSA	0.004	1.13				
Model 2			2.43			0.04
LWMC vs. MWMC	0.478	2.35				
LWMC vs. HWMC	0.058	1.13				
LWMC X STICSA	-0.004	-1.69				
MWMC X STICSA	-0.006	-1.69				
HWMC X STICSA	-0.002	-0.43				

Figure 4. Hierarchical regression interaction for the emotional Stroop task.



Note: The axes do not start at zero.

Memory Recognition Task

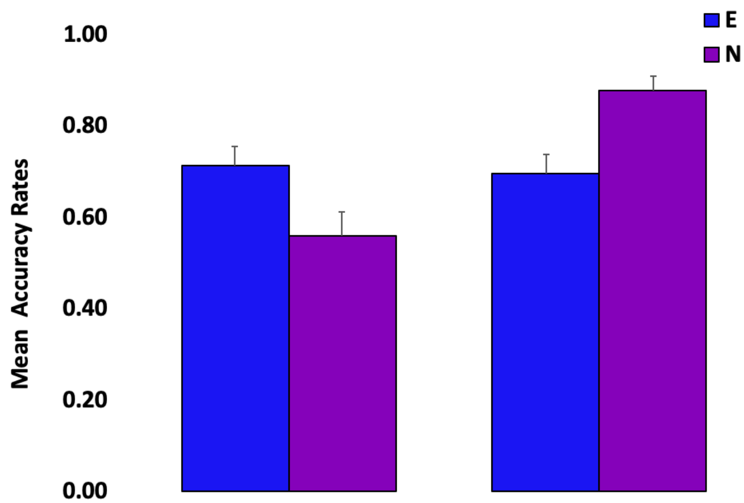
ACC data, shown in Table 4, were submitted to a three-way ANOVA, 2 (Stimulus: Emotional vs. Neutral) X 2 (Answer: Old vs. New) X 3 WMC (Low vs. Middle vs. High) to test whether anxiety groups made a difference. Stimulus and answer were the within-subjects factors and WMC and STICSA were the between-subjects factor. The Old condition consists of accuracy for correctly responding with “Yes” to words that were old (i.e., words that were in the Stroop task that were correctly remembered) and the New condition consists of correctly responding with “No” to words that were new (i.e., words that were not in the Stroop task).

Table 4. Descriptive statistics for the recognition memory data.

		Old		New	
		E	**N**	**E**	**N**
LWMC	M	0.65	0.48	0.73	0.87
	SD	0.07	0.09	0.08	0.06
MWMC	M	0.74	0.60	0.69	0.91
	SD	0.07	0.09	0.06	0.06
HWMC	M	0.76	0.60	0.68	0.85
	SD	0.07	0.09	0.06	0.06

The main effect of Answer was significant, $F(1,104) = 2.34$, $p < 0.001$, $\eta 2 = 0.18$, where participants had higher accuracy for new words than old words. This main effect was qualified with a significant interaction between Stimulus and Answer, $F(1,104) = 91.26$, $p < 0.001$, $\eta 2 = 0.47$; participants were better at responding to old emotional words than neutral words, and participants were better at responding to new neutral words than new emotional words (Figure 5). Furthermore, this interaction showed higher ACC for neutral words that were old than words that were new. The main effect of Stimulus was not significant, $F(1,104) = 1.06$, $p = 0.31$, $\eta 2 = 0.01$. The interaction between Stimulus and WMC was not significant, $F(2,104) = 1.65$, p = 0.20 , $\eta 2 = 0.03$. The interaction between Stimulus, Answer, and WMC was not significant, $F(2,104) = 0.22$, $p = 0.80$, $\eta 2 = 0.004$.

Figure 5. Interaction between Stimuli and Condition in the recognition task.



Note: Shown are 95% confidence intervals.

<u>Regression Analysis.</u> Emotional words that were old served as the dependent variable, STICSA was the predictor variable, and WMC group was the moderator in a hierarchical regression analysis (See Table 5). Overall model consisting of STICSA and WMC was marginally significant, $F(5,101) = 1.96$, $R2 = 0.09$, $p = 0.09$. There was a significant difference between LWMC and HWMC, $b = 0.12$, $t = 2.35$, $p = 0.02$. To further investigate this relationship, the simple slope effects were compared. The LWMC slope, $b = -0.01$, $t = -1.55$, $p = 0.12$, was significantly different from HWMC slope, $b = 0.003$, $t = 1.11$, $p = 0.27$. As anxiety increased for LWMC their accuracy for recognizing words that were in the Stroop decreased. For HWMC, as anxiety increased their accuracy for recognizing words that were in the Stroop task increased. There was a marginal significant

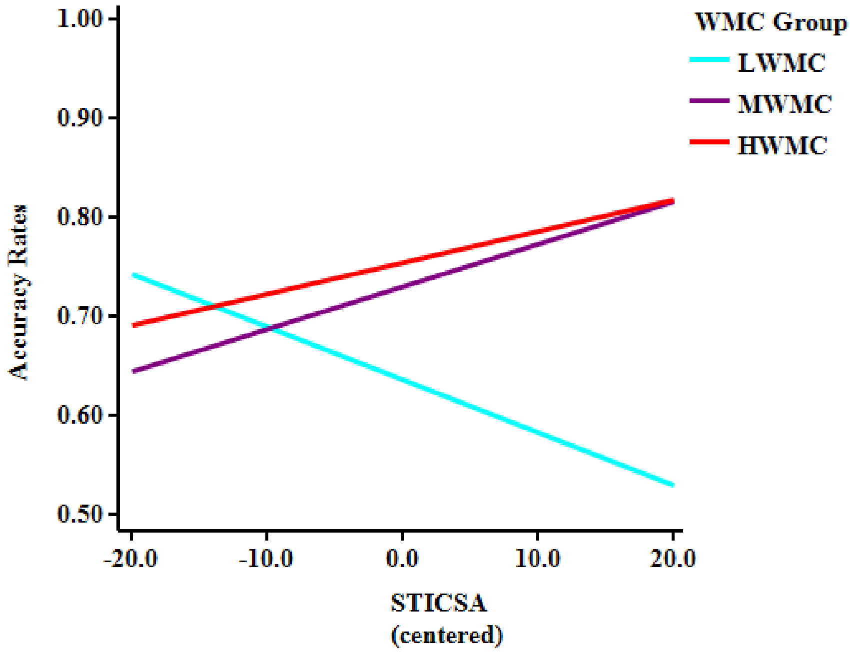
difference in recognizing emotional words between LWMC and MWMC, $b = 0.09$, $t = 1.85$, $p = 0.07$. The MWMC slope, $b = 0.004$, $t = 0.90$, $p = 0.37$, showed a positive correlation. As anxiety increased for MWMC, their accuracy for recognizing emotional words increased. The interaction between LWMC and MWMC was marginally significant, $b = 0.01$, $t = 1.86$, $p = 0.07$, and the interaction between LWMC and HWMC was marginally significant, $b = 0.01$, $t = 1.73$, $p = 0.09$. To examine and interpret these findings, Figure 6 was created.

Table 5. Hierarchical regression for the memory recognition data.

Variable	***b***	***t***	***F***	***R***	R^2	ΔR^2
Model 1			1.96	0.30	0.09	
STICSA	-0.01	-1.55				
Model 2			2.21			0.04
LWMC vs. MWMC	0.09	1.85				
LWMC vs. HWMC	**0.12***	2.35				
LWMC X STICSA	-0.01	-1.55				
MWMC X STICSA	0.004	1.12				
HWMC X STICSA	0.003	0.90				

Note: The asterisk (*) marks significance at the $p < 0.05$ level.

Figure 6. Interaction for the hierarchical regression in the recognition task.



Discussion

The first hypothesis stated in the current proposed anxiety's effects on PE would be contingent upon WMC, such that there will be a positive correlation between anxiety and PE for HWMC, and a negative correlation for PE for LWMC; a strong prediction for the MWMC was not given, but generally differences were not expected to occur. This hypothesis was not supported, as only MWMC showed a negative correlation where their processing efficiency decreased as anxiety increased. In fact, there was an opposite trend where HWMC had a negative correlation, and LWMC had a positive correlation, although not significant.

The second hypothesis stated that there will be differences between the first and second half of trials (i.e., the first and second block): repeated presentation of threat words will cause participants to show higher PE and shorter RTs during the second half of trials because they will become desensitized to the emotional valence of the words over time; moreover, LWMC should show the strongest effect. However, this hypothesis was not supported. Instead, participants showed better performance during the first block than the second block with higher ACC and lower RTs. Furthermore, LWMC differed on their responses between first and second block where they showed better performance during the first block than the second block; however, these differences were only shown in the RTs data and did not persist in the PE or the ACC data. Although there was not a strong prediction for MWMC, there was a difference in accuracy between MWMC and LWMC, where MWMC higher accuracy overall.

The present study's third hypothesis that accurate responses for emotional words would be better for LWMC than HWMC was only partially supported by the results. Participants remembered old emotional words better than old neutral words. However, there was the opposite finding for new words where participants were better at responding to new neutral words than new emotional words. Furthermore, participants performed better on neutral trials if they old than if they were new neutral words. The regression analysis for the recognition task also showed that WMC as a moderator did not improve the model consisting of anxiety scores. However, as shown in Figure 6, there were differences between LWMC and HWMC, and LWMC and MWMC. These results show LWMC's memory for old emotional words decreased as anxiety levels increased, whereas both MWMC's and HWMC's memory increased as their anxiety increased. However, these are not the results that were expected. Memory for emotional words in the Stroop task were expected to be better for LWMC than HWMC; this would be due to HWMC's ability to focus on the color naming task due to their mental capacity for the attentional and memory resources necessary to perform the task. During the emotional Stroop task, LWMC were expected to show an attentional capture of emotional words, increasing RTs during the Stroop task. However, this finding was not shown, and the third hypothesis was further contradicted by these regression results.

In Eysenck et al.'s (2007) attentional control theory, anxiety is hypothesized to affect task performance by affecting WM, leading to a reduction of performance efficiency and effectiveness. Therefore, Owens et al. (2014) hypothesized that WMC may be the connection lost in cognitive performance literature by proposing WMC as a moderator for the anxiety and performance interaction. Owens et al.'s (2014) experiment showed that working memory capacity moderated the relationship between anxiety and cognitive performance, in such a way that task performance increased as anxiety increased for HWMC, that there were no differences for MWMC, and that efficiency decreased as anxiety increased for LWMC.

The present study's results showed that WMC did not improve the model for processing efficiency nor recognition performance. Processing efficiency was not predicted by state anxiety alone, and when WMC was entered into the model results showed that LWMC was significantly different from MWMC, where MWMC were more efficient when performing the Stroop task than LWMC. Interestingly, MWMC's anxiety scores predicted a decrease in processing efficiency: as anxiety scores increased, processing efficiency decreased. This is an unexpected finding that would be more anticipated for LWMC individuals due to their lack of available cognitive resources in order to compensate for the negative effects that anxiety has, in conjunction with their motivation to avoid negative consequences and thus increasing their anxiety, which should cause a decrease in processing efficiency scores (Owens et al., 2014). Overall, the present data did not support the model that WMC would moderate the relationship between anxiety and cognitive performance. There are multiple reasons why the findings did not fully support the hypotheses set forth by the present study.

It is possible that the STICSA scores were not analyzed correctly. When Ree et al. (2008) developed the STICSA to assess state and trait anxiety, their idea was still new and cut-off scores were not set in stone. It wasn't until Van Dam et al. (2013) proposed cut-off scores after they were researched for their validity and reliability. The range of scores for the STICSA is between 21 and 84 and Van Dam et al. found that a cut off score on the STICSA version for trait anxiety was 40 if researchers wanted to utilize the questionnaire in a non-clinical lab setting. The present study did not find differences between WMC and STICSA, and although Van Dam et al.'s (2013) study was focused on trait anxiety, the current study's lack of strong findings regarding WMC and anxiety could be due to the fact that the STICSA scores were not grouped properly and instead were analyzed as a continuous variable. Moreover, each WMC group had a similar average of STICSA scores.

The lack of significant results may also be due to respondent fatigue. Respondent fatigue occurs when participants become bored, tired, or lack the motivation to perform well during a research task or survey. The experiment was one session and lasted for 60 minutes. The session included three WMC tasks, a Stroop task, a recognition memory task, and lastly the STICSA survey. A possible solution is to have two sessions: first session with WMC tasks, and the second session consisting of the Stroop task, recognition memory task, and the STICSA survey. Owens et al. (2014) had their participants conduct their WMC task separately from their anxiety measure and cognitive task. By breaking up the study into two sessions, respondent fatigue may be avoided because there are less tasks to conduct in each session. It is possible that fatigue is not the explanation, and instead the ego depletion effect is. For example, cognitive resources can be depleted after conducting a difficult cognitive task, causing a state where the lack of cognitive control is disabled, which can affect subsequent cognitive tasks even if they are different types of cognitive tasks (e.g., emotional Stroop task and the memory recognition task).

Another possible explanation is a lack of motivation among the participants. It may provide insight to participants' cognitive process of what their motivations are by introducing a motivation scale, developed by Wolfe and Smith (1995). This motivation survey may help to reveal participant's how motivation plays a role in anxiety scores to test the importance of performing well during a cognitive task (See Appendix C) for the complete set of the questions). Wolfe and Smith also suggest that this motivation factor could also be manipulated by informing participants that is it important for them to perform well on a test because they will be sharing their results at the end of the study. As Owens et al. (2014) stated, participants want to avoid negative evaluation and in order to so do they must perform well on the task; LWMC do not have the cognitive resources to compensate for the negative effect that anxiety has on performance. A motivation scale may serve to ensure that this motivation to perform well, to avoid negative evaluation, is occurring.

The utilization of a motivation survey in conjunction with a manipulation of test importance may benefit the literature. For example, informing participants that they will share their results at the end of the task should induce state anxiety, effectively influencing LWMC to perform worse as their anxiety increases, and HWMC to perform better as anxiety increases. Again, HWMC have the cognitive resources (memory and attention) to perform well and LWMC do not have those resources.

The implementation of the aforementioned manipulations may provide a better explanation for the varying results in the emotional Stroop literature. It is important that this research is continued so that those in the real world, such as educators and clinicians, may consider this information when implementing techniques to assist with those that have anxiety and cognitive downfalls.

APPENDIX A

GROS, ANTONY, SIMMS, AND MCCABE’S (2007) STICSA QUESTIONNAIRE

Below is a list of statements which can be used to describe how people feel. Beside each statement are four numbers which indicate the degree with which each statement is self-descriptive of mood at this moment (e.g., 1 = not at all, 2 = A little, 3 = Moderately, 4 = very much so). Please read each statement carefully and circle the number which best indicates how you feel right now, at this very moment, even if this is not how you usually feel.

1. My heart beats fast
2. My muscles are tense
3. I feel agonized over my problems
4. I think that others won't approve of me.
5. I feel like I'm missing out on things because I can't make up my mind soon enough.
6. I feel dizzy.
7. My muscles feel weak.
8. I feel trembly and shaky.
9. I picture some future misfortune.
10. I can't get some thought out of my mind.
11. I have trouble remembering things.
12. My face feels hot.
13. I think that the worst will happen.
14. My arms and legs feel stiff.
15. My throat feels dry.
16. I keep busy to avoid uncomfortable thoughts.
17. I cannot concentrate without irrelevant thoughts intruding.
18. My breathing is fast and shallow.
19. I worry that I cannot control my thoughts as well as I would like to.
20. I have butterflies in the stomach.
21. My palms feel clammy.

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

1. Age: _______

2. Sex: Male Female Decline to answer

3. Class Standing: Freshman Sophomore Junior Senior

4. Ethnicity: ______________________________

5. Handedness: Left-dominant Right-dominant

6. How fluent are you in English? (circle level)

Not fluent at all->1-------2-------3-------4-------5<-Native fluency

7. Other language(s) spoken: _____________________________

8. Have you ever been diagnosed with psychological/neurological condition (e.g., Depression, Anxiety disorder, etc.) by a professional? (PLEASE CIRCLE ONE→) Yes / No

9. If you answered Yes (to question 8):

    a. please list condition(s): ____

    b. list prescription medications you are taking for condition(s):

    c. have you received any CSUSB disability services for condition(s) listed?: Yes / No

APPENDIX C

WOLFE AND SMITH'S (1995) MOTIVATION QUESTIONNAIRE

Please circle one: This test counted. This test did not count.

Please think about the test that you just completed. Circle the number that best represents how you feel about each of the statements below.

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

1. Doing well on this test was important to me.	1	2	3	4	5
2. I am concerned about the score I receive on this test.	1	2	3	4	5
3. This was a very important test to me.	1	2	3	4	5
4. I gave my very best effort on this test.	1	2	3	4	5
5. I could have worked harder on this test.	1	2	3	4	5
6. I did <u>not</u> give this test my full attention.	1	2	3	4	5
7. I am eager to find out how well I did on this test.	1	2	3	4	5
8. I was highly motivated to do well on this test.	1	2	3	4	5

APPENDIX D

IRB APPROVAL

May 21, 2019

CSUSB INSTITUTIONAL REVIEW BOARD

Administrative/Exempt Review Determination Status: Determined Exempt

IRB-FY2019-260

Gia Macias and Hideya Koshino

Department of CSBS - Psychology California State University, San Bernardino

5500 University Parkway

San Bernardino, California 92407

Dear Gia Macias Hideya Koshino:

Your application to use human subjects, titled “Effects of Anxiety and Working Memory Capacity on Performance in the Emotional Stroop” has been reviewed and approved by the Chair of the Institutional Review Board (IRB) of California State University, San Bernardino has determined that your application meets the requirements for exemption from IRB review Federal requirements under 45 CFR 46. As the researcher under the exempt category you do not have to follow the requirements under 45 CFR 46 which requires annual renewal and documentation of written informed consent which are not required for the exempt category. However, exempt status still requires you to attain consent from participants before conducting your research as needed. Please ensure your CITI Human Subjects Training is kept up-to-date and current throughout the study.

Your IRB proposal (IRB-FY2019-260 - Effects of Anxiety and Working Memory Capacity on Performance in the Emotional Stroop) is approved. You are permitted to collect information from [200] participants for [4 units] from [Sona]. This approval is valid from [5/21/2019] to [5/20/2020].

The CSUSB IRB has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval notice does not replace any departmental or additional approvals which may be required.

Your responsibilities as the researcher/investigator include reporting to the IRB Committee the following three requirements highlighted below. Please note failure of the investigator to notify the IRB of the below requirements may result in disciplinary action.

Submit a protocol modification (change) form if any changes (no matter how minor) are proposed in your study for review and approval by the IRB before implemented in your study to ensure the risk level to participants has not increased,

If any unanticipated/adverse events are experienced by subjects during your research, and Submit a study closure through the Cayuse IRB submission system when your study has ended.

The protocol modification, adverse/unanticipated event, and closure forms are located in the Cayuse IRB System. If you have any questions regarding the IRB decision, please contact Michael Gillespie, the Research Compliance Officer. Mr. Michael Gillespie can be reached by phone at (909) 537-7588, by fax at (909) 537-7028, or by email at mgillesp@csusb.edu. Please include your application approval identification number (listed at the top) in all correspondence.

If you have any questions regarding the IRB decision, please contact Dr. Joseph Wellman, Assistant Professor of Psychology. Dr. Joseph Wellman can be reached by email at Jwellman@csusb.edu. Please include your application approval identification number (listed at the top) in all correspondence.

Best of luck with your research.

Sincerely,

Donna Garcia

Donna Garcia, Ph.D., IRB Chair CSUSB Institutional Review Board

DG/MG

REFERENCES

Bertels, J., Kolinsky, R., Pietrons, E., & Morais, J. (2011). Long-lasting attentional influence of negative and taboo words in auditory variant of the emotional Stroop task. *Emotion, 11*(1), 29-37.

Botvinick, M., Braver, T., Barch, D., Carter, C., & Cohen, J. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108*(3), 624-652.

Bower, B. (1992). Brother Stroop's enduring effect. *Science News, 141*, 312.

Braver, T. (2012). The variable nature of cognitive control: A dual mechanisms framework. Trends in Cognitive Sciences, 16(2), 106-113.

Carreterie, L. (2014). Exogenous (automatic) attention to emotional stimuli: a review. *Cognitive, Affective, & Behavioral Neuroscience, 14*, 1228-1258.

Cohen, J., Dunbar, K., & McClelland, J. (1988). On the control of automatic processes: A parallel distributed processing model of the Stroop effect. *Psychological Review, 97*(3).

Daneman, M. & Carpenter, p (1980). Individuals differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*(4), 450-466.

Engle, R. (2018). Working memory and executive attention: A revisit. *Perspectives on Psychological Science, 13*(2), 190-193.

Eysenck, M. & Calvo, M. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion, 6*(6), 409-434.

Eysenck, M.W., Derakshan, N., Santos, R., & Calvo, M. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336-353.

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology, 130*(4) 681-700.

Fraser, N., McKenna, F., Sharrock, R., & Trezise, L. (1986). Colour naming of phobia related words. *British Journal of Psychology, 77*, 97-108.

Gros, D., Antony, M., Simms, L., & McCabe, R. (2007). Psychometric properties of the state trait inventory for cognitive and somatic anxiety (STICSA): Comparison to the state–trait anxiety inventory (STAI). *Psychological Assessment, 19*(4), 369-381.

Holle, C. & Neely, J. (1997). The Effects of blocked versus random presentation and semantic relatedness of stimulus words on response to a modified Stroop task among social phobics. *Cognitive Therapy and Research, 21*(6), 681-697.

Kalanthroff, E., Henik, A., Derakshan, N., & Usher, M. (2015). Anxiety, emotional distraction, and attentional control in the Stroop task. *Emotion*. Advance online publication.

Koster, E., Crombez, G., Damme, S., Verschuere, B., & Houwer, J. (2004). Does imminent threat capture and hold attention? *Emotion, 4*(3), 312-317.

Lang, P., Bradley, M., & Cuthbert, B. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual (Tech. Rep. No. A-8). Gainesville, FL: University of Florida.

Kane, M. & Engle, R. (2003). Working-memory capacity and control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*(1), 47-70.

MacKay, D., Shafto, M., Taylor, J., Marian, D., Abrams, L., & Dyer, J. (2004). Relations between emotion, memory, and attention: Evidence from taboo Stroop, lexical decision, and immediate memory tasks. *Memory & Cognition, 32*(3), 474–488.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological bulletin, 109*(2), 163-203.

MacLeod, C. M. (1996). How priming affects two speeded implicit tests of remembering: Naming colors versus reading words. *Consciousness and Cognition, 5*, 73–79.

McKenna, F (1986). Effects of unattended emotional stimuli on color-naming performance. *Current Psychological Research & Reviews, 5*, 3-9.

McKenna, F. & Sharma, D. (1995). Intrusive cognitions: An investigation of the emotional Stroop task. *Journal of Experimental Psychology, 21*(6), 1595-1607.

McKenna, F. & Sharma, D. (2004). Reversing the emotional Stroop effects that it is not what it seems: the role of fast and slow components. *Journal of Experimental Psychology, 30*(2), 382-392.

Mogg, K., Mathews, A., Weinman, J. (1989). Selective processing of threat cues in anxiety states: A replication. *Behaviour Research and Therapy, 27*(4), 317-323.

Orberauer, K., Farrell, S., Jarrold, C., Lewandowsky, S. (2016). What limits working memory capacity? *Psychology Bulletin, 142*(7), 758-799.

Oswald, F. L., McAbee, S. T., Redick, T. S., & Hambrick, D. Z. (2015). The development of a short domain-general measure of working memory capacity. *Behavior Research Methods, 47*(4), 1343-1355.

Owens, M., Stevenson, J., Hadwin, J. & Norgate, R. (2014). When does anxiety help or hinder cognitive test performance? The role of working memory capacity. *British Journal of Psychology, 105*, 92-101.

Phaf, H. & Kan, K. (2007). The automaticity of emotional Stroop: A meta-analysis. *Journal of Behavior Therapy, 38*, 184-199.

Pratto, F., John, O. (1991). Automatic vigiliance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61*(3), 380-391.

Ree, M. J., French, D., MacLeod, C., & Locke, V. (2008). Distinguishing Cognitive and Somatic Dimensions of State and Trait anxiety: Development and validation of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA). *Behavioural and Cognitive Psychotherapy, 36*(3), 313-332.

Richards, A., French, C., Johnson, W., Naparstek, J., & Williams, J. (1992).

Effects of mood manipulations and anxiety on performance of an emotional Stroop task. *British Journal of Psychology, Vol.83*(4), 479-491.

Scrimin, S., Mason, L., Moscardino, U., 2014. School-related stress and cognitive performance: A mood-induction study. *Contemporary Educational Psychology, 39*, 359-368.

Sharma, D. (2016). Priming can affect naming colours using the study-test procedure: Revealing the role of task conflict. *Acta Psychologica*.

Stroop, J. (1935). Studies of interference in serial verbal reactions. Journal of *Experimental Psychology, 18*(6), 643-662.

Turner, M. & Engle, R. 1989. Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 27-154.

Tzelgov, J., Henik, A., & Berger, J. (1992). Controlling Stroop effects by manipulating expectations for color words. *Memory & Cognition, 20*(6), 727-735.

Unsworth, N., Brewer, G., & Spillers, J. (2009). There's more to the working memory capacity–fluid intelligence relationship than just secondary memory. *Psychonomic Bulletin & Review, 16*(5), 931-937

Van Dam, N., Gros, D., Earleywine, M, Antony, M (2013). Establishing a trait anxiety threshold that signals likelihood of anxiety disorders. *Anxiety, Stress, & Coping, 26*(1), 70-86.

Williams, J., Matthews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120*(1), 3-24.

Williams, J., Watts, F., MacLeod, C., & Mathews, A. (1988). The Wiley series in clinical psychology. Cognitive psychology and emotional disorders. Oxford, England: John Wiley & Sons.

Wolfe, L., Smith, J. (1995). The consequence of consequence: Motivation, anxiety, and test performance. *Applied Measurement in Education, 8*(3), 227-242.

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition and Emotion, 24*(1), 3-47.