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Context processing as a function of anxiety level

Viara Ivanova Stankova

CONTEXT PROCESSING AS A FUNCTION OF ANXIETY LEVEL

A Thesis

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ABSTRACT

Context processing is the foundation of a model of cognitive control set forth by T.S. Braver and colleagues (Braver et al., 2001). According to this model, cognitive functions, such as attention, inhibition and working memory are the product of a single, context processing mechanism. Deficits in context processing have been associated with cognitive development in children, healthy aging, as well as individuals suffering from schizophrenia. The goal of the present investigation was to apply Braver's model of cognitive control to groups selected on their differences in trait anxiety and explore their relationship. Performance on two versions of the AX-CPT (Standard and Distracter) was compared between a high and a low trait anxiety group. The results indicate that there is evidence for group differences in context processing related to trait anxiety level. Interestingly, these differences were not evident during the Standard AX-CPT and both groups displayed good context processing regardless of trait anxiety level. However, when cognitive demand was increased during the Distracter AX-CPT, stable group differences indicated that although the low anxiety group sustained good context processing, the high anxiety group failed to do so. These results, although taken with

caution, are an indication of the relationship between anxiety and context processing deficits. These findings warrant the need for future research of this relationship and have important implications for both the field of basic cognitive research, as well as research that can be applied to the understanding of the origin and perpetuation of anxiety symptoms and their impact on the workplace.

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TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

People in today's world must function more like impeccably programmed computers in order to efficiently process the endless stream of information coming from the environment. An enormous portion of the stimuli that reach the senses are being processed by the nervous system almost automatically without leaving a conscious trace. This processing system must be designed to work in our best interest and the end result of its work that is brought to one's conscious attention must ensure efficiency and promote survival, at the least. On one hand, in every day life we benefit from the automatic nature of processes - from maintaining normal vital function, vision, hearing to reading, driving and playing a familiar musical piece on the piano. On the other hand, people desire to be highly motivated, independent cognitive individuals who are able to freely and voluntarily control their behavior. The question of how independent the voluntary and automatic processes actually are has been investigated not once in the literature.

Context Processing

Introduction to Cognitive Control

The study of high-level cognition processes is of fundamental significance for the understanding of the human psyche. The complexity of the mechanisms behind processes such as attention, inhibition, decision-making and problem solving is often. To exercise cognitive control means to be able to override a reflexatory reaction to a particular stimulus in favor of a more complex and sophisticated sequence of actions. Thus, it is difficult to study cognitive control in animal models. We take for granted the exquisite ability of the human brain to maintain the body still while a doctor is administering a painful but life saving treatment or to solve an algebra problem in a creative and innovative way. Cognitive control can assist with a top-down approach to solve a particular problem or make a decision, rather than relying solely on what is presented as stimuli in the immediate environment. In other words, it represents the ability to actively suppress a particular train of thought or an automatic reaction or to dynamically switch one's attention from one task to another.

Cognitive control is one if the manifestations of the highly developed human brain and its exceedingly powerful abilities to act and not simply react in the environment. People are faced with the necessity to learn and perform new skills and tasks that are high in complexity and demand cognitive power. In summary, using cognitive control one is able to selectively attend to task relevant information in the environment, use memory capacity and previously stored information effectively while inhibiting irrelevant and distractive stimuli.

Context Processing Model of Cognitive Control

A recently developed model of cognitive control allows for all three of its major components (attention, inhibition and working memory) to be examined within a single processing unit (Braver et al., 2001; Braver & Barch, 2002). According to Braver and his colleagues, exercising cognitive control effectively results in the ability to flexibly adapt to the different demands of the environment and act accordingly. Braver proposed that successful execution of the cognitive functions related to attention and inhibition can be accomplished by actively representing and maintaining all information that is relevant. In Braver's model any relevant information is what is referred to as the context. Thus, by effectively maintaining the context, one can successfully focus attention to important stimuli, appropriately inhibit irrelevant ones and therefore minimize interference and maximize performance. This function is undertaken by a context-processing unit which regulates all information that may guide future behavior, and it is proposed to function as a separate mechanism within working memory (Braver & Barch, 2002).

Nearly every situation a person encounters on a daily basis calls for a sequence of covert (thoughts) and overt (behavior) processes that are appropriate for the specific situation. In many cases, a particular behavior, such as answering a ringing telephone is absolutely appropriate. Answering a telephone while driving, however, may not only be out of place, but it can endanger someone. Successfully exercised cognitive control allows for the two situations to be differentiated and for the behavior to be displayed in the former and inhibited in latter. The set of rules in this case, that determine in which situation to answer the telephone, could be thought of as the context. In Braver's theory, context is defined as a form of an internal representation of any information that may be related to an ongoing task or behavior (Braver & Barch, 2002). Thus, context can be the mental framework which when at work can lead to accurate decisions on what behavior is executed and what inhibited, which stimuli in the environment are attended to and which are ignored. Using context successfully can lead the individual to attain a particular target, such as following a particular strategy can help a chess player to win an important match. This means that the player must plan which figures to move sometimes well in advance in order to fit his/her strategy goal. Therefore, working within a particular context can also guide subsequent decisions. The representation of context is thought to be very active and a constantly updating unit. Naturally, in a dynamic environment where changes occur at a high rate, keeping up with the initial "instructions" from the context can be challenging. For example, taking the moves made by the chess player independent from one another places different demands on one's cognitive control than if they were to be considered part of an overarching strategy to corner an opponent and win the game. Not taking an obviously unprotected opponent's figure in order to follow a predetermined path can be difficult at the time but beneficial in the long run. In the same way, context processing is especially important when a routinely appropriate behavior has to be inhibited in order for a goal oriented one to take place. In fact, intact context processing leads to attention and inhibition without directly exercising either process.

Attending or inhibiting a particular aspect of the environment, for example is facilitated by the information used in the context-processing unit. A key feature of Braver's model is that its components account for processes involved not only in inhibitory responses, but also in ones that require attention. The benefit to Braver's model, however, is that they are not being examined independently but as underlying processes of a single context-processing unit.

Neurobiology

A crucial part of Braver's research is aimed to establish the idea that there are active neurobiological pathways responsible for his model of cognitive control (Braver et al., 2001). The internal representations of the context, as well as their active maintenance are suggested to be neural pathways in a portion of the brain, called the dorsolateral prefrontal cortex (DL-PFC). This brain region is associated with higher cognitive functioning, decision-making and problem solving, as well as with the processes related to working memory. Interestingly, the neurotransmitter dopamine (DA) has an active network of pathways in the DL-PFC and it has been associated to various cognitive processes, such as attention and inhibition (Braver et al., 2001). For example, tasks that require the active use of working memory have been shown to suffer serous deficits in performance for individuals with lower levels of DA (Luciana, Collins, & Depue, 1998). When a small dose of a DA antagonist was administered to participants in their experiment, performance on a cognitive control task seemed to deteriorate in comparison with participants with normal DA levels (Braver et al., 2001; Cohen, Braver, & Brown, 2002). Therefore, Braver's theory aims to establish a possible model where the DL-PFC region of the brain and DA play an important role in cognitive processing, namely the active representation and update of relevant context.

The specific function that each of the above components plays in cognitive processing has not been clearly explained by previous research. DA seems to be associated with cognitive deficits and lesions to the DL-PFC appear to result in cognitive impairment, but the precise mechanisms through which this takes place have been successfully presented only in Braver's model. There are several key components of Braver's neural network that will be described in detail next (Figure 1). First, the system has an input flow where the incoming information from the environment enters directly (input unit). Then this information undergoes some internal processing and eventually results in some response. This process simply describes a stimulus - response pattern. When taking context processing into account, Braver adds a component that he calls the "context layer". The context layer, which is found within the DL-PFC, serves as a mediator of the simple stimulus - response reaction. The incoming flow is being affected by the context before it is being released as a response. Braver points out three important characteristics of the context layer that cause its influence over the stimulus-response system (Figure 1). First, an active network of neuronal connections is especially pronounced in the context layer. This network's purpose is to keep the information in the context-processing unit in active circulation and maintenance. Thus, even if the initial stream of incoming information is being interrupted, the context unit can sustain content and continue to feed into the response pathways. This process is called updating. This, in turn, is possible because the context unit has pathways connecting to the direct stimulus-response pathways. Interestingly, there are two independent pathways relaying information from and back to the context-processing unit. The first pathway, from the context unit to the direct stimulus-response pathway, serves to "bias" otherwise independent events with the information that is being actively represented in the context-processing unit. For instance, if we go back to our chess player example, the strategy of winning the match is being actively represented and maintained in the context-processing unit. If we take each move independently, the direct stimulus response pathway may be a sufficient mechanism. However, when the player has to choose among several options, the context-processing unit will activate its connection to the direct pathway in order to produce a biased response favoring the overall strategy to win the game over any other possible move. Interestingly, this is true especially when the player has to show patience and inhibit an obvious, dominant move. This is a perfect example of cognitive control and inhibition where a weaker pathway can influence the response over a stronger one.

An interesting question, however, may be asked - how can the chess player keep his/her strategy protected from all incoming information resulting from the progress of the game and at the same time adjust it according to the opponent's surprising moves? This incoming information may be distractive and irrelevant and it is crucial for the chess player to protect his/her game strategy intact and focused. According to Braver's model, the context processing unit is somewhat protected from the constant flow of information. Its second connection, the one coming from the direct pathway, does not allow the free and constant flow to enter the context unit. It serves as a gateway that protects and feeds into the unit whenever appropriate. It has been suggested that DA projections assist in accomplishing this complicated process (Braver et al., 2001). When the dopamine neurons are active, information can enter the context layer so it is in connection with any changes in the incoming demands as well as its context representations are being updated. In turn, when the pathway is not active, no incoming information enters the context-processing layer, preserving its contents from competing and distracting stimuli. In summary, Braver's model represents an active, neural based system that allows for information to be actively represented in a single context processing unit, which serves as the basis for both the attentional and inhibitory functions of cognitive control.

Testing Braver's Model

To test his model, Braver (Braver et al., 2001; Braver & Barch, 2002) adopted a computer-based cognitive task known as the AX-CPT (Continuous Performance Task). The main goal of the participant in the AX-CPT is to differentiate between target and non-target trials as quickly and accurately as possible. In the AX-CPT each trial consists of a sequential presentation of two letters - cue and probe (Figure 3). The target trials are those where a letter "A" is the cue and letter "X" is the probe. All other combinations of letters are to be regarded as non-target and responded to as such. For the purposes of the description of the task, every non-A cue will be referred to as a B-cue and every non-X probe will be referred to as a Y-probe. Therefore, a condition which consists of a cue letter "A" and a non-X probe will be referred to as the AY condition; a non-A cue and an X probe will be referred to as a BX condition, and a non-A cue combined with a non-X probe will be a BX condition. Braver suggested that these conditions serve as a test for how well context is represented in one's working memory. To create particular cognitive biases, the proportion of target and non-target trials is manipulated within a test list. In fact, participants are exposed to target trials (AX) 70% of the time. This manipulation has specific consequences - two cognitive biases are created. First, an expectation bias occurs when the cue letter A is presented. Individuals learn to use the cue letter A to predict the occurrence of a target probe X because this, in fact, is the case with 70% of the trials. In this case, context processing serves as an agent that directs one's attention to task relevant information - the target letter A. This bias becomes evident on trials where the cue letter A is not followed by the usual target probe X, but by any non-X letter. In these situations, individuals are more inclined to respond to the trial as a target even if the probe is a non-X letter and they should regard it as a non-target trial. As a result, AY trials become susceptible to false alarm type of responses. Further, every time individuals are presented with a target probe "X", their response is also affected by the same bias. They must use context processing effectively to inhibit the reactive response to a target probe "X" on trials with non-A cues (BX trials). As a result, the BX trials become susceptible to false alarm errors as well and serve as an indicator for how well the inhibitory properties of the context-processing unit are functioning.

The AX-CPT is a suitable way to test Braver's model of context processing also because it simultaneously accounts for processes underlying attention and inhibition. Braver suggests that both these principles are functioning within the idea of context processing (Braver et al., 2001). Specifically, when context is represented internally it can guide one's attention toward a particular stimulus or serve as an inhibitory agent for another stimulus. Generally, each trial provides two pieces of information - one comes from the cue and one from the probe. In some instances, the cue and probe are consistent as indicators for a target or non-target response. For example, when the cue letter is A and the probe letter is X, the response should be a target response and both cue and probe correspond to it. When there is a non-target cue (any non-A letter) and a non-target probe (any non-X letter), the response should be non-target and it should be facilitated because both cue and probe indicate a non-target response. Therefore, in the AX and BY trials, cue and probe both suggest a particular response (target or non target). As mentioned earlier, the bias created by the high frequency of AX target trials creates a specific bias whenever the cue A and probe X are presented. Making a correct response is more challenging when the cue suggests a target response, but the probe is a non-target one, or vice versa (BX and AY trails). For instance, inhibition is required in BX trials where the participant has to use the representation of the cue B actively in order to suppress a target response to the probe X. Having a preserved representation of the cue B, as a non-target cue, helps for the successful inhibition of a subsequent target response to the target probe. Therefore, superior inhibition is tested for and evident on all BX trials. Specifically, on BX trials good context processing leads to a decrease in the amount of errors - participants correctly identify B as a non-target cue and successfully inhibit target response, thus eliciting a correct response. On the other hand, the same representation on context can impair performance on other trials, namely, when a participant is presented with an AY trial. In this case, the active representation of the target cue A prepares for a strong tendency for a target response to the probe even if it is not a target probe X. Good context processing, in this case, impairs performance on AY trials.

In summary, good context processing is evident when participants make few errors in BX trials, where they have effectively used the non-target cue B and inhibited the target response to the target probe X (Figure 2). Also, good context processing is evident when participants commit more errors in AY trials. Here, the target cue A is vividly represented in context processing and facilitated by the 70% AX rate bias leads to a false alarm and thus a target response on a non-target probe Y. This is counterintuitive in the sense that more errors in AY condition suggest good context processing, but when the data are examined carefully the distinct pattern of responses on BX and AY trials can be a great illustration of how context can lead to attention or inhibition on the same task. More specifically, examining performance in these two types of trials one can collect evidence for the quality of context processing and can further specify whether potential problems are due to impaired attention, or impaired inhibition or both.

Manipulating the delay between cue and probe presentation allows for additional examination of context processing. Namely, according to Braver's model the representation of context has to be actively represented, maintained and updated over some period of time in order for good performance to occur (Braver et al., 2001). If this is fact is the case, manipulating the length of delay between cue and probe provides additional information. For instance, if context processing is intact, the difference between a trial with a short cue-probe delay and a trial with a longer delay would not be pronounced. If the representation of the cue and maintenance of context function properly, increasing the delay should not affect performance. If, however, context processing is impaired, cue-probe delay variations will be evident in a distinct pattern of results (Figure 3). Specifically, if the cue representation is decaying over the duration of the delay, there will be more errors in the long delay BX condition in comparison with errors in the short delay BX condition. Interestingly, errors in the long delay AY condition will decrease in comparison with errors in a short delay AY, because of the decayed cue representation and its reduced similarity to the target response. A fascinating aspect of the AX-CPT task is that each condition relies on a distinct cognitive process (attention or inhibition, for example) and good performance is granted when a distinct mechanism within the context-processing unit is functioning properly (cue representation or maintenance, for example). This way the model makes very specific predictions about the behavioral pattern of responses on the AX-CPT task and can be a useful tool in identifying cognitive impairments that are due to context processing deficits.

Studies on Healthy Aging

Deficits across various cognitive domains have been documented to accompany healthy aging adults (Braver et al., 2001). For instance, impairments concerning episodic and working memory are evident; also, studies with older adults have revealed problems with selective attention and inhibition. Braver suggests that there is a single underlying mechanism that deteriorates with age and is responsible for these multiple deficits (Braver et al., 2001). Braver's results come mainly from studies on aging, where poor context processing is observed in Alzheimer's patients whose cognitive functioning is grossly impaired by profound brain cell loss (Braver & Barch, 2002). Alzheimer's patients have immense difficulty with inhibition and therefore commit a large number of errors as a result of the inhibition bias, in comparison with healthy control individuals. Alzheimer's patients commit significantly fewer errors in the attention bias, which signals poor attention and representation. In other words, Braver's model relates disturbances found in the DL-PFC and the DA system with the behavioral deficits displayed by the aging population. A similar pattern is displayed by the healthy aging population (Braver & Cohen, 2001; Braver & Barch, 2002). When compared to control participants, the aging sample displays a very distinct pattern of results on the AX-CPT task. Namely, performance dependent on effective inhibition suffers and is demonstrated with increased the error rate on BX trials. Thus, the inability to inhibit a target response is present. Also, a decreased amount of AY errors signals problems with attention, where the target cue A is not being represented affectively. If good context processing, as explained in the above paragraphs, is demonstrated by a lot of AY errors and few BX errors, healthy aging adult sample displays nearly the opposite pattern - fewer AY errors and many BX errors.

In other words, according to Braver's model, the natural deterioration of the DL-PFC with age is the single underlying mechanism that affects the effectiveness of the context processing unit and is therefore the basis for the various cognitive deficits displayed by older adults.

Anxiety

Working Memory

One common goal of science is to explain the changes in behavior that are observed among different populations. It is especially valuable when parsimony is achieved and multiple behavioral manifestations are associated with a single underlying mechanism. It is interesting to observe that there are other populations that exhibit similar cognitive deficits to the ones investigated by Braver and his colleagues. Anxiety patients, for instance, display impairments in multiple cognitive tasks that rely on attention, inhibition and working memory. Nevertheless, a unitary concept of the anxiety symptomatology is lacking in current literature. The purpose of the following review of relevant literature is to demonstrate that although deficits in cognitive processes persist among individuals with anxiety symptoms, there is no agreement as to what mechanisms are responsible. A potential benefit of applying Braver's model to an anxiety sample is to capture a distinct behavioral pattern of responses that can be accounted for by deficits in the context processing mechanism. The concept of working memory was first proposed in 1974 as an alternative to the established model of short-term memory (Baddeley & Hitch, 1974). Instead of a storage unit alone, the new model described an active system where information was being perceived, transformed, integrated and stored. Working memory, according the Baddeley, is an information-processing unit composed of three major subcomponents. The most known and well-studied aspect of working memory is the phonological loop, or the fragment responsible for auditory stimuli. Also, it manipulates speech-related information such as language. The second component, the visuospatial sketchpad, holds and integrates both visual and spatial information. The executive component of working memory is the least investigated and is assumed to supervise, integrate and govern incoming information from other two components, ultimately affecting behavior (Baddeley & Hitch, 1974). This way, the processes that occur within working memory assist one's response decision when competing stimuli are presented.

A large number of findings in the literature suggest that there is a link between performance on working memory tasks and anxiety. In fact, it has been demonstrated that high levels of anxiety are related to performance deficits. Empirical studies contrasting groups of individuals with high and low anxiety levels provide evidence to support this notion. In an experiment conducted by Macleod and Donnellan (1993), high and low anxiety students engaged in a reasoning task. Their performance was measured in two distinct conditions of high and low memory load. As expected, students in the high anxiety group were slower in the reasoning task displaying need for more time for decision making. Interestingly, differences in the high and low memory load condition were found to affect the groups in a similar way. Indeed, the high memory load harshly disadvantaged the elevated anxiety group suggesting that limited working memory capacity is related to the performance deficit (MacLeod & Donnellan, 1993). In other words, anxiety itself can put a strain on one's working memory capacity, and thus impair the ability to perform well.

Attention and Inhibition

Deficits in attention and inhibition are commonly found in individuals suffering from anxiety (Baddeley & Hitch, 1974; Kane & Engle, 2003). The approach through which scientists have examined these two processes, however, is far from unanimous. Some studies look at attention problems only; others focus on deficits in inhibition. Nevertheless, it is rather difficult to think of just attention or inhibition because they are like the flip sides of the same coin. When a person is attending actively to something, he/she is also actively inhibiting other stimuli that are present in the environment. Thus, the following review of literature will entail experiments that aim to reveal the role of both attention and inhibition among individuals suffering from anxiety.

Attention represents a perceptual process in which an organism actively focuses on a particular aspect of the environment while excluding the surroundings (Ackerman, 1987). To ignore certain aspects of the environment, however, is a dynamic and demanding process as well, and it is referred to as cognitive inhibition. Therefore, successful interaction with the world depends on one's ability to both focus and sustain attention upon relevant stimuli, and selectively inhibit distractor stimuli that are irrelevant to the task at stake. Previous findings suggest that the proper function of working memory is tightly related to both attention and inhibition. According to a model developed by Hasher and Zacks (1988), attentional inhibition regulates any information that enters or leaves working memory. For instance, inhibitory mechanisms filter goal irrelevant stimuli before they enter working memory, thus allowing only goal relevant ones to be attended to. Thus, attention inhibition and working memory can prove to be quite useful in tasks where the target/non-target stimuli can change, or when one has to switch attention between relevant and irrelevant stimuli.

The Stroop Task

A popular measure of attention and inhibition in the past few decades has been the Stroop task. Here, participants are presented with words on a screen and are instructed to report the color of ink in which the words appear while ignoring the word's meaning (Kane & Engle, 2003). In some cases, the meaning of the word and its color facilitate performance; for instance, the word "yellow" appearing in yellow ink, or the word "green" in green ink. When participants encounter words that conflict with their color, such as the word "yellow" appearing in green ink, performance is compromised. It has been observed time and again, that when presented with conflicting stimuli most people tend to slow their response rate. In reference to cognitive control, successfully attending to the relevant feature of the stimulus (the color), while inhibiting the irrelevant one (the meaning of the word) ensures successful performance and, it is a sign of good processing skills.

It is believed that individuals who report experiencing anxiety symptoms perform differently on experimental tasks that put a high demand on cognitive processes, such as the Stroop task. A modified version of this task has been used largely to investigate an attentional bias that is exhibited by anxiety patients. Similar to the original version, in the emotional Stroop task, individuals are asked to name the color a word is printed in without reading the word itself For this version of the task, anxiety related and neutral words are presented in different color ink (MacLeod, 1991). The goal is to name the color the word is written in as fast as possible. Generally, when participants are presented with stimuli (words) that are anxiety provoking (e.g. death, faint, rape etc.) their performance is diminished in comparison with performance to neutral stimuli. The intuition behind the emotional Stroop is that the semantic content of a word can produce additional interference (MacLeod, 1991). Specifically, reaction times are significantly slower in the anxiety condition, indicating that there is a bias for anxiety related information. In other words, anxiety related stimuli have the ability to involuntary capture one's attention and interfere with the speed of response. Further, the slower reaction times suggest that the participants may have a difficult time inhibiting the meaning of the anxiety related words, which in itself can degrade response time performance.

Good performance on the modified Stroop task can be achieved if the participants are able to successfully inhibit the meaning of the words and focus exclusively on the color that they are printed in. The use of this strategy, however, is being compromised among individuals with anxiety symptoms. This finding suggests that high anxiety individuals exhibit an attentional bias toward emotionally loaded stimuli; therefore, it takes longer for one to attend and name the color of a word if his/her attention is first drawn to the meaning of the word.

However, results from emotional Stroop paradigms do not always replicate. Interestingly, there are instances when individuals with high anxiety are slower to name both neutral and loaded words (Mogg & Marden, 1990). One possible explanation for this discrepancy comes from the fact that individuals with high anxiety differ tremendously on stimuli that may be triggering their symptoms (gun shot for a post traumatic stress disorder (PTSD) sufferer, a spider for a person with arachnophobia). Further, most robust interference on the emotional Stroop task has been reported when the loaded words are particularly trigger specific (Hope et al., 1990; Buckley, Blanchard, & Hickling, 2002; Thorpe & Salkovskis, 1997). MacLeod (1991) suggests that the specificity of the emotionally loaded words could serve as a confound explanation. In other words, war veterans who suffer from PTSD will respond slower to trauma words related to combat because these are especially relevant for them. In this case, the discrepancy in the literature is explained by the selection of stimuli, rather than a particular processing mechanism.

Dot-Probe Task

Another popular task used to assess processing biases, especially attentional bias in various populations, is the dot probe paradigm. In this task, individuals are asked to determine whether a dot has been presented on the left or right side of the screen. Before each presentation, two images appear on the screen. Similar to the emotional Stroop task, pictures are chosen to be either neutral or emotionally loaded. In anxiety individuals, it has been observed that response time decreases when the dot is preceded by an emotionally loaded picture with the same location. In other words, it may be the case that emotionally loaded images selectively draw attention, which facilitates response if the dot emerges in the same location as the picture (Bradley, Mogg, Falla, & Hamilton, 1998).

It appears that individuals with elevated anxiety attend to emotionally loaded or threat related stimuli more readily than to neutral ones compared to individuals with normal anxiety level. Anew line of research, however, suggests that there may be some evolutionary component in the way we chose which stimuli to process and which to ignore. With a version of the dot probe task, Lipp and Derakshan (2005), tested the idea that attention bias may be observed among a sample of individuals without anxiety problems when pictures of fear-relevant animals are presented. Pictures of snakes and spiders were distinguished as "phylogenetically prepared stimuli" and as such were to produce attentional bias in individuals who did not report a history of snake or spider phobia. The results of this investigation suggest that this in fact is the case. Attentional bias toward the fear-related pictures was observed across the entire sample. An important implication here is the fact that preferential processing of fear related stimuli inflates the observed attentional bias. For other anxiety related stimuli, however, the effect may be underreported. Thus, although widely researched, attention bias in individuals with high levels of anxiety emerges to be a controversial phenomenon.

Information Processing Bias

The effective interaction with one's immediate environment requires not only successfully allocating attention to relevant stimuli, but also filtering out those that are unimportant. Logically, it seems to be the case that by preventing such information from processing, more cognitive resources are being directed to relevant stimuli, ensuring more efficient performance. In the anxiety literature, deficiencies with inhibition are generally linked to individuals with high levels of anxiety. The specific processes that underlie this phenomenon, however, seem to have escaped a straightforward explanation.

One venue of research studies aimed at clarifying the role of cognitive inhibition as a factor in maintaining anxiety symptoms has focused on examining specific cognitive biases that come about when interpreting ambiguous information. Since the individual is constantly bombarded with information from the environment, it is not uncommon for ambiguous stimuli to be a subject of interpretation. It has been suggested that elevated anxiety influences one's interpretation of such indistinct information (Richard & French, 1993). In other words, when it comes to uncertain input of information, individuals with high anxiety tend to process ambiguous information (events, bodily sensations, memories) in a threat favoring way. In an experiment performed by Clark et al. (as cited in McNally, 1999b), panic disorder patients were asked to rate ambiguous bodily sensations (e.g., heart palpitations) as neutral or threatening. It was revealed that an interpretive bias existed, where heart palpitations, for instance, were very often related to a pending heart attack and serious illness rather than a brief condition. These findings can also suggest that the individual failed to inhibit the unpleasant, fearful or threatening meaning and all cognitive resource was directed in the direction of the negative stimulus. Evolutionarily, a similar strategy makes perfect sense – recognizing real danger among a vast array of potentially threatening stimuli will most definitely be an advantage. Overdoing it, however, can prevent the organism from focusing on other vital resources in the environment and can also create a very negative, life-threatening setting.

In a clever experiment, Wood, Mathews, and Dalgleish (2001) used sentences containing ambiguous words with a positive and negative possible meaning, to illustrate the idea that individuals with elevated anxiety have a deficiency in inhibiting negative information. The task consisted of presenting sentences that ended with a homograph (words that have identical spelling but different meaning), such as "At the party she had some punch". The meaning of the sentence was consistent with a positive/neutral meaning of the homograph. However, participants were asked to determine whether a probe word was either related or unrelated to the sentence. Probe words in the test condition were related to the negative meaning of the homograph, such as the word "fist" would be to the example sentence above. In other words, at a first glance the word "fist" is not related to the above sentence, unless both meanings of the word "punch" are active (a party drink and a painful strike). With intact inhibition, the participant would quickly reject the word "fist" as being related to the sentence. The negative meaning of the "punch" homograph has been successfully inhibited. It was expected, that individuals with high anxiety would exhibit longer reaction times in comparison with individuals with normal anxiety levels, signalling inhibition deficits. Interestingly, this was not the case. Reaction times for people with anxiety were comparable to the ones displayed by the control participants. However, when working memory load during the task was increased, the deficiency in inhibiting the negative meaning surfaced and interference in reaction times was recorded (Wood, Mathews, & Dalgleish, 2003). These results are in accordance with the notion that effective inhibition requires the availability of cognitive recourses, such as working memory for instance. Because these resources are limited, the processes that depend on them compete for their allocation. One possible implication is that anxiety, the state of being aroused, takes up a certain amount of the available cognitive resource, taking away from processes such as attention and inhibition (Eysenk &

Calvo, 1992). Therefore, competing processes depending on this resource are impaired.

The Present Investigation

The main goal of this investigation is to demonstrate that Braver and colleagues (Braver at al., 2001) context processing theory of cognitive control provides a parsimonious explanation of processing deficits found in those showing anxiety symptoms. Braver has shown that the execution of processes such as attention, inhibition and working memory can be accounted for by a single mechanism - the context-processing unit. Interestingly, deficits in the same cognitive processes (attention, inhibition and working memory) have been revealed in the current anxiety literature (Liebert & Morris, 1967; MacLeod, 1991a; Mogg & Marden, 1980) as common symptoms in individuals with high anxiety. To date, no research has been conducted to determine whether anxiety sufferers show increased deficits in context processing relative to non-anxiety sufferers. In the present study, we aim to establish a direct link between insufficiencies in context processing and cognitive deficits related to anxiety symptoms and thus enhance the overall understanding of the underlying mechanisms of the observed discrepancies in cognitive performance.

Participants in the present study will be selected on the basis of their scores on a widely used measure of anxiety, the State-Trait Anxiety Inventory, Form Y (STAI, Spielberg, 1983). The STAI contains two scales (STAI-Y-1 and STAI-Y-2) that are designed to measure levels of trait and state anxiety independently. State anxiety refers to an emotional arousal that an individual experiences in the immediate face of real or perceived danger. It is the normal and adaptive reaction to an urgent threat in the environment that is displayed by all individuals. For example, hearing a loud gun shot elicits a moment of increased heart rate, sweating, pupil dilation and worry in everybody. The result is that the organism mobilizes its resources to react to the pending dangerous situation - the basic flight or fight response. Subsequently, when the situation is safe and the organism calms down, the state anxiety is eliminated. On the other hand, trait anxiety is defined as being a stable characteristic and is associated with an established individual difference characterized by a heightened state anxiety response. An individual with high trait anxiety is more likely to respond with an elevated state anxiety in a wide variety of situations that may not necessarily represent immediate danger. It is normal and adaptive to react with fear and anxiety to a dangerous situation, but when there is no need for such reaction, unnecessary anxiety results in lasting and disruptive symptoms. Individuals with high trait anxiety tend to display increased levels of state anxiety in situations that may not be of potential threat or danger, thus the adaptability of the response loses its functionality. If an individual's level of trait anxiety is within a normal range, state anxiety is experienced only when real danger is present or an extremely stressful situation arises. Thus, our interest was focused on the relationship between trait anxiety and context processing, independent of state anxiety in an attempt to detect a stable effect that persist whether in threatening or non-threatening situation.

The STAI-Y-2 will be used to establish the basis for the selection of individuals with high and low trait anxiety. Thus, participants will be divided into high and low anxiety groups based solely on their trait anxiety scores. Levels of state anxiety, however, must be taken into consideration as well. The reasoning behind this concern is that individuals with high trait anxiety tend to experience elevated state anxiety as well. This is true for a wide variety of situations that can be threatening or not, novel or familiar. Thus, it is possible that individuals in the HA group will not only possess greater levels of trait anxiety than individuals the LA group, but greater levels of state anxiety as well. As a result, any difference found in context processing between the HA and LA groups could be attributable to either increased trait or state anxiety. In order to help alleviate the potentially confounding effect of state anxiety on context processing performance, in the present study, state anxiety will be measured and treated as a covariate. By doing so, the relationship between trait anxiety and context processing can be examined while controlling for the effects of state anxiety.

Recall the basic premise of the AX-CPT described earlier in this paper. Participants are presented with single letters one at a time on a computer screen and are required to press the target key when the letter "X" is presented, but only if the letter "A" preceded it. The processes of attention and inhibition are a natural consequence of good context processing and are thus absolutely necessary for one's performance on the AX-CPT (Lorsbach & Reimer, in press). To illustrate this, take an important aspect in the design of the AX-CPT - the disproportionally high rate at which the AX target trials appear (70%). There are two important consequences of this high proportion. First, an expectancy bias to the letter "A" is built. Participants develop high readiness to press the target button to the letter "A" because 70% of the time it is followed by the letter "X" to complete a target trial. Thus, attention to the letter "A" facilitates performance on the target AX trials. However, the same bias proves detrimental on AY trials where participants must resist pressing the target button. Further, a second bias toward making a target response when the probe is the letter "X", even with a non-A cue (BX trials) is formed. The concept here is similar - the high rate of AX trials builds an urge in participants to press target every time they see an "X". In the case of BX trials, one must successfully inhibit the urge to press target by using the representation of the non-target cue "B" (Lorsbach & Reimer, in press).

Also, performance on the AX-CPT relies on the active representation and maintenance of context and therefore provides an excellent opportunity for their examination. For instance, variations in the quality of context representation and maintenance results in predictable performance patterns on AY and BX trials. Details about these patterns will be provided in the following paragraphs. Performance in the BY trials does not depend on either good representation or maintenance of context and therefore can be considered as a baseline condition.

In some of his experiments, Braver (Braver & Barch, 2002) manipulated the delay between cue and probe by having a short (1 sec) and long (5 sec) delay. The difference between the two delays lies in the fact that in the long delay condition participants not only have to represent the cue as relevant context, they must maintain it during the delay. In the present investigation, we will adopt a long (5 sec) delay between cue and probe for all trials because it allows for both representation and maintenance of context to be examined simultaneously.

If context processing is *good*, individuals should be able to successfully inhibit the tendency to press the target key on BX trials and thus the error rate should be lower and reaction times faster in comparison with AY trials. On the other hand, good context processing hinders performance on AY trials because the large number of AX trails creates an expectancy bias toward pressing the target key when the cue is "A". Therefore, with *good* context processing, performance on AY trails leads to more errors and slower reaction time than performance on BX trials. When context processing is *impaired*, the opposite is expected - errors and reaction times on the BX trials should surpass errors and reaction times on AY trials.

Thanks to the delay between cue and probe, context maintenance also can be examined. Therefore, if context maintenance is good, individuals should perform well on BX trials, which require active maintenance of the inhibitory cue "B," and should successfully inhibit the tendency to press the target key. Error rates on BX trials should be lower and reaction times faster than AY trials. On the other hand, good context maintenance comes at a cost in the AY condition. Here, the expectancy bias to press the target key when the cue is "A" is maintained over the delay and results in more errors and slower reaction times in comparison with the BX trials. If context maintenance is impaired, error rates will increase dramatically in the BX condition because participants will fail to inhibit the overwhelming tendency to press the target key when they encounter an "X" probe. Conversely, performance on the expectancy-hindered AY trials should improve. Failing to maintain the cue representation over a long delay lessens the expectancy, thus, improving performance. In short, with context maintenance problems, performance will improve on AY trials and worsen on BX trials.

Examining context processing in individuals with elevated trait anxiety leads to straightforward predictions regarding performance on the AX-CPT. If context processing is impaired, individuals in the high anxiety group will display fewer errors and faster reaction times on AY trails in comparison with individuals in the low anxiety group. Also, the high anxiety group will show impaired performance on BX trials (more errors and slower reaction times) in comparison with individuals in the low anxiety group.

A possibility exists, however, that the effects of anxiety on context processing may not be displayed unless there is an increased level of demand on one's cognitive processing. Some studies suggest that unless there is a demand for cognitive resources, differences between high and low anxiety groups may be undetected. Thus, performance on the standard AX-CPT described above may not differ for the two anxiety groups. To explore this possibility, a high-demand version of the AX-CPT, subsequently referred to as Distracter task, will be used. In this version, a sequence of three distracter stimuli (letters in different color and font) will be presented during the delay (5 sec) between the cue and probe (See Figure 4). The goal of the task remains the same as in the

Standard AX-CPT - to identify and respond to a target probe "X" but only when it is preceded by a target cue "A". Attention, inhibition, as well as intact representation and maintenance of the cue are once again essential for the successful performance on the task. However, unlike the Standard AX-CPT, the high demand version requires participants to actively protect and keep the cue representation intact while being presented with interfering, competing stimuli. It is often thought that individuals who suffer from anxiety are not able to inhibit persistent thoughts or threatening stimuli in their environment and that this inability perpetuates their anxiety symptoms (MacLeod, 1996). It is proposed that individuals with high trait anxiety will have a more difficult time withholding their attention from the distracter stimuli in the Distracter condition than individuals with low trait anxiety. If so, this will negatively affect the maintenance of the cue-letter presented at the beginning of the trial and by the time the probe letter is presented context processing will be compromised. The role of the distracters is to challenge the update and maintenance components of the context processing mechanism.

If context processing is good, participants will be able to successfully represent and maintain context information and respond accordingly even in the presence of distracting stimuli during the cue-probe delay. Good representation of the letter "A" should still come at a cost for participants on AY trials and more errors and slower reaction times should be present. Good maintenance of the representation should also aid participants in resisting the urge to press the target button on BX trials, thus resulting in fewer errors and faster reaction times. On the other hand, when context processing is compromised, we should observe fewer errors on AY trials because the initially poor representation of the letter "A" will worsen in the presence of distracters. In the case of BX trials, distracters will interfere with the maintenance of context representation and participants will experience even greater difficulty inhibiting the overwhelming urge to press the target button in the presence of distracters. This will result in an increased number of errors and slower reaction times in the BX condition.

In the high demand condition, individuals in the high anxiety group are expected to have particular difficulty because their ability to represent and maintain context information, and thus exercising good attention and inhibition in the presence of distracters will be challenged. In this condition, context representation deficits will worsen for the high anxiety group, resulting in even fewer errors and faster reaction times on AY trials in comparison with the AY trials on the Standard AX-CPT. Further, context maintenance deficits will be amplified in the high demand condition as well. Performance of the high anxiety group will decline on BX trials (greater error rate and slower reaction times) in comparison with their performance on BX trials on the Standard AX-CPT.

CHAPTER TWO

METHODS

Participants

A total of 458 CSUSB undergraduates participated in the pre-screening phase of this experiment and completed the STAI-Y-2 scale. Taking part in the screening phase of the study was open to all students. Based on the first pre-screening sample of 153 students, STAI-Y-2 criteria were established. Participants scoring in the top quartile ($M \geq 2.25$) comprised the high anxiety group and those in the bottom quartile comprised the low anxiety group ($M \leq 1.65$). These criteria were used to select individuals for the testing phase on all subsequent pre-screenings. The population norm for the STAY-Y-2 scale has been calculated to be 32.7 (SD = 9.9). From the total of 458 pre-screened students, 212 met the STAI-Y-2 criteria and were selected to be in either the low or high anxiety group. The remaining 246 participants were not selected to continue because they did not meet the test criteria. A total of 61 students (53 female and 8 male) participated in the testing phase. A total of 29 participants (2 male and 27 female) and with mean age of 28.3 years (SD = 10.37) comprised the low anxiety group and scored a mean of 1.38 (SD = .15) and 1.61 (SD = .22) on the STAI-Y-2 (trait anxiety scale) and STAI-Y-1 (state anxiety scale) respectively. A total of 28 participants (5 male and 23 female) with mean age of 23.7 years (SD = 5.51) comprised the high anxiety group and scored a mean of 2.61 (SD = .30) and 2.13 (SD = .46) on the STAI-Y-2 (trait anxiety scale) and STAI-Y-1 (state anxiety scale) respectively. Participants were native English speakers and had normal or corrected-to-normal vision. The students participated voluntarily and were offered extra credit in exchange for their participation. Participants were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 1992).

Design

The design of the present experiment was a 2 (Anxiety level: high vs. low) X 2 (Non-target trial type: AY vs. BX vs. BY) mixed factorial design with anxiety level as the between factor and non-target trial type as the within factor. Error rate and reaction time (RT) were measured for each participant.

Materials

Pre-Screening Phase

Participants were given a screening questionnaire – the State-Trait Anxiety Inventory (Form Y). As mentioned earlier, the STAI consists of two scales measuring state and trait anxiety. The STAI-Y-1, measuring state anxiety, is composed of 20 items and they generally ask participants to rate their feeling of anxiety at the moment on a 4-point scale (1-not at all, 2-somewhat, 3-moderately so and 4-very much so). Examples of the items in the scale are "I am tense" and "I am relaxed". The STAI-Y-2, measuring trait anxiety, is composed of 20 items and asks participants to rate how they feel about themselves in general. Examples of such items are "I feel satisfied with myself" and "I feel nervous and restless" and the rating scale is a 4-point frequency scale (1-almost never, 2 sometimes, 3 often and 4-almost always (Spielberger, 1983).

The first STAI scale was developed in 1970. Since then, its 40 different language translations have been used continuously in clinical practice and empirical work. Data from thousands of college students and hundreds of neuropsychiatric patients have been used in the establishment of the STAI scales. Since 1970, the scales have also undergone a number of revisions to improve their psychometric qualities. For example, in order to represent the anxiety construct better, during the last revision (1983), 30% of the items were replaced because they resembled depression more so than anxiety. Items such as "I feel blue" and "I cry a lot" were eliminated. Also, ambiguous items and items with marginal psychometric properties were excluded. Reliability coefficients for the Trait-anxiety scale are between .65 and .86. The range for the State-anxiety scale was .16 to .62. This lower range reflects the less-stable, situational nature of state anxiety. As evidence for construct validity, Spielberger (1983) presents correlations between the STAI scale and other measures of trait-anxiety: the Taylor Manifest Anxiety Scale (.80), the IPAT Anxiety Scale (.75), and the Multiple Affect Adjective Check List (.52). Further, the STAI scales have high levels of internal consistency; Cornbach's (1951) alpha coefficients for each of the two scales were .90 or higher (Telch, Shermis, &, Lucas, 1989). The correlation between the two STAI scales on a standardized sample of individuals has been measured to range between .59 and .75. The long history of use of this scale is proof of its excellent psychometric qualities as a tool to capture and measure anxiety.

Task and Apparatus

Participants were tested on two versions of the AX-CPT - a Standard version replicating Braver's model and a high-demand (distracter) version, similar to Braver's interference adaptation of AX-CPT. In both cases, participants were instructed to identify target trails and non-target trials. Every trial consists of a cue-probe sequence. In the target trials, the cue was a letter A and was followed by a probe that is the letter X (AX trials). The cue-probe sequences were presented in a pseudo-random order such that the target AX trials appeared at a 70% rate. The frequency of each of the non-target trials (BX, AY and BY) was at a 10% rate. The letters K and Y were excluded from the task because they resemble the target robe X and may hinder proper execution of the task. Each letter was presented in the center of a computer screen with black background. All letters were 24-point uppercase Times New Roman font and red in color. Each stimulus was presented for 300 ms on the screen and the interval between each cue and probe measured 4900 ms (inter-stimulus interval). Also, a 1000 ms interval separated each trial (inter-trial interval).

Participants were instructed to make their response by using keys on a computer keyboard. For right-handed participants, making a target response was possible by pressing the "J" key with their index finger and a non-target response with the "K" key and their middle finger. For left-handed individuals, making a target response was possible by pressing the "D" key with their index finger and a non-target response by pressing the "S" key with their middle finger. Participants were allowed an interval of 1300 ms from the onset of the probe stimulus to respond. Response times slower than 1300 ms were not recorded and a message reading "Respond Faster" appeared on the computer screen to prompt participants to respond within the allowed time. Participants were instructed to respond as accurately and as quickly as possible.

The Distracter AX-CPT differs from the above-described Standard version in that distracter letters (other than A, X, K, or Y) appear on the screen along with the cue and probe. Participants were instructed to ignore the distracter letter. There were three distracter stimuli appearing during the cue-probe delay and they were 24-point uppercase Times New Roman font and white in color. They appeared for 300 ms with a 1000 ms interval between each distracter.

Procedure

Pre-Screening Phase

With the consent of instructors, interested students were asked to complete the STAI-Y-2 screening questionnaire during class time and to provide contact information (i.e., name, telephone number, and electronic mail address). The first sample of 153 completed STAY-Y-2 surveys was used as the basis for creating criteria for the high and low anxiety groups. The top and bottom quartiles were selected to be the high and the low anxiety groups. Students of any age, sex, and race/ethnicity were invited to participate, as long as they met the screening criterion, are native English speakers and have normal or corrected-to-normal vision. Students who met the screening criterion were telephoned and invited to participate by the investigator or undergraduate research assistants.

Test Phase

Upon entering the laboratory, students were asked to read and sign an informed consent document notifying them about the purpose and procedure of the experiment. All participants were asked to complete the STAI-Y-1 scale as well. Then, participants were given instruction on how to proceed with the AX-CPT task. A detailed description of the task goals was displayed on the computer screen. The testing session consisted of 5 blocks of 30 trials for each of the two conditions (Standard and Distracter AX-CPT). There were a total of 150 trials per condition and participants had a short break between each condition before they began the task again. The first block of 30 trials were practice trials and were removed from all statistical analyses. Also, the condition order and block order were counterbalanced across all participants. All participants were instructed to respond as quickly but as accurately as possible. Upon completion of both conditions, participants were debriefed, thanked for their participation, and excused. The test phase required approximately 45 min to complete.

CHAPTER THREE

RESULTS

Table 1 presents means and standard deviations for relevant sample variables. As expected, the high and low anxiety groups differed significantly on their state anxiety scores, $t(54) = -5.4$. Also, the two anxiety groups differed significantly in age, $t(54) = 2.028$. The mean ages for the two groups were 28.3 and 23.7, respectively. Table 2 presents the mean error rates and RTs of the high and low anxiety groups in the target (AX) and non-target (AY, BX, and BY) conditions. Trials in which the RTs were less that 200 were assumed to be error given that cognitive processing followed by motor response could not have completed in less than 200ms. In addition, any RTs that were greater than 1200ms were considered outliers given that such responses would have fallen more than 3 standard deviations from the grand mean. On such trials, it was unclear if participants were not properly following task instruction to respond as quickly but as accurately as possible.

Trials in which correct RTs were less than 200 ms or greater than 1200 ms, were excluded from the analysis. In addition, two participants from the low anxiety group and one participant from the high anxiety group were excluded from the analyses because they committed excessive number of errors. Data from the Standard and Distracter tasks were analyzed separately. Within each analysis, error rate and RT data were analyzed separately for the target trial (AX) and non-target trials (BY, BX, and AY). This was done because target and non-target trials are presented to participants at a different frequency rate (70% for target trials and 30% for all non-target trials) and require different response (target vs. non-target button). Only correct responses were included in the analyses involving RTs. Accuracy of performance in the target trials was assessed using a d′-context measure and using false alarms in the non-target trials. An alpha level of .05 was used for all statistical tests. Participants′ scores on the two anxiety scales were significantly positively correlated, r = .61.

Standard Task

Target Trials

Consistent with previous research using the AX-CPT (e.g., Braver, Satpute, Rush, Racine, & Barch, 2005; Braver, Barch, Keys, et al., 2001; Cohen, Barch, Carter, & Servan-Schreiber, 1999; Lorsbach & Reimer, 2008; Paxton, Barch, Racine, & Braver, 2007), the analysis of performance accuracy also examined d′ context, a signal detection measure that is based on the proportion of trials in which a subject responds correctly in AX trials by pressing the "Yes" key (Hits), relative to the proportion of trials in which the subject responds incorrectly in the BX condition by pressing the "Yes" key (False Alarms). Because d′ context is computed using only BX false alarms, and not all types of false alarms (i.e., AY, BX, and BY), it is considered to provide a specific estimate of sensitivity to context (Cohen et al., 1999). That is to say, d′ context provides a measure of one's ability to use prior context (A or non-A) to differentiate target and non-target responses to the letter X. Before calculating d′ scores, the hit and false alarm rates were corrected by adding .5 to each frequency and dividing by N + 1, where N equals the number of old or new trials (Snodgrass & Corwin, 1988). The low (M = 3.60) and high (M = 3.34) anxiety groups produced statistically comparable d′ context scores, $t(55) = 1.289$. This was also the case when the covariate (state anxiety measured by STAI-Y-1) was included in the analysis, $F(1,54) = .031$, $MSE = .574$.

Error rates and RTs for target AX trials were also analyzed for both groups. There was no significant mean difference in error rates on the target (AX) trials among the high (*M* = 6.6%) and low (*M* = 2.7%) anxiety groups, $t(55) = 1.260$. Similarly, the mean RTs for the low (*M* = 528 ms) and high (*M* = 511 ms) groups did not differ significantly, $|t| < 1$. Thus, the high and low anxiety groups were comparable in terms of their error rates and RTs on target trials. Similarly, when the covariate was analyzed, no differences in error rates, $F(1,54) = .130$, $MSE = 0.013$, and RTs, $F(1,54) = 1.59$, $MSE = 9549.03$, were detected among the two groups.

Non-Target Trials

Non-target error rates and RTs were submitted separately to a 2 (Anxiety group: low vs. high) × 3 (Non-target trial type: AY vs. BX vs. BY) mixed design analysis of variance (ANOVA), with non-target trial type as the within-subject factor (see Figures 8 & 9). For error rates, there was a marginally significant main effect of anxiety group, $F(1,55) = 2.885$, $MSE = 0.006$, $p = .095$, and a significant main effect of non-target trial type, $F(2,110) = 15.755$, $MSE = 0.005$. For the main effect of trial type, post hoc comparisons revealed that participants committed more errors on the AY trials

(M = 8.6%) than BX (M = 2.9%) and BY (M = 1.3%) trials. However, mean error rates were not significantly different on BX (M = 2.9%) and BY (M = 1.3% trials. The interaction between anxiety group and trial type was not significant, $F < 1$. When the covariate was included in the analysis, the effects weakened. Specifically, there was no significant main effect of anxiety group, $F(1,54) = 1.877$, $MSE = 0.007$, and only a marginally significant main effect of non-target trial type, $F(2,108) = 2.979$, $p = .055$. The interaction between anxiety group and trial type was not significant, $F(2,108) = 1.617$, $MSE = 0.005$

With the RT data, the main effect of anxiety group was not significant, $F(1,55) = .021$, $MSE = 41741.29$. However, there was a significant main effect of trial type, $F(2,110) = 117.386$, $MSE = 4634.21$. Post hoc comparisons revealed that RTs were significantly slower on AY (M = 649 ms) than BX (M = 493 ms) trials, which were in turn significantly slower than BY (M = 469 ms) trials. Finally, the trial type by anxiety group interaction, $F < 1$, was not significant. Results for the RT data when the covariate was included were identical.

Performance on AY and BX trials is of crucial importance for the interpretation of participant's ability to process context effectively. If there are deficits in context processing, individuals perform worse on BX trials (more errors and slower RTs) than AY trials (fewer errors and faster RTs). Therefore, planned comparisons were conducted to examine whether error rates and RTs differed on AY and BX trials separately for low and high anxiety groups. With the low anxiety group, participants were significantly slower on AY (M = 656 ms) than BX (M = 488 ms) trials, $F(1,28) = 59.922$, $MSE = 6818.49$. In addition, error rates associated with AY trials (M = 6.7%) were greater than error rates associated with BX trials (M = 2.9%) and this difference approached significance, $F(1,28) = 3.718$, $MSE = 0.0006$, $p = .064$. The results with the inclusion of the covariate indicate that both effects (RTs and error rates) were not significant. As with the low anxiety group, participants in the high anxiety group also produced significantly slower RTs on the AY (M = 643 ms) than the BX (M = 499 ms) trials, $F(1,27) = 34.675$, $MSE = 8361.75$. Similarly, error rates associated with AY (M = 10.5%) were significantly greater than the error rates associated with BX (M = 3.1%) trials, $F(1,27) = 8.661$, $MSE = 0.009$. This effect was not present in the covariate analysis. However, the RT main effects remained significant indicating that even when the covariate was included in the analysis, participants in the high anxiety were slower on the AY (M = 643) trials in comparison with the BX (M = 499) trials, $F(1,26) = 14.230$, $MSE = 7221.82$.

Distracter Task

Target Trials

Identical to the analysis in the Standard task, context sensitivity was again assessed in the Distracter test data by using d′ context analysis. In contrast to the Standard task data, in the Distracter task, low anxiety participants produced significantly larger d′ context scores than high anxiety participants, Ms = 3.73 and 3.25 respectively, $t(55) = 3.096$. When the covariate was included, the results mirrored the direction of the above pattern. However, the difference in context scores between the two groups only approached significance at $F(1,54) = 3.546$, $p = .065$.

There was no significant mean difference in error rates on target (AX) trials among the high (M = 2.5%) and low (M = 1.5%) anxiety groups, $t(55) = 1.270$. However, participants in the low anxiety group (M = 537 ms) produced slower RTs than did their high anxiety counterparts (M = 486 ms), and this comparison approached statistical significance, $t(55) = 1.751$, $p = .086$ (see Figures 10 & 11). When the covariate was included in the analysis, no significant mean differences were found for both error rates, $F < 1$, and RTs, $F(1,54) = 1.327$, $MSE = 14.517$.

<u>Non-Target Trials</u>

As with the Standard task set of analyses, non-target error rates and RTs from the Distracter task were submitted separately to a 2 (Anxiety group: low vs. high) × 3 (Non-target trial type: AY vs. BX vs. BY) mixed design ANOVA, with non-target trial type as the within-subject factor. With the error rate data, the main effect of anxiety group was not significant, $F(1,55) = 2.455$, $MSE = 0.012$, however, there was a significant main effect of non-target trial type, $F(2,110) = 20.475$, $MSE = 0.009$. Post hoc comparisons indicated that error rates on the AY ($M = 11.4\%$) trials were greater than those on the BX ($M = 5.4\%$) trials, which were in turn greater than those on the BY ($M = 0.4\%$) trials. However, this main effect was qualified by the presence of a marginally significant non-target trial type by anxiety group interaction, $F(2,110) = 2.773$, $p = .067$ (see Table 1 for means). Results for the error rates when the covariate was included were comparable.

With the RT data, the main effect of anxiety group was not significant, $F(1,55) = 2.196$, $MSE = 36404.54$. However, the main effect of non-target trial type was significant, $F(2,110) = 170.619$, $MSE = 3676.69$. Post hoc comparisons revealed that RTs were slower on AY ($M = 658$ ms) than BX ($M = 459$ ms) trials, which were in turn slower than BY ($M = 499$ ms) trials. Finally, as with the error rate data the non-target trial type by anxiety group interaction approached significance, $F(2,110) = 2.981$, $p = .055$. Results for the error rates when the covariate was included were comparable.

Recall that AY and BX trials are of great importance when context processing is interpreted. Therefore, planned comparisons were again conducted to examine whether error rates and RTs differed on AY and BX trials separately for low and high anxiety groups. With the low anxiety group, participants were significantly slower on AY ($M = 669$ ms) than BX ($M = 497$ ms) trials, $F(1,28) = 126.97$, $MSE = 3385.39$, $p < .001$ In addition, error rates associated with AY trials ($M = 11.1\%$) were significantly greater than error rates associated with BX trials ($M = 1.8\%$), $F(1,28) = 14.704$, $MSE = .009$, $p < .001$. The effects in RTs remained even after the covariate was included, $F(1,27) = 18.927$, $MSE = 3038.11$, $p < .001$. The effect in error rates was marginally significant, $F(1,27) = 3.994$, *MSE* = .008, $p = .056$.

As with the low anxiety group, participants in the high anxiety group also produced significantly slower RTs on the AY (*M* = 647 ms) than the BX (*M* = 422 ms) trials, $F(1,27) = 149.14$, *MSE* = 4741.13, $p < .001$. However, unlike the low anxiety group, in the high anxiety group, error rates associated with AY (*M* = 11.7%) trials did not statistically differ from the error rates associated with BX (*M* = 9.1%) trials, $F < 1$. With the covariate, the results for the high anxiety group were similar. Specifically, there was no effect of error rate and the effect of RTs remained, as AY RTs were slower than those in BX, $F(1,26) = 11.94$, *MSE* = 4871.

CHAPTER FOUR

DISCUSSION

The goal of the present study was to apply an existing model of cognitive control to a new population – individuals with elevated anxiety. By doing so, we hoped to demonstrate that attention and inhibition deficits experienced by individuals with high anxiety are related to deficits in context processing. Recall that the basic premise of Braver's model is that context processing relies on the successful representation and maintenance of context information. The process of representation allows context to be used to direct behavior and resist interference and the process of maintenance allows this context information to be stored over time within working memory. In AX-CPT, context information is provided by the cue, which guides the appropriate response to the probe (target or non-target). The high frequency of target AX trials (70%), results in tendency to press target to the probe X, regardless of the cue (BX trials) and to press target to the cue A, regardless of the probe (AY trials). The expectancy bias to the letter "A" facilitates performance on the target AX trials but hinders it on the non-target AY trials. Here, participants with good context processing are able to represent the cue A successfully and therefore cannot resist the urge to press target in the instances where the probe is a Y (non-target AY) instead of an X (target AX). Thus, good context processing results in poor accuracy and slower RTs on AY trials. The high frequency of AX trials creates a bias affecting performance on BX trials as well. The expectancy bias to the letter "X" creates a tendency for a target response to the probe "X", regardless of the cue. On BX trials, individuals with good context processing are able to use context information from the non-target cue "B" and effectively inhibit their inclination to press target. Good context processing results in fast and accurate responses on BX trails. Generally, individuals with poor context processing do not represent cue information well and, thus, are not able to inhibit the biased target response and display more BX than AY errors.

Target trial (AX) error rates and RTs for the Standard task were comparable for the two anxiety groups, when STAI scores were not included as a covariate. Specifically, both groups were fast and accurate in identifying AX trials as target trials. This comes to indicate that group differences in trait anxiety did not interfere with individuals' ability to use context in the

AX trials. Further, analysis of the d′ context scores indicated that both anxiety groups were equally sensitive to using prior context information. Thus, the valid (A) and non-valid (non-A) cues were used to successfully guide context equally with both groups. That is to say, anxiety did not interfere with participant's ability to distinguish between AX and BX trials.

The pattern of results on non-target trials for the Standard task is consistent with the analyses of target trials. Specifically, of the two main effects, anxiety group and trial type, only the latter one was significant. Trait anxiety did not interfere with participants' ability to represent and use context and therefore both groups performed comparably. Participants displayed the signature pattern of good context processing, where responses on AY trials were slower and less accurate in comparison with performance on BX trials (see Figure 8 & 9). Thus, despite anxiety group differences, all participants were able to represent and use context information successfully. Comparable error rates and RTs in the AY vs. BX conditions for each group indicate that due to the high frequency target AX trials 1) participants formed strong expectancy bias toward the cue A and falsely identified even non-target trials containing the cue A, such as AY, as target trials and 2) participants formed strong expectancy bias toward the probe X but used context provided by the non-target cue B to overcome it and successfully identified BX trials as non-target ones. More accurate and fast performance on BX trials in comparison with AY trials, across both groups, signals good context processing despite anxiety differences. Further supporting this conclusion, planned comparisons revealed nearly identical pattern of performance for each group. There were significantly more errors and slower RTs in the AY condition in comparison with the BX condition, and this was the case for each anxiety group. Once again, pattern of good context processing was evident.

In addition, the Standard task used a long (5 s) cue-probe delay, which in Braver's studies, is used to test one's ability to maintain context representation over time in working memory. Thus, the cue must not only be represented, but also actively maintained in working memory over the delay. The performance on AY and BX trials observed in our experiment (faster and more accurate BX than AY) is evidence for good maintenance of context by both anxiety groups. All participants, regardless of their anxiety level, were able to both form a context representation and maintain this representation in working memory.

In summary, recall that in Braver's signature pattern of good context processing there are greater AY errors and slower RTs than errors and RTs associated with BX trials (see Figure 2). Using the two biases created by the high frequency AX trials, context improves performance in the BX trials and hinders performance in the AY trials. The lack of group difference in the Standard task was unanticipated. Initially, we expected that trait anxiety would affect performance on the AX-CPT differentially, hindering the high anxiety group. In the present experiment, we find no evidence for anxiety interference on context processing. At the level of the low demand Standard task, both anxiety groups were able to use context information successfully.

This finding, although unexpected, is particularly noteworthy because individuals with high anxiety are known to display cognitive deficits in attention and inhibition (Baddeley & Hitch, 1974; Kane & Engle, 2003).

According to Braver (Braver & Barch, 2002), the context-processing unit is vital not only in attention and inhibition, but also in processes dependent on cognitive control in working memory. The second, Distracter task, used in this experiment was designed to increase cognitive demand (i.e., working memory capacity) during the AX-CPT. Recall from earlier discussion that the Distracter task differed from the Standard task only in one aspect - three distracter letters appeared during the cue-probe delay (Figure 4). The purpose of this manipulation was to test context processing performance in a condition of increased cognitive demand. Based on analysis excluding the covariate, the results from the Distracter task provided evidence supporting the overall hypothesis that individuals with high and low anxiety differ in their ability to use context under conditions of high cognitive demand.

In the Distracter task, target trial (AX) error rates and RTs were comparable for the two anxiety groups, when STAI scores were not included as a covariate. Both groups were fast and accurate in identifying AX trials as target trials, which indicates some initial level of good context processing. However, in contrast to the Standard task data, in the Distracter task, low anxiety participants produced significantly larger d′ context scores than high anxiety participants. The larger d′ scores of low anxiety participants indicate that they were, relative to high anxiety participants, more proficient at using prior context information in their attempt to distinguish targets and non-targets. That is to say, the group differences in d′ context scores indicate that when presented with an X probe, participants in the low group were more sensitive to the preceding context (i.e., A or non-A) than participants in the high group.

Overall analysis of non-target trials painted picture similar to the one in the low demand, Standard task where we found a robust main effect of trial type but no effect of anxiety on performance. However, the marginally significant trial type by anxiety group interaction demanded that planned comparisons for each group are examined independently. These comparisons revealed that the low anxiety group performed comparably on both tasks (Standard and Distracter) by displaying the signature pattern of good context processing. Specifically, error rate was higher and RTs were slower in the AY condition compared to the BX condition. Participants in the low anxiety groups used context successfully to overcome the bias to press target in BX trials and identified BX as non-target trials fast and accurate. Thus, inhibitory response on BX trials was effective. The low anxiety group was able to use context information from the non-target B cue and successfully override the tendency to press target when the probe X is presented. Also, the increased number of AY errors indicates that low anxiety participants were able to represent context well and form the strong expectancy bias toward the cue letter A and therefore were slower and less accurate than in the BX condition. Remarkably, this pattern of good context processing persisted in the presence of the distracter letters. They did not interfere with low anxiety participants' ability to actively maintain context representation even under condition of increased demand on working memory.

The high anxiety group, however, performed differently on non-target trials than the low anxiety group in the Distracter task. While displaying good context processing in the Standard task, participants with high trait anxiety were challenged in the high demand task and displayed a pattern of error rates and RTs characteristic of poor context processing. Specifically, error rates and RTs on the non-target AY and BX trials were comparable. As pointed out earlier, the successful use of context improves performance in the BX trials and hinders performance in the AY trials. In the case of the high anxiety group, however, during the Distracter task performance was hindered in both, the AY and the BX condition.

This comes to say that trait anxiety had no influence on participants' ability to process context successfully unless conditions of high cognitive demand were present. In fact, the low anxiety group was able to use context effectively and show the signature pattern of good context processing despite distracter interference. The predicted differences were revealed only when the high anxiety group failed to maintain context in the presence of distracters. Recall that good performance on an AX-CPT with a long delay between cue and probe requires active context maintenance. In the present experiment, both tasks (Standard and Distracter) had a long (5sec) delay and thus provided context maintenance assessment. This assessment indicates that context maintenance was good for both groups during the Standard task; specifically, high and low anxiety groups were able to hold the cue information in working memory over the 5sec delay and use it effectively to guide probe responses. Further, this type of performance persisted for the low anxiety group in the Distracter task, where interfering stimuli were displayed during the 5sec delay. Participants in the low anxiety group were able to overcome the possible negative effect of distracters and despite the increased demand on working memory were still able to use context effectively. As revealed by the pattern of performance, this was not the case with the high anxiety group. The presence of distracters compromised their ability to effectively maintain cue context in working memory and when faced with the decision to respond to a probe "X" with target or non-target, high anxiety participants were unable to resist the urge to press target. Their performance during the Distracter task had comparable error rates and RTs for both AY and BX trial types, instead of more errors and slower RTs in AY in comparison with BX condition. Therefore, the present study does provide indication of existing group differences in context processing, but only under condition of increased cognitive demand. Recall that both tasks had a long delay between cue and probe presentation, which somewhat increases cognitive demand in comparison with a short delay AX-CPT and requires active maintenance of context within working memory. In the Standard task, anxiety did not interfere with context maintenance. However, in the presence of distracters, the high anxiety participants experienced great difficulty to actively maintain and protect context. The difference between the two groups must be attributed to processes related to the resistance-of-interference component of context maintenance.

As discussed earlier, accounts of the detrimental effect of anxiety on some cognitive processes have a long history in the empirical literature (Liebert & Morris, 1967; MacLeod, 1991a; Mogg & Marden, 1980). Anxiety or being occupied with worrisome thoughts, is considered to interfere with one's ability to attend and process task relevant information and thus results in performance deficits on the task overall. Recall that numerous studies have attempted to describe and explain cognitive deficits in attention and inhibition (Baddeley & Hitch, 1974; Kane & Engle, 2003; MacLeod, 1991a) as well as working memory (MacLeod & Donnellan, 1993) that individuals with high anxiety seem to display on a consistent basis. Despite the abundance of such studies, a straightforward and parsimonious explanation of the origin of anxiety-related cognitive deficits was lacking. The main goal of this investigation was to set a unitary framework where attention, inhibition and working memory are the results of a single mechanism, the context processing mechanism. This approach would allow for assessment of all three common cognitive deficits to be tested simultaneously. If deficits were detected, they would be ultimately associated with context processing, a mechanism that is grounded in neurobiology and is tested via task that allows for its three main components (attention, inhibition an working memory) to be assessed concurrently and independently. Moreover, the purpose of having two versions of the AX-CPT task, Standard and Distracter, was to differentiate between situations with normal and high cognitive demand. The reasoning here was that it is possible that the effects of anxiety on context processing may not be displayed unless there is an increased level of demand on one's cognitive processing. Thus, even if context processing was comparable for both groups in the Standard task, we predicted that differences would arise during the high demand Distracter task and the high anxiety group will show performance deficits characteristic of poor context processing. The results of this investigation provide evidence to support this notion.

A theory set forth by Eysenc and Calvo (1992) proposes that processing efficiency accounts for performance deficits associated with anxiety. This theory suggests that elevated anxiety hinders performance on tasks that rely on some involvement of working memory. This is the case because the anxiety and anxious thoughts these individuals experience take some processing resources away from the actual task at hand (Richards, French, Keogh, & Carter, 2000). Similarly, the Distracter task used in the current investigation placed a heavier demand on resources used within working memory - participants had to hold and protect the representation of context and the goal of the task in working memory during a 5 second delay and in the presence of distracter stimuli. When interfering stimuli were not present (Standard task), both groups performed well and showed good context processing, even with a long 5-second delay. In the Distracter task, however, the high anxiety group failed to protect context in the presence of distracter and showed poor context processing.

Interestingly, when scores from the STAI-Y-1 (state anxiety scale) state were included in the analyses as a covariate, the effects described above were generally weaker, and, in some cases, disappeared. This indicates that although differences in context processing appear to be associated with high anxiety, it is unclear whether they are due to trait, state or of the effects of both types of anxiety. The groups in the present investigation were based on stable, personality differences in trait anxiety and although evidence of their association with deficits in context processing was found, state anxiety appears to play a role as well. Consistent with literature using state and trait anxiety measures, scores on both scales in this investigation were significantly positively correlated (.61). In the spirit of this relationship, individuals with high trait anxiety are also likely to display heightened sensitivity to anxiety provoking situation and thus display elevated state anxiety scores. It is possible that participants treated the novel lab environment where they were tested and where they completed the state anxiety questionnaire, as one provoking anxiety. Thus, it is impossible to disentangle the relationship between state and trait anxiety to a degree to which their unique effect on context processing can be determined. Also, it is possible that the relationship between trait anxiety and context processing is partially mediated by state anxiety.

Limitations

It is important to note that the current investigation is the first of its kind to test the context processing model of cognitive control on individuals with high and low anxiety, and therefore has some reasonable limitations. Specifically, although a large number of potential participants were pre-screened (458), less than half (212) qualified by meeting the screening criteria. Of this number, an even smaller fraction (61) participated in the lab portion of the study. Therefore, the small sample may bear some responsibility on the effects that were only marginally significant. With a larger sample, these effects, which are in the expected direction, can be anticipated to be significantly so. Also, the STAI-Y-2 (trait anxiety scale) cut-off score for the high and low group was based on the top and bottom quartiles of the first pre-screening group of 153 students. It was anticipated that this sample would be sufficient for the selection of all participants needed for the experiment. As pointed out earlier, however, fewer than expected numbers of students answered the call to come into the lab and complete the AX-CPT session. Therefore, the need for subsequent pre-screening arose. The cutoff scores established from the first sample of 15 students for the high and low anxiety groups were used in the subsequent screenings. It is possible that these cut-off scores were not discriminative enough. Specifically, compared to the norm score for the STAY-Y-2 scale (32.7), the low anxiety group scores were 27.6, which is close but not quite one standard deviation (9.9) below the normative score. The mean score for the high anxiety group score was 56, which is well above one standard deviation from the norm. Thus, the cutoff score for the low anxiety group should have been set at least one standard deviation below the norm. Further, it has been reported than men tend to underreport on the STAI-Y-2 scale and therefore separate cutoff scores for the male and female participants should have been established. Since both genders were considered at the same time, the lower scores of the male participants may have caused a lower overall mean for trait anxiety. The effect of differential reporting may have been particularly problematic given the fact that there were more male in the high group (5) than in the low group (2). Future studies may consider using more stringent and consistent criteria for selecting high and low anxiety participants, as well as selecting from a male and female sample independently. Another possible limitation regarding the STAI-Y-2 scale is that participants completed the scale only at pre-screening. It is possible that some participants' (in both the low and the high anxiety group) score would have regressed toward the mean for the STAI-Y-2. If participants had to take the scale as part of the lab session, a more precise measure of trait anxiety could have been obtained. Only participants who scored consistently above or below the STAI-Y-2 mean could have been selected for the experiment. It is possible that the lack of significant anxiety effects in the Standard task is due to the diluted trait anxiety scores.

In regards to the AX-CPT itself, some alterations may be beneficial. The first block of trials in the current study was not included in the investigation because it was used as a demonstration for the participants. This led to only four complete blocks of trials per task be included in the final analysis. Further, although Braver's ratio of 70% target (AX) and 30% non-target (BY, BX, and AY) trials in the AX-CPT was unchanged, the total number of trials was slightly reduced in order to shorten the total duration of the experimental session. Ideally, participants would be invited to participate in two experimental sessions, one for the Standard and another for the Distracter task. Although the order of AX-CPT versions was completely randomized for all participants, there may be some interference associated with participants' level of fatigue. The AX-CPT is a monotonous task that requires participants to be continuously attentive and motivated to respond as quickly but as accurately as possible. If participants take each AX-CPT version at a different time, they could be exposed to a larger overall number of trials in a shorter amount of time, which will remove some of the fatigue related error.

It is worth noting that the two groups were significantly different in age. The low anxiety group was comprised of participants that were older than the participants in the high anxiety group. Although there is no theoretical reason to expect differences in context processing in a sample if healthy young adults, such difference was detected. Interestingly, individuals in the low anxiety group displayed good context processing on both tasks, while, participants in the younger, high anxiety group displayed poor context processing on the Distracter task. Thus, although an unexpected difference was detected, it was in direction opposite of possible theoretical expectations. Last, the design of the present investigation does not allow of the independent effect of state and trait anxiety on context processing to be examined precisely. Participants were selected on their score on the STAI-Y-2 (trait anxiety) scale and their state anxiety was merely assessed at the time of testing. Future experimental designs may include a state anxiety manipulation on a randomly selected population to identify how anxiety that stems from the situation itself, can be affecting context processing.

Implications

Readers must keep in mind that the present study is the first in associating anxiety and context processing deficits. However, the results of this study, although interpreted with caution, are important in providing a research framework for investigating anxiety symptoms and their relation to attention, inhibition and working memory. Moreover, these results are especially important for the anxiety literature because it has examined anxiety related cognitive deficits one dimensionally. The present investigation provides evidence of a single underlying mechanism (context processing) that can explain multiple cognitive deficits concurrently. Such unitary explanation is simpler and more integrative in accounting for cognitive deficits.

In addition to contributing to our understanding of the effects of anxiety on cognitive control, although the present study was not designed to examine cognitive control in the workplace, it may have implications for the workplace. The workplace provides situations high in stress and/or task complexity that are analogous of the situations created in this experiment. Therefore, we may speculate that in conditions of low cognitive demand or low demand on working memory capacity, as in the Standard task, differences in anxiety will not interfere with task performance. Individuals with high trait anxiety in entry level positions or ones with more basic and routine task load, may not experience any deficits based on their personality characteristic. Most workplaces, however, are dynamic, stress provoking, and filled with tasks and demands that are rarely predictable and stable. This is especially the case in middle and high-level positions. Recall that in such high demand situations, participants in the high anxiety group experienced deficits in cognitive control and performed worse than individuals in the low anxiety group. The implication for these individuals in the workplace is that as demand and complexity of tasks increase, performance deficits will begin to surface.

Therefore, stable individual differences in trait anxiety can be a predictor of job performance and promotion rate. An employee with high trait anxiety can perform successfully in an entry-level position, where most tasks are predictable and routine, and close supervision and one-on-one training are available. However, in mid- and high-level positions, complexity and ambiguity in daily tasks increase dramatically. Employees with high trait anxiety who have worked successfully in an entry-level position will be exposed to work situations that resemble the Distracter version of our task. They will be required to hold more information in working memory, have higher interruption rate and will have to be effective in selecting what information is relevant and needs their attention and what information is irrelevant and distractive. Individuals with high trait anxiety may fail to perform at higher-level positions or in occupations where one must withstand the presence of distracters. Thus, it is possible that employees with high trait anxiety have difficulties promoting into mid- and high-level positions.

APPENDIX A

TABLES

Table 1 Means and standard deviations for relevant sample variables

	Age		Trait Anxiety		State Anxiety	
	Mean	SD	Mean	SD	Mean	SD
Low Anxiety Group	28.3	10.4	1.38	0.15	1.61	0.23
High Anxiety Group	23.7	5.5	2.61	0.3	2.13	0.46

Table 2. Mean error rates and RTs of high and low anxiety groups in target (AX) and non-target (AY, BX, and BY) conditions

			Error Rates				RTs			
			AX	AY	BX	BY	AX	AY	BX	BY
Standard Task	Low	Mean	2.3	6.7	2.7	0.3	529	656	488	475
		SD	0.1	0.8	0.1	0.01	91	103	145	114
	High	Mean	0.1	10.5	3.1	2.4	512	643	499	463
		SD	0.1	0.1	0.1	0.1	105	106	176	124
Distracter Task	Low	Mean	1.5	11.1	1.8	0.3	537	669	497	516
		SD	0.1	0.1	0.1	0.01	113	128	124	131
	High	Mean	2.5	11.7	9.1	0.4	487	647	422	483
		SD	0.1	0.2	0.1	0.02	103	123	108	108

APPENDIX B

FIGURES

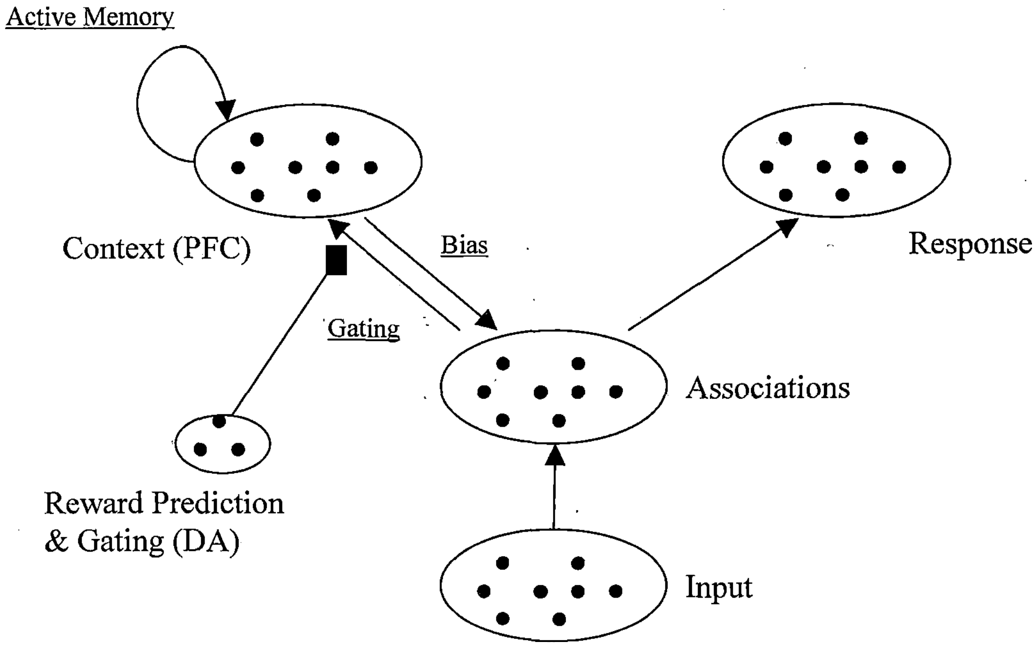

Figure Captions

Figure 1. Braver's canonical model (PFC – prefrontal cortex, DA – dopamine)

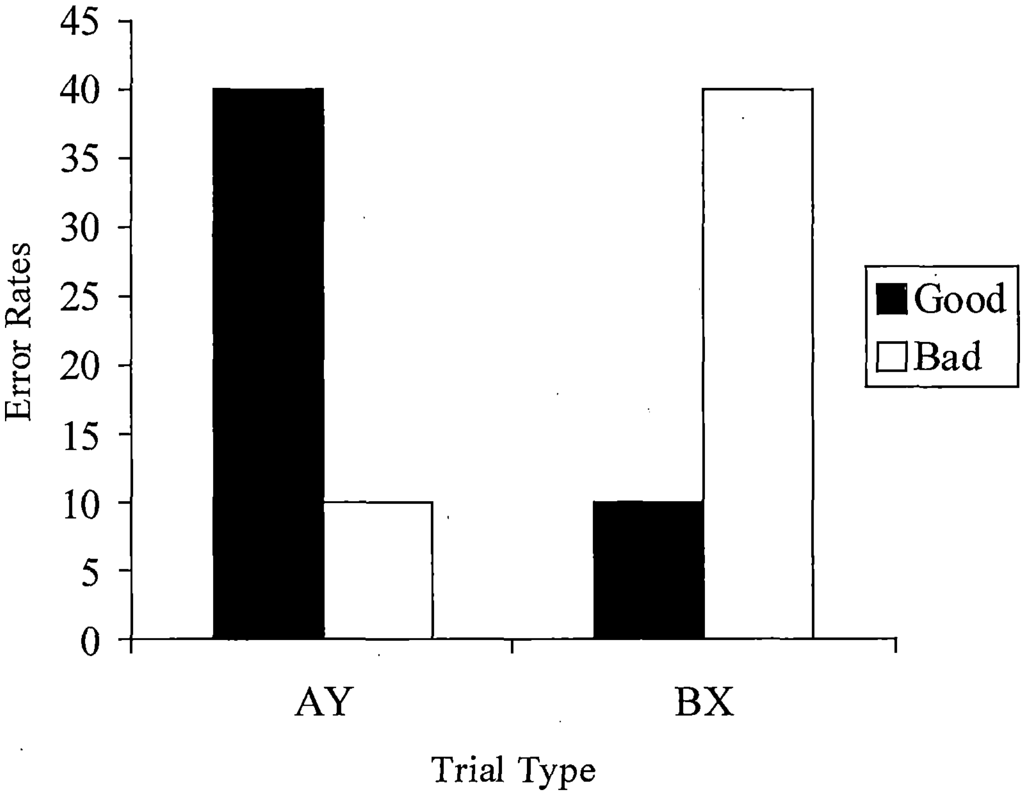

Figure 2. Context Processing Signature Pattern – Standard AX- CPT

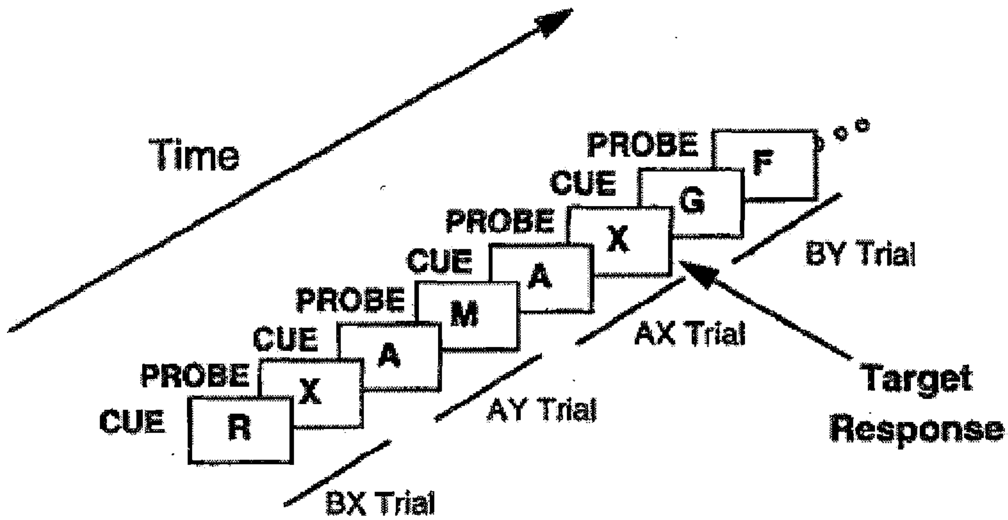

Figure 3. AX-CPT – Task Presentation

Standard **<u>AX-CPT:</u>** **A........ ....X....... B...**

Distracter **<u>AX - CPT:</u>** **A.....D......H......K.....X ......B.....**

Figure 4. Two task conditions - Standard and Distracter AX-CPT

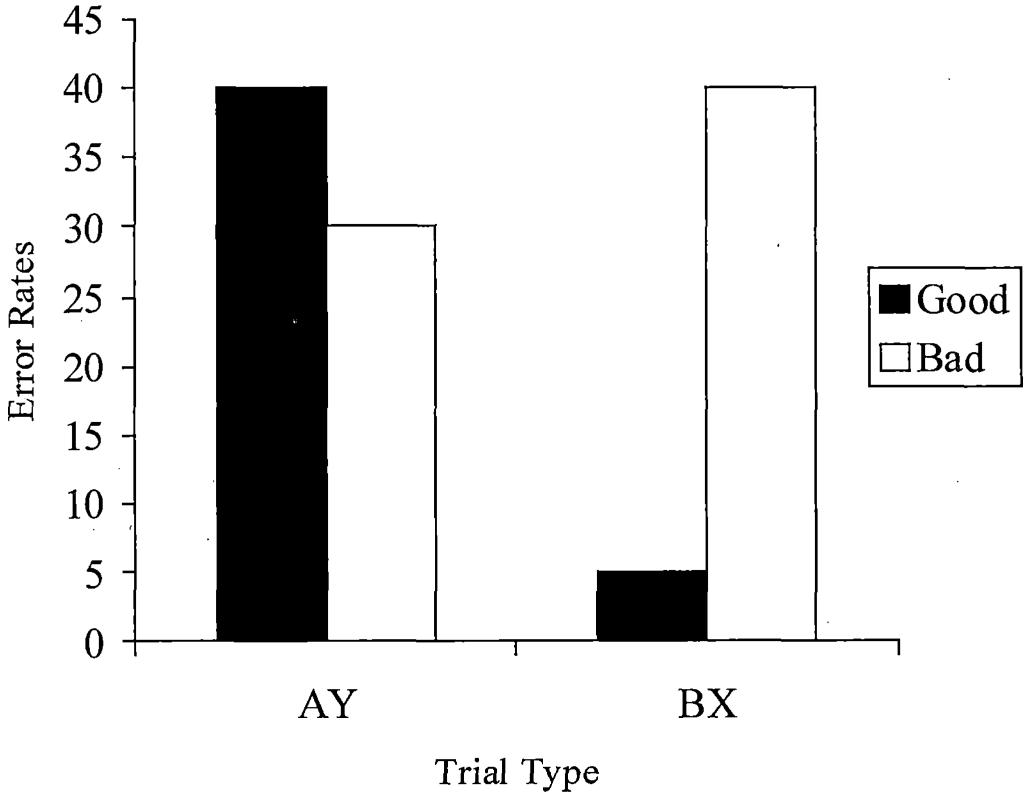

Figure 5. Expected Performance on the High Demand AX-CPT

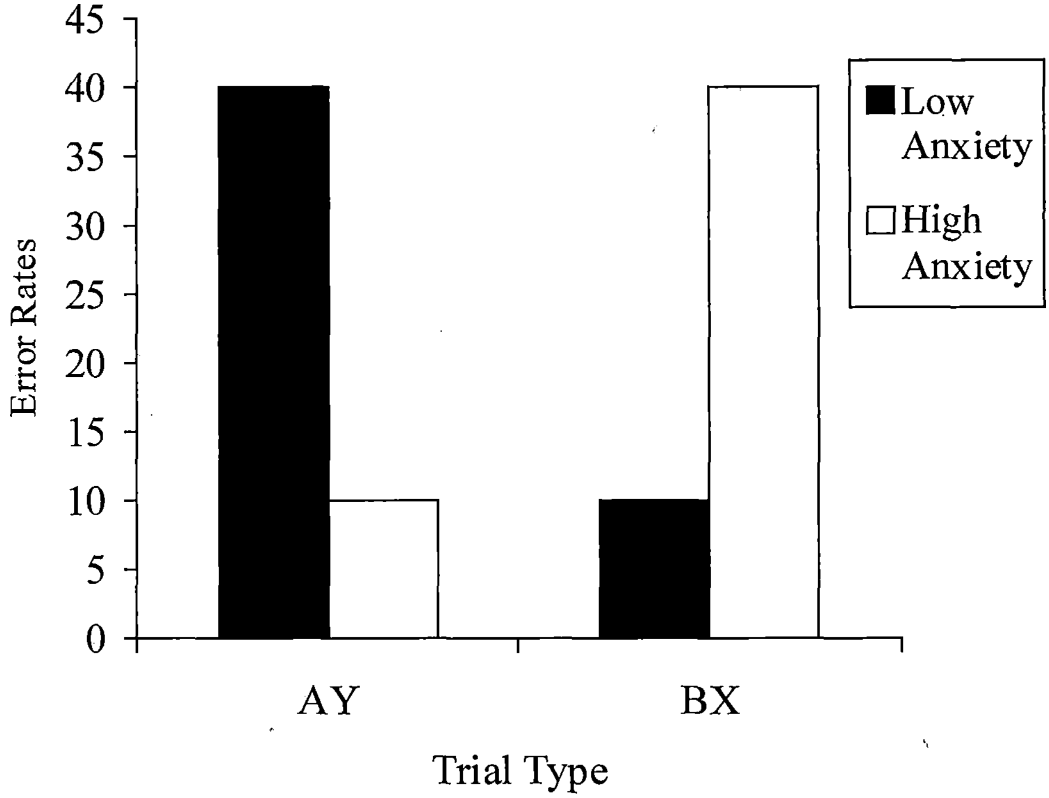

Figure 6. High and Low Anxiety Groups Performing on the Standard AX-CPT

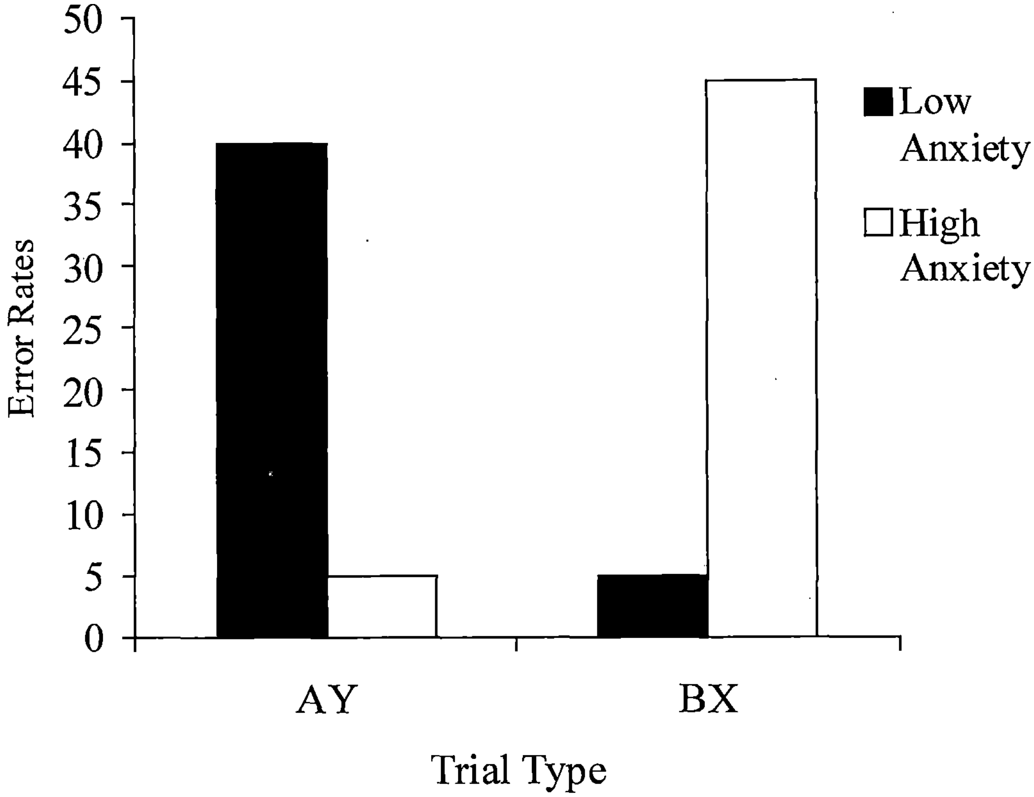

Figure 7. High and Low Anxiety groups performing on the high demand AX-CPT

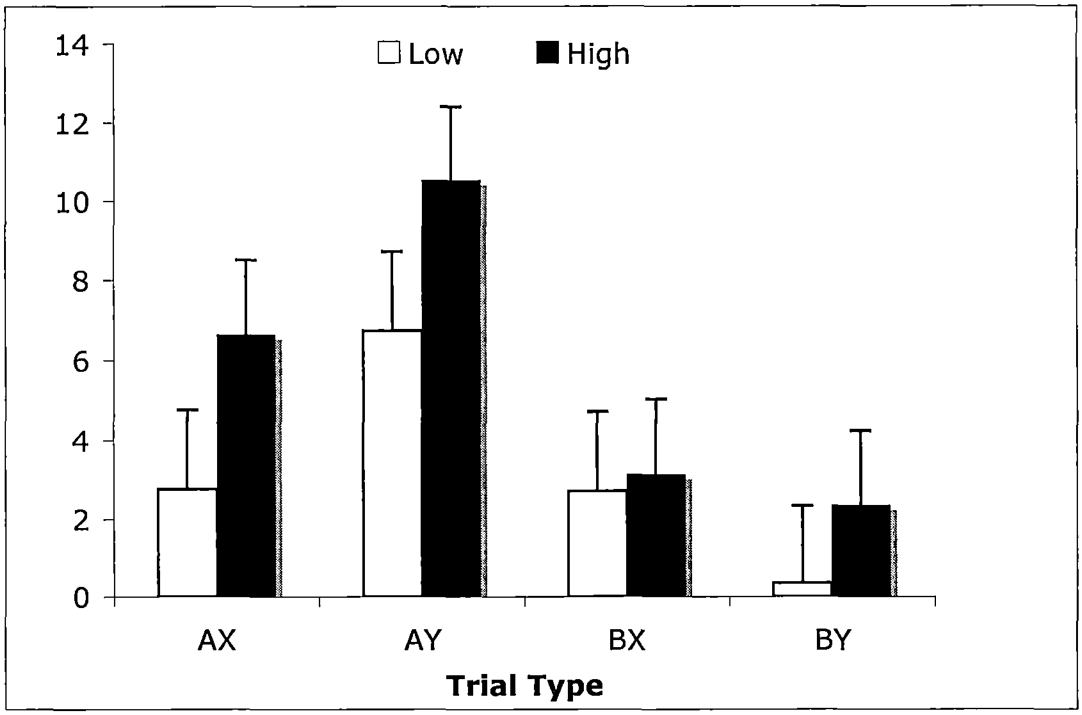

Figure 8. Standard Task: Error rate performance of low and high anxiety groups each of the target and non-target trial types. Error bars reflect standard errors of the means.

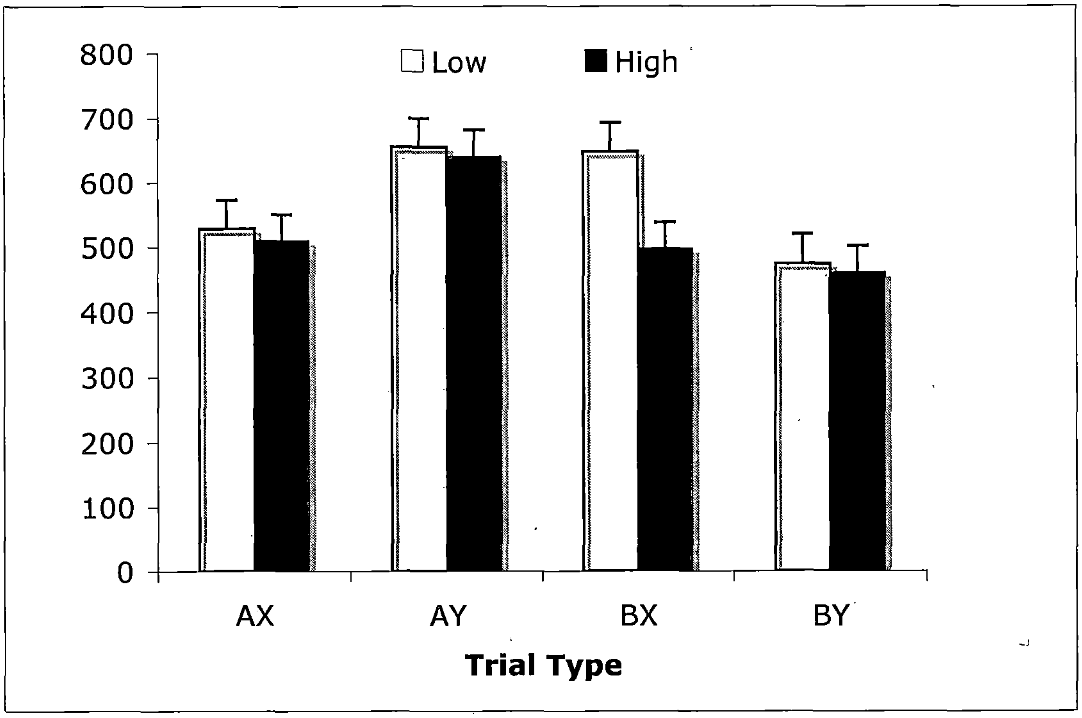

Figure 9. Standard Task: RT performance of low and high anxiety groups each of the target and non-target trial types. Error bars reflect standard errors of the means.

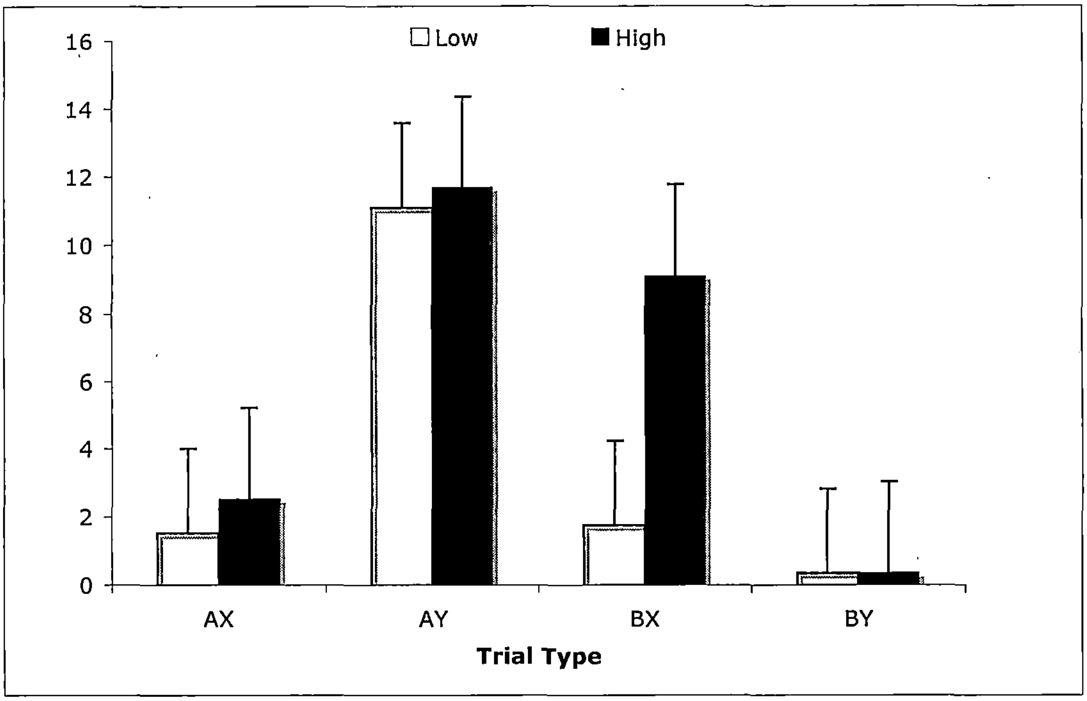

Figure 10. Distracter Task: Error rate performance of low and high anxiety groups each of the target and non-target trial types. Error bars reflect standard errors of the means.

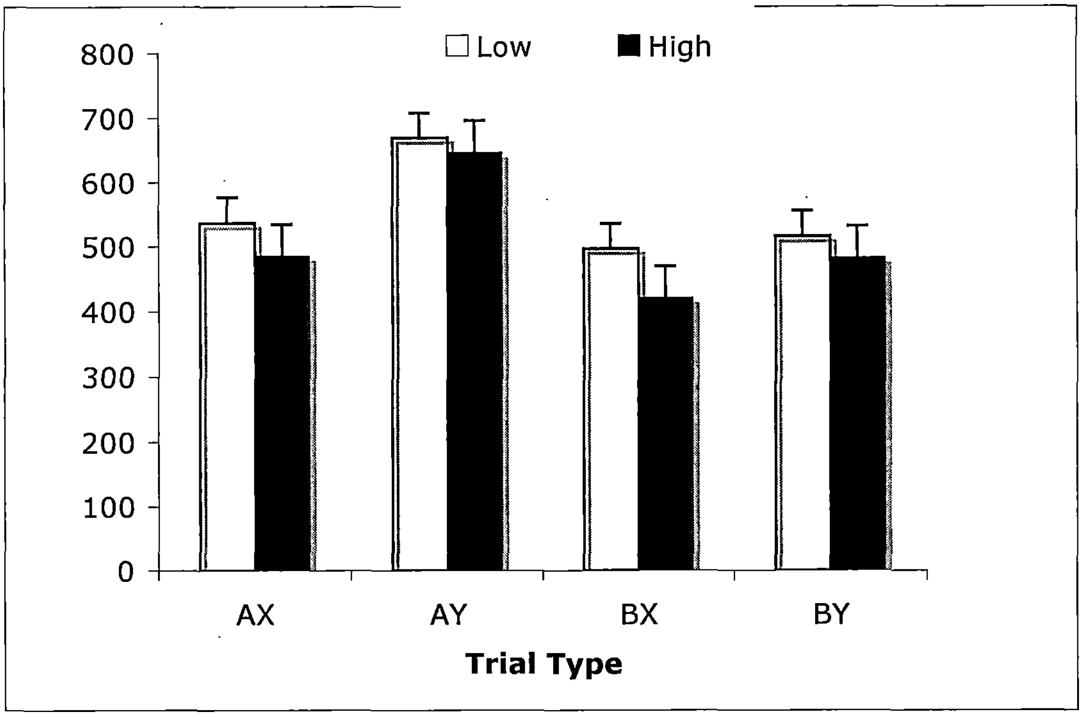

Figure 11. Distracter Task: Performance of low and high anxiety groups each of the target and non-target trial types. Error bars reflect standard errors of the means.

APPENDIX C

SCALES

STAI-Y-1 Scale measuring state anxiety

STAI – FORM Y – 1

DATE: AGE: GENDER:

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and circle the number on the scale below 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.

#	Statement	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
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 worried 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

STAI-Y-2 scale measuring trait anxiety.

STAI – FORM Y – 2

DATE: AGE: GENDER:

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and circle the number on the scale below to indicate how you feel 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.

#	Statement	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
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 steady person	1	2	3	4
40	I get in a state of tension or turmoil as I think over me recent concerns and interests	1	2	3	4

APPENDIX D

INFORMED CONSENT

INFORMED CONSENT

STAI - Prescreening

You are invited to participate in a study designed to investigate cognitive processing. This study is being conducted by Viara Stankova under the supervision of Dr. Jason Reimer, Professor of Psychology. This study has been approved by the Department of Psychology Institutional Review Board Sub-Committee of the California State University, San Bernardino, and a copy of the official Psychology IRB stamp of approval should appear on this consent form.

In this study you will be asked to respond to a survey. The survey will take approximately 20 minutes to complete. All of your responses will be held in the strictest of confidence by the researchers. You are being asked to provide contact information that will be used to invite you for follow up research session. Be assured that all data will be kept in strictest confidentiality and will be reported in group form only. Results from this study will be available from Dr. Jason Reimer (909) 537-7578 after January 1, 2009.

Your participation in this study is totally voluntary. You are free not to answer any question and withdraw at any time during this study without penalty. This study involves no risks beyond those of everyday life, nor any direct benefits to you as an individual. When you have completed the survey, you will receive a debriefing statement describing the study in more detail. In order to ensure the validity of the study, we ask that you not discuss this study with other participants.

If you have any questions or concerns about this study, please feel free to contact professor Jason Reimer at (909) 537-7578.

By placing a check mark in the box below, I acknowledge that I have been informed of, and that I understand, the nature and purpose of this study, that I freely consent to participate, and that at the conclusion of the study, I may ask for additional explanation regarding the study. I also acknowledge that I am at least 18 years of age.

Place a check mark here □

Today date: ____________________

INFORMED CONSENT

Context Processing

You are invited to participate in a study designed to investigate cognitive processing. This study is being conducted by Viara Stankova under the supervision of Dr. Jason Reimer, Professor of Psychology. This study has been approved by the Department of Psychology Institutional Review Board Sub-Committee of the California State University, San Bernardino, and a copy of the official Psychology IRB stamp of approval should appear on this consent form.

In this study you will be asked to complete a computer based task, where you will be presented with a series of letters on a computer screen. You are asked to respond to specific sequences of letters with either target or non-target response. The task should take no longer than 40-50 minutes of your time. All of your responses will be held in the strictest of confidence by the researchers. All data will be reported in group form only. Since no identifying information is collected on the survey, all your responses will be completely anonymous. Results from this study will be available from Dr. Jason Reimer (909) 537-7578 after January 1, 2009.

Your participation in this study is totally voluntary. You are free not to answer any question and withdraw at any time during this study without penalty. This study involves no risks beyond those of everyday life, nor any direct benefits to you as an individual. When you have completed the survey, you will receive a debriefing statement describing the study in more detail. In order to ensure the validity of the study, we ask that you not discuss this study with other participants.

If you have any questions or concerns about this study, please feel free to contact Dr. Jason Reimer at (909) 537-7578.

By placing a check mark in the box below, I acknowledge that I have been informed of, and that I understand, the nature and purpose of this study, that I freely consent to participate, and that at the conclusion of the study, I may ask for additional explanation regarding the study. I also acknowledge that I am at least 18 years of age.

Place a check mark here □

Today date: ____________________

APPENDIX E

DEBRIEFING STATEMENT

Debriefing Statement

STAI - Prescreening

The short survey that you have just completed was designed to measure your anxiety level. There are two types of anxiety assessed by this survey – state and trait anxiety. State anxiety is defined as unpleasant arousal in the face of danger or in threatening situation. Trait anxiety on the other hand, measured stable individual differences in the tendency to respond with state anxiety in the anticipation of threatening situations.

We have asked that you provide contact information in case you wish to participate in the second part of this study. If you chose to do so, your contact information will only be used to contact you and set up your visit in our research lab. After that, your contact information will be separated from this survey and destroyed. We assure you that your confidentiality will be kept at all times during the research process.

Thank you for your participation and for not discussing the contents of this study with other students who may in the future participate as well. If you have any questions about the study, please feel free to contact Professor Jason Reimer at (909) 537-7578. If you would like to obtain a copy of the group results of this study, please contact Professor Jason Reimer at (909) 537-7578 in February 2009.

Debriefing Statement

Context Processing

This study you have just completed was designed to investigate how anxiety levels may be related to the representation and maintenance of information in memory in order to guide future decisions. In the computer task that you just completed, you had to use context in order to perform well. There were four conditions where the letters were manipulated: AX (both cue and target were valid), AY (cue was valid but target was not valid), BX (non-valid cue but valid target). BY sequences were used as a control condition since both cue and probe were non-valid. Typically adults perform well on the AX condition, but make more errors in the AY condition than the BX condition. This pattern indicates good use of context to guide future behavior. In this experiment we will compare the performances of groups of individuals that have either high or low trait anxiety and examine the pattern of their performance.

Thank you for your participation and for not discussing the contents of this study with other students who may in the future participate as well. If you have any questions about the study, please feel free to contact Professor Jason Reimer at (909) 537-7578. If you would like to obtain a copy of the group results of this study, please contact Professor Jason Reimer at (909) 537-7578 in February 2009.

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