ANXIETY AND COGNITIVE PERFORMANCE: A TEST OF PREDICTIONS MADE BY COGNITIVE INTERFERENCE THEORY AND ATTENTIONAL CONTROL THEORY

Jebediah J. Northern

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Committee:

Dr. William H. O'Brien, Advisor

Dr. Margaret E. Brooks
Graduate Faculty Representative

Dr. Robert A. Carels

Dr. Steve M. Jex
ABSTRACT

Dr. William H. O’Brien, Advisor

A well-established link between anxiety and impaired cognitive performance exists. Researchers have put forth several theories to explain the mechanisms of this relationship. Two such explanations are Cognitive Interference Theory (CIT) and Attentional Control Theory (ACT). The present study used a sample of 97 undergraduate students to test hypotheses made by both theories. Participants completed a demographic questionnaire and measures of state anxiety, evaluation anxiety, cognitive interference, and attentional control. They were randomly assigned to either an anxiety or a non-anxiety instruction condition and were then administered various cognitive tasks, which included measures of phonological loop, central executive, and visuospatial sketchpad functioning. The central executive tasks completed included measures of inhibition, switching, and updating. Results indicate that many CIT hypotheses were supported. Most notably, those receiving anxiety-inducing instructions experienced greater levels of evaluation anxiety and made more negative self-statements on a measure of cognitive interference. The anxiety condition was also associated with worse performance on measures of phonological loop and central executive, but not visuospatial sketchpad, functioning. Negative self-statements mediated the relationship between anxiety condition and performance on central executive tasks, accounting for approximately 23% of the variance in the relationship. Negative self-statements did not mediate the relationship between anxiety condition and phonological loop functioning, and accounted for very little of the variance in the relationship. Partial support was found for ACT. Specifically, measures of attentional control did not predict performance on central executive tasks. This held true for both measures of task effectiveness (errors made on
the tasks) and task efficiency (time taken to complete tasks). The results were interpreted within both the CIT and ACT contexts. Implications for both models and future research are discussed.
This dissertation is dedicated to my Grandma Shirley, who has provided so many people with so many opportunities.
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INTRODUCTION

Anxiety is a negatively-valenced psychological state that arises under threatening circumstances and results in affective, physiological, and cognitive changes. An individual’s ability to execute tasks involving attention, language, memory, visual or auditory perception, or problem solving is termed cognitive performance (Lezak, 1995). Certain cognitive tasks require the use of only one of these abilities, but most situations require multiple abilities to meet task demands. A link between anxiety and diminished cognitive performance on cognitive tasks has been noted by several researchers (for reviews, see Eysenck, 1992; Eysenck, Deakshan, Santos, & Calvo, 2007; Sarason, Sarason, & Pierce, 1990). This relationship is robust, as it has consistently been found using a wide array of anxiety measures and a variety of cognitive tasks.

Evaluation anxiety is one particular form of anxiety that typically occurs during situations in which an individual’s performance is being evaluated in social, academic, or work settings. Evaluation anxiety is comprised of both affective and cognitive components (Deffenbacher, 1980). Researchers refer to the cognitive aspect of evaluation anxiety as worry and consider it aversive (Borkovec, 1994). Worry occurs in reaction to either evaluation or failure-related concerns (Borkovec, 1994). Negative self-statements and task-irrelevant thoughts are often the content of worry (Sarason, 1984; Sarason & Stroops, 1978).

As with general anxiety, researchers have found a reliable association between evaluation anxiety and performance on cognitive tasks (see Zeidner & Matthews, 2005 for a review). Researchers have generated several explanations to understand how evaluation anxiety and cognitive processes interact. Two such theories are Cognitive Interference Theory (CIT) and Attentional Control Theory (ACT).
Both theories use the Tripartite Model of Working Memory to provide a mechanistic explanation of how anxiety impairs cognitive performance. The Tripartite Model of Working Memory proposed by Baddeley (1986) posits that working memory is comprised of three subsystems: the phonological loop, the visuospatial sketchpad, and the central executive. The phonological loop is involved in processing auditory information whereas the visuospatial sketchpad processes visual information. The central executive was initially described in vague terms. It was said to control the two systems through the allocation of attentional resources. However, investigators have recently started to identify more clearly several functions of the central executive. Three functions are particularly well understood: inhibition, shifting, and updating. Inhibition refers to an intentional effort to suppress a near-automatic response. Shifting is the ability to change cognitive sets when signaled by environmental contingencies. Updating is the process of maintaining information in short term memory while performing an unrelated operation. Inhibition and shifting rely heavily on voluntary, controlled attention processes while updating is largely independent of those processes.

Proponents of Cognitive Interference Theory (CIT) postulate that negative self-statements frequently accompany evaluation anxiety and may interfere with working memory processes. More specifically, processing negative self-statements diverts attentional resources from on-task processing, resulting in decrements in task performance. Moreover, CIT predicts that components of the working memory subsystems are differentially affected by negative self-statements. According to CIT theorists, negative self-statements are automatically processed by the central executive. The result is that the central executive has fewer resources to devote to task demands. In addition, given the verbal nature of negative self-statements, phonological loop
functioning is likely to be impaired. The model predicts that visuospatial sketchpad functioning should not be impaired by anxiety.

Several studies support the relationship between evaluation anxiety and increases in negative self-statements. Investigators have also found increases in negative self-statements were associated with poorer cognitive functioning. Coy, O’Brien, Tabaczynski, Northern, and Carels (2010) found support for the CIT model. Anxiety-provoking instructions were found to be associated with an increase in evaluation anxiety. Subsequently, evaluation anxiety was related to an increase in negative self-statements. Higher levels of evaluation anxiety were found to predict poorer performance on phonological loop and central executive tasks, but not visuospatial sketchpad tasks. Finally, negative self-statements were found to almost completely mediate the relationship between evaluation anxiety and phonological loop performance. However, only weak partial mediation effects were found for cognitive interference in the evaluation anxiety/central executive functioning relationship. This could because the researchers used only a Stroop task to evaluate central executive functioning. Such a limited assessment of executive functioning may contribute to an evaluation of CIT that is limited in scope.

Attentional Control Theory (ACT) is an alternative theoretical framework that is helpful in understanding how anxiety affects cognitive performance (Eysenck et al., 2007). According to ACT, two attentional systems exist, and together form the basis of central executive functioning. One system is goal-directed and is associated with deliberate, intentional control of attention. The other is stimulus-driven and is controlled primarily by automatic processes. Typically, both systems function in a state of balance, using about equal cognitive resources. Threatening conditions, however, lead to an imbalance such that cognitive resources are diverted from the
goal-directed system to the stimulus-driven system. Fewer resources are available for the system associated with voluntary control of attentional processes.

Because anxiety detracts from the resources available to control attention, ACT theorists propose that executive functions that largely rely on attentional control (e.g., inhibition and shifting) are more likely to be adversely affected by anxiety. Several studies support these claims using various measures of inhibition (e.g., Stroop task) and shifting (e.g., Wisconsin Card Sort Task). Updating functioning could theoretically be impaired if conditions were extremely stressful. Evidence supporting this claim is mixed. However, at present no study has compared the relationship between anxiety, attentional control, and performance of various central executive tasks.

A differentiation between processing effectiveness and processing efficiency is an important theoretical underpinning in ACT (Eysenck, 1992). Effectiveness refers to an individual’s performance on a task in terms of correct answers. Efficacy refers to the degree of cognitive resources that are devoted to achieving a given level of effectiveness. Longer response latencies on cognitive tasks are a typical measure of efficiency. ACT predicts that efficiency will always be impaired by anxiety before effectiveness. In fact, mild anxiety may have no impact on effectiveness according to ACT, and some empirical evidence supports this claim. ACT theorists argue that the effectiveness/efficiency is an important distinction to make, yet relatively few studies have actually done so.

In summary, evaluation anxiety negatively influences cognitive performance. Negative self-statements, a component of evaluation anxiety, are also associated with poor cognitive performance. CIT argues that the verbal nature of negative self-statements detracts from the available processing resources of the phonological loop and the central executive resulting in
impaired performance. ACT theorists posit that negative self-statements divert attentional resources away from a goal-directed attention system to a stimulus-driven attentional system. Subsequently, fewer resources are available for deliberate, controlled attention that can be used for on-task processing.

The goal of the present study is to expand upon previous research on CIT and ACT. It will attempt to replicate findings reported by other researchers (Coy et al., 2010) and build on previous research assessing performance on a number of central executive tasks. This study will simultaneously test predictions made by the ACT model. Specifically, it will assess the effect of self-rated attentional control and anxiety on performance of three central executive tasks. No study has compared cognitive performance on central executive tasks using attentional control as a predictor. Moreover, this study will measure performance in terms of both efficacy and effectiveness, which few studies have. By making this performance differentiation, a more precise evaluation of ACT can be made and a clearer understanding of how anxiety affects cognitive performance can be gleaned. This study is clinically relevant as it will use tasks that are common during neuropsychological assessments.
CHAPTER I: LITERATURE REVIEW

The literature review that follows starts by detailing the Tripartite Model of Working Memory along with a brief review of the evidence supporting the existence of three primary components. Empirical support documenting the inverse relationship between anxiety and working memory is then presented. This is followed by a detailed discussion of CIT and the studies that support this theory. Finally, ACT and supporting literature are presented.

Tripartite Model of Working Memory

Working memory is responsible for the short-term storage and manipulation of information (Baddeley, 1986; Baddeley, 2001). Working memory is comprised of three components (Baddeley, 1986; Baddeley, & Hitch 1974; Baddeley & Hitch, 1994). The first component is the phonological loop and is responsible for short-term storage of auditory information. The phonological loop is comprised of two subcomponents. The phonological store maintains auditory information in memory for approximately two seconds before the auditory information begins to decay. The second subcomponent, the articulatory control system, acts to refresh auditory information in the phonological store. In other words, the phonological store acts as an “inner ear” while the articulatory rehearsal component acts as an “inner voice.”

The second component is termed the visuospatial sketchpad. Far less is known about the sketchpad compared to the phonological loop, but it is functionally similar to the phonological loop with the primary difference being that it stores and manipulates visual information. It is proposed that the visuospatial sketchpad has separate subsystems to maintain color/form information and spatial/kinesthetic information in working memory (Baddeley, 2001). Together, the phonological loop and the visuospatial sketchpad have been termed “slave systems” because they are under the control of the central executive.
The central executive is the third component of working memory and serves two primary functions (Baddeley, 1986). First, this system acts as a self-regulatory mechanism that controls and distributes attentional resources. Baddeley (2001) explains that the central executive controls attention in three primary ways: by focusing it, by dividing it, and by shifting it. Second, the central executive has limited capacity to process information. Executive function has been speculated to be “housed” in the frontal lobe of the brain (Baddeley, 2001). The tripartite model of working memory is depicted in Figure 1.

**Empirical Support for the Tripartite Model of Working Memory**

Much evidence supports the tripartite model. Three lines of evidence support the existence of the phonological loop. First, the phonological loop can account for the mechanism driving phonological similarity findings. That is, words that sound similar are harder to remember than words that sound different. Additionally, no effect is found for semantic similarity, suggesting that words are coded phonologically (Conrad & Hull, 1964). Second, the negative effects of articulatory suppression on working memory performance can be explained using the phonological loop as a model. Articulatory suppression consists of saying something aloud while trying to maintain auditory information in short-term memory. The action of speaking is thought to interfere with the action of the articulatory control system resulting in decay of auditory information in the phonological store (Baddeley, Thomson, & Buchanan, 1975). A third line of evidence is drawn from code transfer studies. Typically, adults name visually-presented information and sub-vocally rehearse the information to maintain it in short term memory (Murray, 1968). However, articulatory suppression has been found to interfere with this process, suggesting that the articulatory control system plays a role in transforming visual code to auditory code.
Support for the existence of visuospatial sketchpad is also well-documented. For example, visual memory can be impaired by requiring participants to tap a pattern of keys on a keyboard (Baddeley & Lieberman, 1980). Moreover, irrelevant distracting visual patterns have been found to impair visual memory (Logie, 1986; Quinn & McConnell, 1996). Finally, neuropsychological evidence supports the visuospatial sketchpad (see Della Sala & Logie, 2001 for a review).

The three attention-control sub-processes of the central executive have received empirical support. For example, generating random digits, a task thought to heavily tax the executive, interfered with participants’ ability to generate chess strategies (Robbins et al., 1996). Research performed in patients with Alzheimer’s Disease, which is speculated to cause central executive dysfunction, supports the notion that the central executive plays a role in dividing attention. One study found that performance on two tasks drops significantly when Alzheimer’s patients are asked to perform them concurrently versus performing them independently (Baddeley, Bressi, Della Sala, Logie, & Spinnler, 1991). Neuropsychological evidence supports the notion that shifting attention falls under executive control. Specifically, frontal lobe damage has been found to impair an individual’s ability to shift their attention (Shallice, 1988).

_A Closer Examination of Central Executive Sub-processes_

One criticism directed toward the tripartite model is the vague nature of the central executive (Baddeley, 2001; Monsell, 1996). Originally conceived as a homunculus that oversaw the slave systems, recent research has started to clarify the nature of the central executive (Engle Tuholski, Laughlin, & Conway, 1999; Miyake et al., 2000). Though not exhaustive, three particular functions are well-supported as central executive functions: inhibition, shifting, and updating (Baddeley, 1996; Lyon & Krasnegor, 1996; Rabbitt, 1997; & Smith & Jonides 1999).
Inhibition is similar to Baddeley’s notion of focusing attention. It has been defined as a deliberate, internal act of control that is used to stop the automaticity of previously learned or dominant responses. The Stroop task, for example, is classified as an inhibition task because it requires individuals to deliberately suppress a dominant response (naming the color ink that the word is printed in) and instead name the color spelled out in the text. The commonality between all inhibition tasks is that a relatively automatic response must be inhibited for a less automatic response (Miyake, 2000).

Shifting (or what Baddeley refers to as switching) is conceptualized as the use of attentional control to switch between multiple mental operations that are necessary to complete a given task (Monsell, 1996). It requires an ability to disengage from irrelevant processes and reengage in relevant processes. Researchers have also postulated that shifting may also be representative of an ability to perform a new operation despite proactive interference or negative priming (Allport & Wylie, 2001). The Wisconsin Card Sort Test (WCST), in which an individual shifts classification strategies based on feedback from the experimenter, is an example of a shifting task.

The final task function is updating, which is a two-part process. The first aspect requires incoming information to be monitored and coded. The second aspect requires existing information being maintained in working memory to be updated with new, task-relevant information (Morris & Jones, 1990). Unlike inhibition and shifting, updating is a memory-related function and does not require a high degree of deliberate attentional control (Miyake et al., 2000). Reading span, a task in which participants read consecutive sentences and then recall the last word from as many sentences as they can remember, is an example of an updating task. Updating is similar to Baddeley’s notion of dividing attention.
A source of debate in the field has been the degree to which central executive tasks are related (Duncan, Johnson, Swales, & Freer, 1997). Experimental evidence has been conflicting, offering some support that these functions are unitary, and should thus be classified as falling under a single dimension of executive functioning (Duncan, Emslie, Williams, Johnson, & Freer, 1996; Engle, Kane, & Tuholski, 1999), while some evidence suggests that these functions are diverse and should not be grouped together as executive functioning (Lehto, 1996; Lowe & Rabbitt, 1997; Robbins et al., 1998). Miyake and colleagues (2000) used confirmatory factor analysis techniques to further investigate the disparities in previous research. Their study used a sample of 137 undergraduate students who completed 12 central executive tasks. Four were hypothesized to be inhibition tasks (antisaccade task, stop-signal task, Stroop task, Tower of Hanoi task), four were hypothesized to be shifting tasks (plus-minus task, number-letter task, local global task, Wisconsin Card Sort task), and four were hypothesized to be updating tasks (keep track task, tone monitoring task, letter memory task, operation span task). The confirmatory factor analysis results provided support that the tasks measured the constructs that they were hypothesized to measure. Factor loadings ranged from .38 to .59 for the shifting tasks, from .33 to .57 for inhibition tasks, and from .45 to .63 for updating tasks. Table 1 provides a summary of the confirmatory factor loadings.

In terms of the three central executive functions, the authors found that though the functions were distinguishable, they were interrelated. That is, a three factor model that included inhibition, shifting, and updating fit the data best, but only when the three factors were allowed to intercorrelate. Additionally, the intercorrelations were of moderate to high magnitudes ($r$’s ranged from .42 to .63). The authors concluded that the intercorrelations likely represented certain similarities across all tasks such as maintenance of a goal in working memory and the
requirement to deliberately control attention. In other words, the authors support a unitary view of central executive functioning, but noted the presence of central executive sub-processes.

Anxiety and Working Memory

A relationship between anxiety and impaired performance on working memory tasks has long been noted (see Sarason et al., 1990, and Zeidner & Matthews, 2005 for reviews). Evaluation anxiety is a particular form of anxiety that has been defined as anxiety that arises under conditions of either real or imagined personal evaluations in social situations (Leitenberg, 1990). Correlational and experimental studies supporting this link are reviewed below.

Correlational Studies

One of the original studies that investigated anxiety and cognitive performance used the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Luchene, 1970) in relation to performance on the Finger Tapping Test (King, Hannay, Masek, & Burns, 1978) in a sample of undergraduate students. The researchers found a moderate negative correlation between trait anxiety and performance, but for females only.

Another study also used STAI scores in relation to performance on Block Design, Digit Symbol Coding, Finger Tapping, and the Word Fluency Test in a sample of undergraduates (Buckelew & Hannay, 1986). The experimenters examined the relationship between state anxiety scores, which were obtained prior to administration of each test, and performance. State anxiety was found to predict performance on Block Design and the Word Fluency Task such that greater state anxiety was associated with poorer performance.

Darke (1988) investigated the role of anxiety on an individual’s ability to draw inferences from statements. Anxiety was measured using the Test Anxiety Scale. A paradigm in which participants read several statements and subsequently answered questions based on inferences
from the statements was used as a measure of cognitive functioning. A median split was used to divide the participants into either high- or low-anxiety groups. A main effect for anxiety was found such that the high-anxiety group performed worse than the low-anxiety group.

Larue and D'Elia (1985) used a sample of middle aged and elderly community members to examine the relationship between memory and problem solving. Three problem solving situations classified as “traditional” (e.g., proportional reasoning) and three classified as “practical” (e.g., adjusting proportions in a recipe) were used as measures of cognitive performance. Additionally, the Raven’s Colored Progressive Matrices and the Similarities subtest were administered. Anxiety was assessed using the STAI. Significant state anxiety/performance relationships were found for the middle-aged participants on all four types of tasks. The researchers found significant state anxiety/performance relationships on the practical problems and similarities for the elderly group.

A similar study investigated anxiety and cognitive performance in a sample of elderly participants (Rankin, Gilner, Gfeller, & Katz, 1994). Again the STAI was used to assess for trait anxiety, and participants were classified into either high- or low-trait anxiety groups based on a median split. Digit Span, Logical Memory, and Visual Reproduction were used as measures of cognitive performance. The high-trait anxiety group performed worse on the Digit Span Forward subtest than their low-trait anxiety counterparts. No performance differences were noted for the other measures.

A third study using elderly participants examined the effects of anxiety as measured by a visual analogue scale on cognitive performance (Cockburn & Smith, 1994). Raven’s Colored Progressive Matrices and the Rivermead Behavioral Memory Test were used as measures of
cognitive function. Statistical analyses indicated that higher levels of anxiety predicted worse performance on both cognitive measures.

A correlational study investigated the relationship between anxiety and cognitive performance in a psychiatric population (Gass, Ansley, & Boyette, 1994). Anxiety was assessed using the ANX subscale of the Minnesota Multiphasic Personality Inventory-Second Version. Cognitive performance was assessed using the Controlled Oral Word Association Test (COWAT), Design Fluency, and Mazes subtests. Anxiety was negatively correlated with performance on COWAT and Design Fluency measures.

These studies taken together provide support for a link between anxiety and cognitive performance across a variety of tasks in a number of different populations. Though establishing this preliminary link is helpful, these studies do little in the way of establishing possible mechanisms by which anxiety may affect performance. Moreover, the selection of cognitive tasks for most of these studies was non-systematic. That is, little rationale was provided by the researchers for why they selected the cognitive tasks that they did.

**Experimental Studies**

Hodges and Spielberger (1969) conducted an experiment that manipulated anxiety by using anxiety-inducing feedback in a sample of undergraduate students. Subjects were initially assessed using the Taylor Manifest Anxiety Scale and then classified into high- or low-anxiety groups. Digit Span Backward was then administered. Participants then received either positive or negative feedback on their performance, were assessed on state anxiety using the Affect Adjective Checklist, and then were retested. No effect for anxiety was found on the initial test, but state anxiety was found to predict participants’ performance on the second administration of Digit Span Backwards.
In a similar study, Tyler and Tucker (1982) identified high- and low-anxiety groups based on scores from the STAI in a sample of undergraduate students. Additionally, the investigators administered either stress-inducing or supportive instructions. A battery of cognitive tasks was then administered. The battery consisted of the Verb Count Task, the Mooney Closure Faces Test, Digit Span Forward, and the Seashore Tonal Memory Test. State anxiety data were collected following the completion of the last test. Results indicated significant effects for state anxiety on nonverbal, but not verbal, tests. Moreover, an interaction between STAI and instruction condition was noted such that those higher in state and trait anxiety performed more poorly on the nonverbal, but not verbal, tests.

Another study used administration conditions to manipulate anxiety in an undergraduate sample (Martin & Franzen, 1989). The anxiety condition consisted of standard task administration whereas the supportive condition consisted of supportive instructions. Trait anxiety scores were collected prior to testing and state anxiety scores were collected following the conclusion of all cognitive tasks. The Randt Memory Battery, the Knox Cube Tapping Task, the Stroop Color Word Test, and the Finger Tapping task were used to measure performance. State anxiety was found to influence performance on the Randt Memory Battery subtests and on the Stroop Color Word Test, but not on the Knox Cube Tapping test or Finger Tapping Test.

Al’Absi and colleagues (2002) used the experimental stressor of a public speech task to manipulate anxiety reactions in a community sample of male adults. Performance on a serial mathematics task and a dichotic listening task were used as cognitive performance measures. The researchers found that performance on the serial subtraction task, but not the dichotic listening task, was negatively impacted by anxiety. This study also incorporated measures of circulating
blood cortisol to act as a manipulation check. Results indicated that the public speech task was associated with an increase of cortisol levels.

Coy and colleagues (2010) experimentally manipulated anxiety by randomly assigning participants to either an anxiety-inducing or supportive instruction condition. The Revised Test Anxiety Scale was administered after the instructions to assess for anxiety. Results indicated that the anxiety-inducing instructions were effective for increasing anxiety in participants. Moreover, receiving the anxiety-inducing instructions was associated with impaired performance on the Stroop Color Word Test and on the Digit Span Test. The Visual Memory Span and Brief Test of Attention were also administered, but no condition effect was found on these tasks.

**Summary**

In summary, several researchers have noted a link between anxiety and impaired cognitive performance. Anxiety measured in a wide variety of ways has been negatively correlated with numerous measures of cognitive functioning. Furthermore, experimental studies that manipulated levels of anxiety in participants have indicated that there may be a causal relationship between anxiety and cognitive performance.

Investigators have posited several theories in an attempt to explain this relationship between anxiety and cognitive performance. Two theories in particular have received substantial scrutiny: Cognitive Interference Theory and Attentional Control Theory. In the next sections these two theories will be reviewed.

**Cognitive Interference Theory**

CIT was developed in an effort to understand how anxiety influences cognitive functioning. Proponents of CIT postulate that performance tasks can lead to an increase in evaluation anxiety. Evaluation anxiety, in turn, leads to an increase in negative self-statements.
Attentional resources are diverted from the task demands to process these negative self-statements which act as a form of cognitive interference. Consequently, impaired performance on cognitive tasks results (Sarason, 1988; Wine, 1982). The research supporting the development of CIT is reviewed in the next section. This is followed by a discussion of the current status of the CIT model.

_Evaluation Anxiety and Cognitive Performance_

Evaluation anxiety occurs when an individual is concerned with how they are being perceived and appraised by others, and is comprised of affective, physiological, behavioral, and cognitive components (Leary & Kowalski, 1995). The cognitive aspect is linked to an increase in apprehensive thoughts regarding how the person will be evaluated by themselves or others (Trower, Gilbert, & Sherling, 1990). Various forms of evaluation have been documented (e.g., test anxiety, math anxiety, sports anxiety, social anxiety), but the commonality between all types is the prospect of personal evaluation in real or imagined social situations (Leitenberg, 1990; Zeidner & Mathews, 2005).

The link between evaluation anxiety and lower levels of cognitive performance is well-documented. Several studies illustrate the association between evaluation anxiety and impaired performance on a variety of cognitive tasks including block design (Mandler & Sarason, 1952), analogies (Deffenbacher, 1977), memory (Mueller, 1977, Sarason & Stoops, 1978), and problem solving (Greene, 1985). Additionally, a meta-analysis of 562 studies examined the relationship between test anxiety and cognitive performance (Hembree, 1988). An effect size of $r = -.31$ was found between measures of evaluation anxiety and cognitive performance.

_Evaluation Anxiety and Negative Self-Statements_
Negative self-statements may mediate the relationship between evaluation anxiety and impaired cognitive performance. Ganzer (1968) was one of the first researchers to investigate this link. Using a sample of 72 undergraduates, he divided them into either high- or low-evaluation anxiety groups based on scores from the Test Anxiety Scale. Participants then engaged in a serial learning task while experimenters recorded task-irrelevant verbalizations. Those high in evaluation anxiety emitted more negative self-statements than those low in evaluation anxiety (Ganzer, 1968).

Sarason and Stroops (1978) continued and expanded this line of research by creating the Cognitive Inference Questionnaire (CIQ), a 22 item self-report measure of potential thoughts commonly experienced during cognitive tasks. Items were grouped into either task-relevant or task-irrelevant categories. Items in the task-relevant category are thoughts that are relevant to the task, but negative in nature (e.g., “I thought about how poorly I was doing”).

Researchers used the CIQ in a sample of 451 undergraduates after assessing for evaluation anxiety using the Reactions to Tests scale and administering an arithmetic test (Sarason, Sarason, Keefe, Hayes, & Shearin, 1986). Significant positive correlations between evaluation anxiety and task-relevant thoughts and task-irrelevant thoughts were found.

Hunsley (1987) administered the CIQ to a sample of 96 undergraduate students in a statistics course following each of three examinations. Additionally, the Debilitating Anxiety Scale of the Achievement Anxiety Test was used as a measure of evaluation anxiety. Again, significant, positive correlations were found between evaluation anxiety and negative self-statements.

In summary, a number of research findings support the notion that evaluation anxiety is a particular form of anxiety that is linked to decrements in cognitive functioning. Moreover,
evaluation anxiety appears to be linked to increases in negative self-statements. This line of research has provided the theoretical underpinnings of CIT. The model has since been updated to incorporate the Tripartite Model of Working Memory. A description of the model in its current state and a review of the supporting research follow in the next section.

**Current State of Cognitive Interference Theory**

CIT in its original form postulated that negative self-statements impaired cognitive resources, but failed to specify how. More recently, researchers have argued that negative self-statements drain working memory resources (MacLeod, 1996). As previously discussed, the working memory system is comprised of three subsystems (Baddeley, 1986). Of particular interest within a CIT framework are the phonological loop and the central executive.

The phonological loop is of particular interest to CIT researchers because it involves language-mediated processes (Baddeley & Hitch, 1994). Subvocal rehearsal processes are necessary to maintain auditory information in the phonological loop (Baddeley, 1986). An increase in task-relevant or task-irrelevant self-statements could interfere with the rehearsal function of the Articulatory Control System. Consequently, information in the phonological store would decay, thus causing decrements in performance on tasks requiring the maintenance of auditory information in the phonological loop.

CIQ theorists argue that both task-relevant and irrelevant statements interfere with central executive functioning. In particular, it has been speculated that task-irrelevant thoughts impair the central executive’s ability to direct attention (Sarason, 1984). It follows that task performance would suffer if less attention is devoted to the task being performed. Additionally, some researchers posit that processing task-relevant negative self-statements may be automatic. Control of resource allocation between automatic processes and deliberate, goal-directed
processes is a central executive task. Thus, an increase in self-statements that are automatically processed by the central executive may deter goal-directed central executive functioning (Crowe, Mattews, & Walkenhorst, 2007).

**Empirical Support**

Rapee (1993) examined the effects of a worry-induction task on one of four working memory tasks in a sample of 68 undergraduate students. Participants completed the trait version of the STAI and the Penn State Worry Questionnaire prior to the task. The tasks employed were an articulatory suppression task (i.e., repeating the word “one” every second), a random letter generation task, a task that required participants to strike numbers on a keypad in a particular order, and a task that required participants to strike random numbers on a keypad. Participants then engaged in a worry-induction task followed by 10 blocks. During five of the blocks participants were instructed simply to worry. Participants were instructed to worry while engaged in the task during the other five blocks. At certain intervals a tone would sound and participants stated their immediate thought aloud. The content of these thoughts were coded as either being worry-related or non-worry related. These were used as the independent variable.

Results suggested that while the phonological loop and central executive were in use, the frequency of worry-related thoughts decreased. This study provides evidence that worry, a language-mediated process similar to negative self-statements, is processed by central executive and phonological loop components of working memory.

Researchers have more directly investigated the effects of negative self-statements within a CIT framework. Hammermaster (1989) assessed test anxiety using the Test Anxiety Scale in a sample of 214 undergraduate students. The Wisconsin Card Sort Task (WCST) was then administered followed by the CIQ. Results indicated that participants high in test anxiety
experienced more cognitive interference and worse cognitive performance relative to individuals low in test anxiety.

Blankenstein, Toner, and Flett (1989) assessed evaluation anxiety using the Test Anxiety Scale in a sample of 47 undergraduate students. Anxiety-inducing instructions were then given and the participants completed as many of 10 anagrams as they could. The CIQ was administered following the anagram task. Test anxiety was positively correlated with cognitive interference. Moreover, CIQ scores were negatively correlated with task performance.

Yee, Hsieh-Yee, Pierce, Grome, & Schantz (2004) conducted a study exploring the relationship of interfering thoughts and performance on an internet search task. A sample of 62 college undergraduates was instructed to complete an internet search task. Following completion, participants completed the CIQ and a self-evaluation of their performance. Frequency of self-evaluative thoughts was predictive of poorer search performance and less self-rated satisfaction with their search.

The three preceding studies offer support for CIT in that they demonstrate relationships between anxiety, negative self-statements, and decreased cognitive impairment. Moreover, each of the employed tasks is a complex task that requires the central executive. That anxiety is linked with performance decrements on these tasks suggests that the central executive may be impaired by negative self-statements. None of these studies, however, compared performance on tasks that use different aspects of working memory.

To address this shortcoming, Ikeda, Iwanga, & Seiwa (1996) tested verbal and spatial working memory in either high- or low-test anxious participants in a sample of 36 undergraduate students. Test anxiety was measured using the Test Anxiety Scale. High test-anxious individuals were found to have higher rates of worry during the task as measured by the CIQ. Moreover,
participants performed worse (as measured by reaction time) on the verbal, but not spatial, memory task. This study lends support to the notion that performance on phonological loop tasks is decreased by anxiety. Yet the study did not include a central executive task. This would indeed be helpful in determining the degree to which anxiety interferes with different components of working memory.

Coy and colleagues (2010) examined how negative self-statements affect all three working memory subsystems within a cognitive interference framework. In this study 88 non-clinical college undergraduates completed five working memory tasks after receiving either supportive or anxiety-inducing instructions. Participants completed measures of trait test anxiety and cognitive interference. Digit Span Forward and Backward were administered as a phonological loop task and the Visual Memory Span Forward and Backward were used as a measure of visuospatial sketchpad functioning. To assess central executive functioning, the Stroop Color and Word Test and the Brief Test of Attention were administered.

Results from Coy and associates indicated that individuals in the anxious condition reported more cognitive interference (task-relevant and -irrelevant self-statements) and performed worse on both phonological loop tasks and one of the central executive tasks (Stroop Color and Word). Moreover, cognitive interference almost completely mediated the relationship between evaluation anxiety and phonological loop functioning. Cognitive interference was also found to partially mediate the relationship between evaluation anxiety and performance for the central executive task.

This study provides evidence that cognitive interference diminishes performance on phonological loop and central executive tasks. Moreover, the relationship between evaluation
anxiety and cognitive performance is partially mediated by task-relevant and irrelevant thoughts, though the mediational effect seems to be stronger for phonological loop tasks.

Attentional Control Theory and Processing Efficiency Theory

ACT has been developed as an alternative framework to explain how anxiety interferes with cognitive performance (Eysenck et al., 2007). Attentional control theory is an elaboration of Processing Efficiency Theory (PET; Eysenck & Calvo, 1992). In the following section, processing efficiency theory and attentional control theory will be presented and critically evaluated.

Processing Efficiency Theory

A major tenet of processing efficiency theory is the differentiation of efficiency and effectiveness of cognitive processing. Efficiency can be thought of as the cognitive resources allocated to achieve a certain performance level (Eysenck & Calvo, 1992). Using fewer cognitive resources used to achieve a given level of performance represents a higher level of efficiency. Alternatively, effectiveness refers to the quality of the task performance (Eysenck & Calvo, 1992; Eysenck et al, 2007). In other words, effectiveness can be thought of task accuracy (i.e., power) whereas efficiency is conceptualized as reaction time (i.e., speed).

Proponents of PET argue that the cognitive aspect of anxiety, negative self-statements and task-irrelevant thinking (referred to as worry by some researchers) is the mechanism by which anxiety impairs cognitive performance. Processing negative self-statements give rise to two potential scenarios. In the first, the individual activates additional cognitive resources that were formerly unused or adapts alternative strategies to meet task demands. The second scenario arises when additional resources are unavailable. Under these circumstances, attentional resources that would otherwise be used for task-relevant processing must be diverted to
processing the negative self-statements. In the former situation, effectiveness would remain unchanged but efficiency would decrease because more resources were required to complete the task. In the latter scenario, effectiveness would decrease.

Negative self-statements place a demand on the processing and storage resources of the working memory system. Supporters of PET also argue that the resources required to process negative self-statements are drawn primarily from the central executive. To a lesser extent, the verbal nature of negative self-statements is also likely to interfere with phonological loop functioning. This occurs because negative self-statements occupy “space” in the Articulatory Control System, and without rehearsal, information in the phonological store decays. The visuospatial sketchpad is thought to be unaffected by negative self-statements.

PET is notably vague in describing how anxiety actually interferes with central executive processing (Eysenck et al., 2007). This criticism served as an impetus for the subsequent evolution of PET to ACT. A more in-depth explanation of this relationship is provided in the ACT section.

In sum, PET provides a useful framework to understand how anxiety can interfere with cognitive performance. PET makes two predictions, the first of which is that anxiety is more likely to cause a decrease in efficiency rather than effectiveness. The second is that central executive functioning, and to a lesser degree phonological loop functioning, are more likely to be impaired.

**Empirical Support for Processing Efficiency Theory**

Three studies provide support for decrements in processing efficiency rather than effectiveness. Weinberg and Hunt (1976) assessed anxiety in a sample of undergraduate students using the STAI and then administered a motor performance task (throwing a ball). High-anxious
participants were less efficient in completing the task as measured by muscle energy expenditure using an electromyogram. Performance as measured by overall accuracy, however, was equal across both groups.

A study conducted by Ikeda and colleagues (1996; detailed in the Cognitive Interference Theory Section) also lends support that efficiency is more likely to be impaired. This study was conducted on a sample of undergraduates who were assessed for anxiety using the Reactions to Tests scale. Results demonstrated that accuracy on a verbal learning task was not different between high-anxiety and low-anxiety groups. Reaction time, however, was significantly longer for high-anxiety participants.

Finally, Elliman, Green, Rogers, and Finch (1997) investigated the effects of anxiety on a task-sustained attention task that is speculated to assess central executive and phonological loop functioning. The task was structured into six blocks, and accuracy and reaction time were recorded. In terms of reaction time, a main effect was found for time (block), but no main effect was found for anxiety. Yet a time by anxiety interaction effect was discovered such that the reaction time of the high-anxiety group increased precipitously as the experiment progressed compared to that of the low-anxiety group. No main or interaction effects were found for task accuracy.

Evidence supporting the prediction that central executive functioning should be most affected by anxiety is sparse. One reason for this is that few studies have compared performance on cognitive tasks that specifically tap all three components of working memory. One study that did investigated the effects of self-reported worry on central executive, phonological loop, and visuospatial sketchpad functioning (Crowe, Matthews, & Walkenhorst, 2007). Results indicated significant effects for worry on only the central executive task (dual task). Additionally, findings
from some studies indirectly support this claim. For example, researchers have noted that anxiety does not seem to impair visuospatial sketchpad functioning (Coy et al., 2010; Crowe et al., 2007; Ikeda et al., 1996).

To summarize, several studies support the first prediction of PET. The second hypothesis has received limited direct support, though several studies provide indirect support. Eysenck and colleagues noted that a potential reason for the limited support was that PET was limited in scope in terms of explaining how anxiety interferes with executive functioning. This was one impetus for elaborating on PET, which subsequently became ACT. The next section describes ACT and reviews literature supporting the model.

*Attentional Control Theory*

ACT retains the efficiency/effectiveness distinction, but builds on PET by positing that there are two interactive attentional systems that share a finite level of processing resources. Together, these systems are responsible for central executive tasks. The first attentional system is thought to be a top-down system that is located in the frontal regions of the brain. This subsystem has been termed the anterior attentional system, and functions as a goal-directed system. This system contributes to central executive functioning by controlling voluntary attentional processes. The bottom-up subsystem has been termed the posterior attentional system, and is thought to be driven by stimulus properties. It acts to scan the environment for threatening stimuli and is responsible for the processing and memory aspects of central executive functioning (Derryberry & Reed, 2002).

Under non-threat conditions the two systems are in a balanced state of interaction, but when a goal becomes threatened, the stimulus-driven system predominates over the goal-directed system. The purpose of this shift is to facilitate assessment of the threat so that actions to
mitigate the threat can be planned and executed. As a result, attentional resources are directed towards processing of threat-related stimuli. ACT theorists posit that the shift of resources to the stimulus-driven attentional system results in a decrease of available resources that can be used by the goal-directed system for voluntary attentional control. Consequently, central executive functions that require voluntary control of attention operate with fewer resources and performance becomes impaired.

An analogy of a spotlight can be used to describe the attentional systems. The goal-directed system acts as an operator of the spotlight and directs the focus of attention to meaningful contextual stimuli. This type of operation works under non-threatening circumstances. Under threat conditions, three changes occur. First, the narrow focus of the spotlight becomes broader to increase the chances of detecting other threatening stimuli. This change, however, comes at the cost of the luminosity of the spotlight, which represents the second change. Finally, automatic attentional processes override the volitional focusing efforts of the spotlight operator. Rather, the stimulus-driven system acts as though automatically programmed to broadly scan the environment for threat-related stimuli.

Consider, for example, a reaction time task that requires individuals to view a computer screen and press a key when a stimulus appears only in the middle of the screen. Distracter words, which participants are instructed to disregard, appear in the four quadrants of the screen prior to the presentation of the stimulus. ACT theorists would predict that reaction time would be slower if threatening, as compared to neutral, words were used as distracters. This is because threatening words activate the stimulus-driven system to scan the environment for threat. This activation process redirects attentional resources that were being used by the goal-directed
system. As a result, fewer resources are available to attend to and complete the goal, and impaired performance results.

Under this model, anxiety is considered an internally-generated threat in which worrisome thoughts act as the anxiety-inducing stimuli. Studies suggest that anxiety aids in threat detection. For example, anxious individuals preferentially attend to threatening stimuli and experience difficulty disengaging from threat-related stimuli (Egloff & Hock, 2001; Mogg & Bradley, 1998; Wilson & MacLeod, 2003). Thus, individuals high in trait anxiety are more likely to have fewer resources available for control processes than persons low in trait anxiety. Additionally, manipulations that increase anxiety in individuals (regardless of trait anxiety) will detract from the available control resources.

This framework represents a significant step forward from PET in that it specifically predicts which central executive functions should be more impaired. As previously discussed (see section entitled ”A Closer Examination of Central Executive Subprocesses”), researchers have identified the specific central executive functions of inhibition and shifting as more prone to the effects of anxiety because they require more voluntary attentional resources. That is, deliberate control is required during inhibition tasks to suppress semi-automatic responses. Additionally, the shifting function requires deliberate control to disengage from a cognitive set, generating a plan to engage in a new cognitive set, and then engaging in the new cognitive set. Updating, conversely, primarily requires information processing and memory functions of the central executive. Voluntary control is thought to be necessary with updating tasks in that it is needed to consciously change between the demands of the mental task and remembering a piece of information that is presented at the end of the mental task, but the degree of voluntary control in this process is substantially less than with inhibition and shifting. Therefore, performance on
updating tasks should not be impaired by decreases in the available resources for controlled attentional processes. Yet under extremely trying conditions, performance on updating functions may also be impaired (Eysenck et al., 2007).

To summarize, attentional control theory builds on evidence of two attentional subsystems. The anterior attentional system is associated with top-down, goal-oriented, and voluntary attentional processes. The posterior attentional system functions as a bottom-up, stimulus-driven, and automatic system. Because anxious individuals generate more internal threatening stimuli under evaluative conditions, the posterior attentional system predominates to a larger degree than in low-anxious individuals. Consequently, anxious individuals experience a reduction in central executive resources available for control, which results in impaired shifting and inhibition functioning.

**Empirical Support for Attentional Control Theory**

The following section provides an overview of the research that supports ACT. First, a description of the development of self-report measures used to assess attentional control is provided. Next, studies that support the link between anxiety and impaired inhibition and shifting functions are described. The section ends with a review studies that examined the effect of anxiety on updating function.

**Measuring Attentional Control.** Two self-report inventories have been used to assess attentional control, the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982) and the Attentional Control Scale (ACS; Derryberry & Reed, 2002). Both measures conceptualize the ability to exert control over attentional processes as a trait-like construct. Greater detail on each measure is provided in the following paragraphs.
An inability to complete tasks because of an automatic tendency to engage in a well-learned response appears to be the basis for many CFQ items. Thus, cognitive failures may result from lapses of executive functioning, particularly control lapses. To test this hypothesis, Friedman and Miyake (2004) administered the antisaccade task, the stop signal task, and a Stroop task to 220 undergraduates. All tasks are considered to tap the inhibition function of the central executive. Structured Equation Modeling results indicated a significant association between CFQ scores and performance on inhibition tasks (.29). The scope of this paper was focused on inhibition tasks, so the relationship between CFQ scores and other tasks of central executive functioning were not reported, though these results support a link between CFQ scores and executive functioning processes that rely heavily on attentional control.

A second measure of attentional control, the Attentional Control Scale (ACS; Derryberry & Reed, 2002), has also been created. This scale is a combination of two previously developed scales, the Attentional Focusing Scale (nine items) and the Attentional Shifting Scale (11 items; Derryberry & Rothbart, 1988). These measures were developed to assess how well individuals voluntarily control and shift attention between tasks despite experiencing negative emotion.

Relationships between ACS scores and executive functioning tasks in adult samples have not been well documented. However, Muris, Mayer, van Lint, and Hofman (2008, Study 1) identified a relationship of $r = .40$ between a version of the ACS for children and anxiety in a sample of 82 children. Furthermore, ACS scores were associated with performance on the Test of Everyday attention for Children after controlling for anxiety in a different sample of 50 children (Murris et al., Study 2). Moreover, a Japanese version of the ACS predicted better performance on a Stroop task (Yamagata, Takahashi, Shigemasu, Ono, & Kinjima, 2005).
In summary, two self-report measures have been used to assess attentional control, the CFQ and the ACS. Both instruments were soundly developed and display good psychometric properties. Both measures have been shown to be related to measures of inhibition, but the relationship between these attentional control measures and performance on shifting and updating tasks has not been established. Despite the lack of a documented relationship between self-report measures of attentional control and performance on shifting tasks, ACT predicts that because inhibition and shifting share an attentional control component, these measures should be associated with performance on shifting tasks.

Anxiety and Performance on Inhibition and Shifting Tasks. This section reviews the empirical support that anxiety interferes with control-related executive functioning. Three studies investigated the relationship between inhibition and anxiety on Stroop tasks. The first found that high trait-anxiety individuals, as measured by the STAI, performed worse than low trait-anxiety individuals on the Stroop Color-Word task only when automatic responses had to be inhibited (Pallak, Pittman, Heller, & Munson, 1975). That is, high-anxiety participants’ performance was worse when they were required to read color names that were not printed in their own color ink.

Similar results were observed in two other studies in which state anxiety was manipulated (Hochman, 1967, 1969). Participants were assigned to complete a Stroop task high and low-stress conditions. The low-stress condition consisted of normal directions whereas the high-stress condition included anxiety-inducing instructions. Both studies found that the high-anxiety condition predicted worse performance as measured by inhibiting automatic responses.

These studies support a link between both trait and state anxiety and inhibition performance, lending some support to ACT predictions. However, none of the studies assessed for frequency of negative self-statements, so they cannot support the ACT hypothesis that
anxiety-related thoughts are the mechanism that impairs performance. Moreover, neither study supports the notion that attentional control underlies poorer performance.

With regards to the shifting function, one study using the Wisconsin Card Sorting Task (WCST) as a measure of shifting functioning is of note (Goodwin & Sher, 1992). The investigators found that high-anxiety participants \((N = 159)\), relative to low-anxiety \((N = 490)\), participants performed worse in efficiency (time taken to complete the test) and effectiveness (number of preservative errors made). Anxiety in this study was assessed using the Maudsley Obsessional-Compulsive Inventory.

Two other studies used a shifting task that resembles the WCST. The paradigm required participants to switch sorting randomly presented digits based on a number of characteristics that change without the participant being told (e.g., whether the number is even or odd, falls between one and five or six and nine, or whether the first letter of the number falls between A and R or S and Z). Santos and Eysenck (2006) found that state anxiety predicted no difference in task effectiveness, but significantly diminished processing efficiency (as measured by time taken to complete the task). Santos, Wall, and Eysenck (2006) found the same pattern of results in a similar study. This study elaborated on the previous study by incorporating fMRI imaging. High-anxious subjects were found to have greater brain activation in a brain region associated with the switching function of the central executive. Greater brain activation was interpreted as consuming more resources for the same level of performance. Here again, high-anxious participants took more time to complete the task but displayed no difference in effectiveness. These two studies support the notion that anxiety impairs the efficiency of the shifting function.

*Anxiety and Updating Performance.* ACT theorists argue that because the updating function relies little on attentional control, anxiety is unlikely to have an effect on updating tasks.
Three studies assessing updating function (Calvo & Eysenck, 1996; Calvo Eysenck, Ramos, & Jimenez, 1994; Santos & Eysenck, 2005) found no main effect for anxiety on performance on an updating task, supporting this claim. The argument has been made, however, that very high states of anxiety may potentially interfere with the updating function (Eysenck et al., 2007). Four studies have compared high-anxious to low-anxious subjects using stress-inducing instructions to investigate the updating function, but the results have been mixed. For example, two studies found reading span to be impaired in high-anxiety participants when a stress-inducing condition was used (Calvo, Ramos, & Estevez, 1992; Darke, 1988), but two studies found no interaction effect (Sorg & Whitney, 1992; Santos & Eysenck, 2005). Thus, evidence is mixed, but impairment in the updating function is more likely to be seen in high-anxiety individuals when they are in stressful contexts.

In summary, substantial evidence supports many of the predictions of ACT. Specifically, anxiety can be internally-generated (trait anxiety) or externally-generated by manipulating experimental conditions to increase state anxiety. Anxiety acts to limit central executive resources available for attentional control. Lower levels of attentional control have been associated with impaired cognitive performance on inhibition and shifting tasks. Additionally, indices of efficiency are more likely to be impaired than measures of effectiveness. Finally, stressful enough circumstances, usually observed when highly anxious individuals are in stress-inducing experimental contexts, may affect performance on updating tasks.

Integration of Cognitive Interference Theory and Attentional Control Theory

It is important to note that CIT and ACT accounts of how anxiety affects performance are not mutually exclusive. Thus, the present study is not a test of competing theories. In fact, CIT
and ACT can be viewed as complimentary in their mechanistic accounts of how anxiety affects performance.

A particular strength of CIT is the mechanistic explanation that describes how phonological loop functioning is impaired by anxiety. Though PET and ACT acknowledge that phonological loop functioning is likely to be impaired, both theories fail to explain how. CIT provides a viable explanation of how this might occur that does not conflict with ACT.

Likewise, ACT provides solid theoretical grounding to account for central executive impairment due to anxiety. The explanations proffered by CIT theorists are notably vague and difficult to test. ACT provides clarity and testability to the predictions made by CIT supporters.

In fact, predictions made from both models may compatible here. The notion of a change in attentional system dominance may be associated with an increase in negative self-statements. The loss of volitional control of attention due to the presence of anxiety may lead to an increase in negative self-statements. Perhaps attentional control resources were being used by the individual to suppress negative self-statements. Alternatively, a change to the threat-oriented attentional system could lead to more resources being allocated to attending to and processing negative self-statements. The underlying notion in the proposed scenarios is that negative self-statements may be negatively associated with attentional control.

The following summary is provided to illustrate how CIT and ACT may be complementary rather than competing explanations. Anxiety may lead to a shift in attentional systems, which results in less attentional control. This in turn leads to either an increase in negative self statements or more attentional resources being automatically diverted to processing existing negative self-statements. More processing resources are devoted to these negative self-statements, resulting in interference with phonological loop processing. Concurrently, the change
in attentional system dominance causes the deficiencies in inhibition and shifting, but not updating central executive functions.
CHAPTER II: SUMMARY AND HYPOTHESES

Anxiety negatively impacts cognitive performance in a complex way. A number of studies established a preliminary link between higher levels of anxiety and poorer cognitive performance. CIT theorists argue that higher anxiety leads to higher levels of task-relevant and –irrelevant negative self-statements, an assertion that has received a high degree of empirical support. It is argued that processing these thoughts diverts working memory resources from on-task performance. Specifically, the verbal nature of these thoughts is thought to interfere with processing other auditory information and should impair performance on measures of phonological loop functioning. Moreover, the automatic nature of these thoughts is associated with a decrease of central executive resources that are available for on-task processing. ACT argues that these thoughts cause a shift in the balance of two attentional systems. This shift results in a reduced availability of cognitive resources that can be used for voluntary cognitive processes. Specifically, the central executive functions of inhibition and shifting should be most impaired. ACT proponents also posit that, to a lesser degree, phonological loop functioning should be impaired by anxiety.

CIT and ACT make several predictions and provide empirical support for these hypotheses. However, no known studies have attempted to compare the mechanisms posited by these theories to provide a fuller understanding of the anxiety/cognitive performance relationship. The present study will assess state-anxiety and attentional control, and will consist of five tasks that assess various functions of working memory. Specifically, tasks that require the use of the inhibition, shifting, and updating functions of the central executive will be used. Additionally, measures of phonological loop and visuospatial sketchpad functioning will be
administered. Participants will randomly be assigned to either a supportive or a stress-inducing condition.

The current study seeks to contribute to the existing literature in a number of key ways. First, it seeks to garner support for CIT by testing a number of hypotheses:

1. Participants who receive anxiety inducing instructions, relative to supportive instructions, will report higher levels of state and evaluation anxiety as measured by self-report questionnaires.

2. Participants who receive anxiety inducing instructions, relative to supportive instructions, will perform worse on phonological loop and central executive, but not visuospatial sketchpad, tasks.

3. Participants who receive anxiety inducing instructions, relative to supportive instructions, will report higher levels of negative self-statements on a measure of cognitive interference.

4. Greater levels of evaluation anxiety will be associated with greater levels of negative self-statements on a measure of cognitive interference.

5. Scores on a measure of cognitive interference will partially mediate the relationship between condition and performance on central executive and phonological loop, but not visuospatial sketchpad, tasks.

Additionally, the present study will incorporate predictions from ACT by testing the following hypotheses:

6. Higher scores on measures of attentional control will be negatively associated with performance as measured by efficiency and effectiveness on inhibition and shifting, but not updating, tasks.

7. Anxiety will be negatively associated with performance as measured by efficiency and effectiveness on inhibition and shifting, but not updating, tasks.
CHAPTER III: METHOD

Participants

Participants were recruited from psychology classes at a large Midwestern state university using an online recruitment system and in-class recruitment announcements. Depending on instructor policy, participants either received experimental credits or extra credit for participation. Participants were also entered into a drawing for one of 4 $25 gift cards to a local grocery store.

A sample of 97 was obtained based on a power analysis based on the findings of a similar study (Coy et al., 2010) that suggested a necessary sample size of 90 for a .8 power level at the $p = .05$ alpha level. Forty-six participants were assigned to the anxiety condition and the remaining 51 received supportive instructions.

Participants were excluded if they reported any of the following: 1) a history of alcohol or substance abuse; 2) a head injury that resulted in a loss of consciousness; 3) a medical illness that could affect cognitive performance; 4) a psychiatric/psychological condition that could affect cognitive performance; 5) use of psychotropic medication; 6) enrollment in psychotherapy; and 7) color-blindness.

The average age of participants was 20.91 (SD = 4.79) and a majority were female (60.8%). The sample was predominantly Caucasian (69.8%), followed by African American (12.5%), Multi-racial (7.3%), Asian American (5.2%), and Latino/a (5.2%). In terms of year in college, 48.5% were freshmen, 18.6% were sophomores, 5.2% were juniors, 22.7% were seniors, and 5.2% indentified as fifth year or more.

Measures

*Demographic Questionnaire*
A questionnaire was used to collect demographic information (see Appendix A). Information on age, gender, ethnicity, year in school, medical history, psychiatric history, and high school grade point average was obtained using this questionnaire.

**Anxiety**

*State-Trait Anxiety Inventory*

The state (STAI-S) version of the State-Trait Anxiety Inventory was used to assess state anxiety (Spielberger, et al., 1970; see Appendix B). The STAI is comprised of 20 statements related to anxiety such as “I feel nervous and restless”. Each statement is rated on a scale ranging from 1 (seldom/never) to 4 (very often). The STAI-S version asks participants to rate how they currently feel.

Factor analysis of the STAI indicates the presence of two subscales, anxiety-present and anxiety-absent (Spielberger, et al., 1970). Anxiety-absent items are reversed-scored, meaning that lower scores reflect less anxiety, and a total anxiety score is obtained by adding the total scores from both subscales. Cronbach’s alphas exceeding .90 were found in several college samples (Spielberger, 1983).

The STAI-S was completed two times by each participant. The first occurred after the instructions were read to the participant (pre STAI-S). The second (post STAI-S) was administered after participants had completed all of the tasks and served as an indicator of instruction condition efficiency in elevating anxiety for the entire duration of cognitive testing.

*Revised Test Anxiety Scale (RTA)*

The RTA is an 18-item self-report inventory designed to measure trait test anxiety (Benson, Moulin-Julian, Schwarzer, Seipp, & El-Zahhar, 1992; See Appendix C). The RTA is a combination of items from the Test Anxiety Inventory (Spielberger, 1980) and the Reactions to
Tests Inventory (Sarason, 1984). Items are rated on a four-point Likert scale based on the degree to which the statement describes them (1 = almost never; 2= sometimes; 3= often; 4= almost always). High reliability (Cronbach’s alpha = .88) and a stable four-factor structure has been established for the RTA (Benson et al., 1992). The four subscales are: tension, worry, bodily symptoms, and test-irrelevant thinking.

The tension factor contains five items that assess feelings of muscle tension (e.g., “I get a headache during an important test”). The worry factor contains six items that assess the presence of worrying thoughts (e.g., “During tests I find myself thinking about the consequences of failing”). The bodily symptoms factor contains five items that assess physiological aspects of anxiety (e.g., “I sometimes find myself trembling before or during tests”). Finally, test-irrelevant thinking consists of four items that measure the frequency and intensity of thoughts that are unrelated to the task (e.g., “I think about current events during a test”).

The RTA was completed twice by each participant during this experiment. The first time (pre-RTA) occurred after participants received the task instructions. Items were re-worded in a manner such that participants could predict how their current state of evaluation anxiety would affect them on the tests. Participants also completed this measure immediately following the completion of the tests (post-RTA). Items were worded in the past tense so participants could report on the degree of evaluation anxiety that they experienced. The measure was completed a second time to determine if the instruction condition was effective in elevating evaluation anxiety for the entire duration of cognitive testing. Individual scale subscores were calculated used as measures of evaluation anxiety.

**Attentional Control**

*Attentional Control Scale*
The ACS was used to evaluate the degree of control that the individual perceives he or she has over their attention (Derryberry & Reed, 2002; see Appendix D). This measure consists of twenty statements (e.g., “When I try to concentrate, I find it difficult not to think about other things”) are rated on a 1 (almost never) to 5 (always).

The ACS is a combination of two previously developed scales, the Attentional Focusing scale and the Attentional Shifting scale. These were originally developed on a sample of 231 undergraduate students, thirty of whom completed the measure again two weeks later. A Cronbach’s alpha and test-retest reliability exceeding .80 were found for the Attentional Focusing scale while the Attentional Shifting Scale produced Cronbach’s alpha of .65 and test-retest reliability of .84. Items on each of the original scales were found to load onto a single factor.

The ACS demonstrates construct validity. It has been found to correlate with extraversion ($r = .40$), neuroticism ($r = -.39$), and fear of negative evaluation ($r = -.53$; Derryberry & Reed, 2002). Moreover, the ACS scores are correlated with trait anxiety ($r = -.42$; Derryberry & Reed, 2002). An even more robust association of $r = -.55$ was found in an unpublished study (Derryberry & Reed, unpublished data). The ACS was administered prior to participants receiving task instructions.

*Cognitive Failures Questionnaire*

In addition to the ACS, the Cognitive Failures Questionnaire (CFQ) will also be used to evaluate attentional control (see Appendix E). The CFQ was designed as a self-report measure of cognitive failures in perception, memory, and motor function (Broadbent et al., 1982). Cognitive failures are defined as cognitive mistakes on relatively simple tasks that a person normally should be able to complete without error (Martin, 1983). The scale consists of 25 statements
(e.g., “Do you find that you forget appointments?”) and asks participants to respond on a 0 (never) to 4 (very often) scale.

The scale consists of 25 questions that ask participants to rate the frequency of common cognitive slips on a one to four scale. Several samples totaling 905 participants were used originally to develop the instrument including undergraduate samples from two universities, laundry workers, student nurses, managers, car factory workers, and skilled workers. Moderate to large correlations were demonstrated with other measures of cognitive slips of action, absentmindedness, and forgetting scales in the original normative samples. A correlation of .31 was noted between the CFQ and the STAI. Encouraging test-retest reliabilities (all $r$’s $< .80$ and all $\tau$’s $< .55$) for the original normative sample.

Subsequent psychometric studies of the CFQ have established good internal consistency (Cronbach’s alpha = .91) and re-affirmed strong test-retest reliability ($r = .82$; Vom Hofe, Mainemarre, & Vannier, 1998). Additionally, the CFQ has been found to correlate with the CIQ ($r = .34$; Yates, Hannell, & Lippett, 1985).

Broadbent and colleagues contended that the CFQ consisted of a single factor. However, several researchers have found contrary evidence, though the results of the factor analyses in the different studies varied widely (Larson Alderton, Neideffer, & Underhill, 1997; Matthews, Coyle, & Craig, 1990; Pollina, Greene, Tunick, & Puckett, 1992; Wallace, Kass, & Stanny, 2002). Of these studies, one is clearly more methodologically rigorous (Wallace et al., 2002). An exploratory factor analysis was conducted in a sample of 335 individuals (223 undergraduate students, 112 United States Navy Personnel). Four factors were identified accounting for 54% of the variance. The factors were named Memory (8 items; Cronbach’s alpha = .86), Distractibility (9 items; Cronbach’s alpha = .84), Blunders (7 items; Cronbach’s alpha = .82), and Names (2
items; Cronbach’s alpha = .76). Items that loaded onto the Memory scale pertain to memory and forgetfulness. Distractibility items relate to an inability to keep attention focused on a task. Items associated with both social and motor mistakes loaded onto the Blunder scale. The Names scale included items specifically related to forgetfulness in remembering names of individuals. The CFQ was administered prior to participants receiving task instructions.

**Cognitive Interference Questionnaire**

Cognitive interference was measured using the Cognitive Interference Questionnaire (CIQ; see Appendix F). The CIQ was developed to assess the frequency of self-statements that an individual experiences during a task (Sarason & Stroops, 1978). Researchers have identified two factors on the CIQ (Sarason et al., 1988). Ten items evaluate the frequency of task-relevant thoughts (CIQ-TR) and 12 items measure the frequency of task-irrelevant thoughts (CIQ-TI). The first 21 items are rated on a 1 (never) to 5 (very often) scale while the final item asks participants to rate the degree to which their mind wandered during the task on a 1 (not at all) to 7 (very much) scale.

The CIQ was originally designed to measure negative self-statements about the task at hand (Sarason, 1978). Sarason (1984) later created the Reactions to Tests scale, which consisted of four subscales. One subscale, the Task-Irrelevant Thinking subscale, measured the frequency of negative off-task thinking. This subscale was later added to the CIQ to form the current 22-item scale.

Internal consistency for the overall score was found to be adequate in a sample of 96 college students (Cronbach’s alpha = .71), and test-retest reliabilities ranged from $r = .66$ to $.70$ in a sample that completed the measure with a one month interval (Hunsley, 1987). Convergent validity for the scale has been documented with associations between trait anxiety ($r = .46$;
Hunsley, 1987), CFQ scores \( r = .36 \); Yates et al., 1985), worry \( r = .51 \), tension \( r = .28 \), and physiological reactions to anxiety \( r = .24 \); Sarason, 1984). The CIQ also demonstrates moderate to high correlations with other measures of test anxiety (Coy et al., 2010; Kurosawa & Harackiewicz, 1994). The CIQ was administered after participants had completed all cognitive tasks.

### Cognitive Tasks

#### Central Executive Tasks

**Inhibition**

A computerized version of the Stroop Color Word Test was used to evaluate the inhibition function of central executive component of working memory. This task consists of participants naming the color of text in which words are printed. The words are color names, but no color names are printed in their own color. For instance, the word ‘red’ will be presented in blue text. A correct response in this case would be blue.

A practice block of 10 trials was presented, and participants were instructed to respond as quickly as possible without making a mistake. Feedback consisting of whether or not the response was correct and the reaction time was provided to participants during this practice phase. At least 80% of the responses needed to be correct for participants to proceed to the experimental trial. If this cutoff was not obtained, the practice block was re-administered.

The experimental block consisted of the presentation of the name of one of three colors (red, blue, and green) that are presented in incongruent text color. Prior to the presentation of the word, a black plus sign appeared on the screen for 500 ms to cue participants to the upcoming presentation of the stimulus. The stimulus appeared on the screen for 3 seconds after which the participant responded on a keyboard. The response keys on the keyboard were labeled with the
corresponding response colors. The experimental block consisted of 192 trials. Each stimulus word was presented in each of the other two colors 32 times. For instance, the word red appeared in blue text 32 times and in green text 32 times for a total of 64 presentations of the word red. The same process occurred for the words green and blue. The software presented stimuli in a random order.

E-Prime software and a Dell GX 260 computer were used to administer this task. The software recorded reaction time to a thousandth of a second, and this was used as a measure of inhibition efficiency. The overall number of errors served as a measure of inhibition effectiveness.

Test-retest reliability of the original Stroop Color Word Test after a mean of approximately 60 days was high ($r = .90$; Trenerry et al., 1988). The Stroop was validated in samples of clinically brain-damaged and healthy normals. Strong correlations have been found between the Stroop and other indices of impaired functioning (WAIS-R Full Scale IQ, Verbal IQ, Performance IQ, Block Design, and Vocabulary scores; Trennerry, Crosson, DeBoe, & Leber, 1988). Additionally Miyake and associates (2000) performed a confirmatory factor analysis of several measures of cognitive functioning. The Stroop was found to load onto an inhibition factor with other cognitive tasks that were also predicted to measure inhibition (e.g., antisaccade task, stop-signal task) in the best-fitting model.

**Shifting**

A computerized version of the Wisconsin Card Sorting Test (WCST; Heaton, 1981) was used to evaluate the shifting function. The computerized version was presented using Psychology Experiment Building Language software. This task required participants to match cards from two decks of response cards to one of four stimulus cards. Cards can be sorted based on color, form,
or number of shapes on the card. The program provides initial instructions and then provides participants with “correct” or “wrong” as feedback following a response. Initially, cards are sorted based on color. Following ten correct categorizations, the program changes the categorization criterion to form without informing the participant. After 10 correct classifications, the criterion is changed to number. The process is repeated so that the criterion is changed from form to color to number to form after 10 correct responses are provided. Time to complete the task was used as a measure of processing efficiency and the number of perseverative responses was used as a measure of processing effectiveness.

The WCST was normed on samples of patients with frontal lobe brain damage and healthy controls. WCST scores are correlated with Full Scale IQ scores. Perseveration scores are reliable predictors of frontal lobe cognitive impairment (Heaton, 1981). Consecutive administrations of alternative forms in a normal population resulted in low reliability ($r = .60$), but this is understandable considering that fewer errors should be made once the proper shifting strategy is identified (Bowden et al., 1998). Miyake and colleagues (2000) found that the WCST loads with other tasks (e.g., plus-minus task, number-letter task, local-global task) on a shifting factor.

**Updating**

A computerized version of the Operation Span Task (OST; Unsworth, Heitz, Schrock, & Engle, 2005) based on the original task proposed by Turner & Engle (1989) was used to measure the updating function. The OST required participants to solve simple mental math problems on a computer. After completing each problem, a single stimulus letter will be presented to participants on a separate screen. If the math problem was not solved within four seconds, the computer automatically moved on and presented a letter, and a time error was recorded. This
functioned to prevent participants from rehearsing the stimulus letters during the math task. At the end of a set, the computer signaled participants to recall all of the stimulus words since the last time that they received a signal. This process consisted of presentation of a screen with a 4 x 3 matrix of letter choices with response boxes located to the left of each word choice. Participants were instructed to respond by clicking the response box that corresponded with the order of the letter presentations. Participants were instructed to leave response boxes blank next to letters that were not presented.

A practice block of three trials of set size two was first presented to familiarize participants with the program. After, five trials of each set size ranging from three to seven were presented in random order. The set length will vary automatically so that participants cannot anticipate the number of problem-word sets for any given trial.

E-Prime software was used for this task. The number of speed errors served as a measure of processing efficiency. If a participant did not complete a set correctly, all of the letters in that set were summed and counted as erroneous. The total number of letters missed was used as the measure of effectiveness. A correlation of .71 was found between performance on the automated version of OST and the original, manually administered version of the task. Additionally, a test-retest coefficient of $r = .83$ was found in a sample of 78 military recruits with a 13 day lag between testing (Unsworth et al., 2005). Cronbach’s alpha of .78 was found in the same sample.

A meta-analysis of OST and reading span tasks, a similar cognitive task, indicates a test-weighted mean retest reliability of $r = .8$ (Daneman & Merikle, 1996). Poor OST or reading span performances are associated with low performance on tasks that require the maintenance of a memory load while performing linguistic tasks (Just & Carpenter, 1992) and tests of sustained attention (Conway & Engle, 1994; Turner & Engle, 1989). Operation span was found to load
onto a factor with other cognitive tasks theoretically linked to the updating function (Miyake et al., 2000).

_Phonological Loop Tasks_

**Digit Span**

A computerized version of the Digit Span subtest from the Wechsler Adult Intelligence Scale–Third Edition (The Psychological Corporation, 1997) was used to assess phonological loop functioning. E-Prime software was used to present this task. The Digit Span test consists of two subcomponents, Digit Span Forward (DSF) and Digit Span Backward (DSB). DSF administration consisted of a computerized voice reading digits at one-second intervals. When signaled, participants then typed the digits on a keyboard in order. The number of digits starts at four and increases to eight. Three trials were administered for each digit length, meaning that a total of 15 trials were presented to participants. DSB administration differed from DSF in that participants are required to recall the numbers in the reverse order of which they presented. A practice block consisting of two four-digit sets was presented to participants prior to the DSF test to familiarize them with the task. After completion of DSF, two four-digit sets of DSB were administered for practice.

DSF and DSB were used as an indicator of efficiency. Participants were also timed to determine how long it takes to generate responses, and this was used as a measure of effectiveness.

Average test-retest reliability for the Digit Span is $r = .90$ across several normative samples (The Psychological Corporation, 1997). Digit Span loads onto a working memory index with arithmetic and letter-number sequencing, and has been found to correlate well ($r = .48$) with the Short-Term Memory index of the Stanford-Binet Intelligence Scale–Fourth Edition. Digit
Span is also well correlated with the Mental Control Scale from the Wechsler Memory Scale—3rd Edition, the Serial Digit Task, the Speech Perception Test, the Seashore Rhythm Test, and the Knox Cube Test (Bornstein, 1983; Larrabee & Curtiss, 1995). Additionally, a convergent validity coefficient of .69 was found between a computerized version of the digit span task and normal administration (Tractenberg & Freas, 2007).

**Visuospatial Sketchpad Task**

**N-Back Task**

A computerized visual n-back task (Shackman et al., 2006) was used to assess visual working memory. This task required participants to view a computer screen with several groups of one of six letters clustered together for 500 ms. A box encompassed a group of one type of letter. Participants then responded yes or no when asked if the location of the box was in the same location as the stimulus presented three trials earlier. Thus, the location of the box must be maintained in visual working memory. Additionally, asymmetric, non-cardinal locations were used to preclude the use of verbal strategies. Match and non-match trials occurred equally as often and no feedback was provided to participants in terms of answer correctness. Four non-recorded practice trials were presented to participants in order to familiarize participants with the task.

Hockey and Geffen (2004) evaluated the psychometric qualities of this task using a sample of 85 undergraduate students. Test-re-test reliabilities (separated by a week) of $r = .73$ and $r = .81$ were reported for the accuracy and reaction time measures of this task, respectively. Additionally, reaction time scores ($r = -.27$) and accuracy scores ($r = .26$) were found to correlate with the performance subscale from the Multidimensional Aptitude Battery. Accuracy scores
were not significantly related to the verbal subscale, suggesting that this task does not tap verbal working memory.

E-Prime software was used to administer this task. The software recorded reaction time to a thousandth of a second, and this was used as a measure of efficiency. The overall number of errors served as a measure of effectiveness.

Instruction Conditions

The instructions that were used were developed and used in a previous study (Coy et al., 2010; see Appendix G). A sample of undergraduate students identified aspects of a testing situation associated with feelings anxiety or support. The anxiety inducing instructions included elements of: close observation and scrutiny by the experimenter, being informed that the cognitive tasks were predictive of intelligence and future success, being warned of the difficulty of the tasks, being timed, and being informed that performance would be compared to that of other individuals. The supportive instructions informed participants that the purpose of the present study was to determine if the tasks were suitable for a future study. They were informed that performance did not matter, not to worry about their performance, and to remain relaxed while performing the tasks. Two raters classified the responses into categories. Two other raters calculated response frequencies. Interrater reliabilities were .93 for the anxiety condition and .92 for the supportive instructions.

The study used the RTA and heart rate to test if the experimental manipulations were effective. Participants completed the Revised Test Anxiety Scale twice, once after receiving instructions and again after completing the tasks. Statistical tests indicate that instruction condition predicted both pre- and post-test test anxiety. Additionally, instruction condition was found to be a predictor of CIQ scores.
Procedure

Upon arrival to the lab, each participant received the informed consent form and a brief explanation of the procedures of the study. Participants then completed the Demographic Questionnaire, the ACS, and the CFQ.

Randomization procedures were followed to determine instruction condition. Instructions were then given, and the participant completed the pre-STAI-S and pre-RTA questionnaires. Cognitive tasks were then administered on the computer in random order. Administration directions were manualized to ensure standardized administration. Shortened versions of the anxiety or supportive instructions were given to participants prior to the second, third, fourth, and fifth cognitive tasks.

After the completion of the last cognitive task, participants were asked to complete the post-STAI-S, the post-RTA and the CIQ. Participants were then fully debriefed to the nature of the study.

Data Reduction and Analyses

Missing data on self-report questionnaires were replaced with the mean score of the items that a participant did endorse. This procedure was used only if the participant had completed at least 80% of the items on the questionnaire. This procedure had to be used for less than 5% of all responses. Due to computer malfunctions, some participants were unable to complete every task. A total of 18 (3.1%) individual cognitive tasks were not collected. To preserve analytic power without compromising the integrity of the analyses, data were replaced with the grand mean, as opposed to the group mean, of the particular task that was missing.

All analyses were conducted on PSAW Statistical Software version 18 or Amos version 18. Mean item scores, standard deviations, internal consistency and normality for all questionnaires
and cognitive test results were calculated. The method of analysis differed depending upon the hypothesis being tested and each is described in detail in the following section.
CHAPTER IV: RESULTS

Comparisons of Pre-Experimental Variables

The first analyses evaluated potential demographic differences between participants assigned to the anxiety condition and supportive condition (see Table 2). Chi square analyses were used to compare group differences in categorical variables and t-tests were used to compare continuous variables. No significant differences were observed on gender, ethnicity, year in college, age, or high school grade point average.

Next, between-group differences on the self-report questionnaires completed before the experimental manipulation were evaluated. As Table 3 illustrates, no significant differences were observed between groups on the ACS and on three of the four CFQ subscales. However, on the distractibility subscale, a significant group difference was observed such that individuals in the anxiety condition rated themselves as being more easily distracted ($t(95) = 2.55, p = .01$).

Test of Hypotheses

Hypothesis 1

It was predicted that those receiving anxiety-inducing instructions would report significantly higher levels of state and evaluation anxiety. This hypothesis serves as a manipulation check to determine if the anxiety-inducing manipulation was successful. To accomplish this, a 2 (condition) x 2 (time: pre/post) repeated measures MANOVA was conducted. State anxiety and the four Revised Test Anxiety subscale scores were entered as dependent variables. Significant effects were found for condition (Hotelling’s Trace = .15; $F(5,91) = 2.73; p < .025$), time (Hotelling’s Trace = .36; $F(5,91) = 6.59; p < .001$), and the condition by time interaction term (Hotelling’s Trace = .16; $F(5,91) = 2.93; p < .025$). Independent samples t-tests were conducted as follow-up analyses on pre and post STAI-S and
RTA subscales to test the effect of condition immediately after instructions and after testing was concluded (see Table 4). Pre-STAI-S scores differed significantly by group \((t(95) = 2.26, p < .01)\) with those in the anxiety instruction condition reporting higher levels of state anxiety. The pretest tension \((t(95) = 2.30, p < .025)\) and worry \((t(95) = 3.90, p < .001)\) subscales of the RTA were also significantly different between groups while the bodily sensations and the irrelevant thoughts subscales were not. Again, the means of those scales indicate that those anxiety condition experienced greater levels evaluation anxiety. Identical follow-up analyses were conducted with the post-STAI-S scores and the post-RTA subscales. Post-STAI-S scores did not significantly differ by condition. Interestingly and unexpectedly, a condition by anxiety interaction effect was found such that post-STAI-S scores dropped from pre-STAI-S scores in the anxiety instruction condition \((\text{pre-STAI-S } M = 43.59, SD = 5.46; \text{post-STAI-S } M = 41.33, SD = 6.44; t(45) = 2.56, p < .025)\), while it significantly increased in the non-anxiety condition \((\text{pre-STAI-S } M = 39.88, SD = 8.06; \text{post-STAI-S } M = 44.22, SD = 6.09; t(50) = -3.53; p < .001)\). The tension \((t(95) = 2.41, p < .025)\) and worry \((t(95) = 2.15, p < .05)\) subscales of the RTA remained significant. Again, the pattern of means illustrates that those in the anxiety condition generally experienced greater levels of evaluation anxiety.

To summarize, these analyses indicate that the manipulation was effective in generating greater levels of state anxiety and evaluation anxiety immediately following the manipulation. Moreover, the manipulation was powerful enough to maintain elevated levels of aspects of evaluation anxiety across the duration of the experiment. An unexpected interaction effect was discovered such that those in the anxiety condition started with elevated levels of state anxiety, which decreased by the completion of the experimental tasks. Those in the non-anxiety condition
initially had lower levels of state anxiety which then increased by the end of the experiment. Thus, Hypothesis 1 was partially supported.

**Hypothesis 2**

It was hypothesized that participants who received anxiety inducing instructions, relative to supportive instructions, would perform worse on the phonological loop tasks and the central executive tasks, but not the visuospatial sketchpad, tasks. To test this hypothesis, MANOVA models were conducted for phonological loop and central executive tasks in which task performance was entered as the dependent variable and condition as the independent variable. To avoid excessively restrictive post hoc alpha levels, the multivariate models were considered significant at the .10 level. If the multivariate tests were significant, follow-up univariate comparisons were then conducted. Bonferroni adjustments were used on univariate analyses to control for joint alpha. Because only one measure of visuospatial sketchpad performance was used, a one-way ANOVA was used to test the effect of condition on visuospatial performance. As this hypothesis is focused on testing the proposed CIT model, only measures of effectiveness were used in these analyses.

For the phonological loop tasks, the multivariate model was found to be significant (Hotelling’s Trace = .06; F(2,94) = 2.89; \( p < .10 \)). Two follow-up univariate comparisons were conducted, the first used DSF data and the other used DSB data. With the Bonferroni correction, univariate comparisons with alphas less than .05 were considered significant. Condition was a significant predictor of both DSF performance (F(1,95) = 4.39; \( p < .05 \)) and DSB performance (F(1,95) = 4.02; \( p < .05 \)). In both cases participants in the anxiety condition performed significantly less well than participants in the non-anxiety condition.
The multivariate model that tested central executive performance was significant (Hotelling’s Trace = .11; F(3,93) = 3.36; \( p < .05 \)). Three follow-up univariate comparisons were conducted on the individual central executive tasks, which resulted in a corrected alpha level of .033. These comparisons indicated a significant effect for condition on WCST performance (F(1,95) = 4.72; \( p < .033 \)). The effect approached significance on Stroop performance (F(1,95) = 4.46; \( p < .04 \)), while no effect was found for OST performance (F(1,95) = .81; NS). Again, those in the anxiety condition performed more poorly than those in the non-anxiety condition on all three central executive tasks.

Finally, the effect of condition on visuospatial sketchpad performance was assessed using a one-way ANOVA. These results indicate that condition was not a significant predictor of performance on visuospatial sketchpad tasks (F(1,95) = .04; NS). On this task those in the anxiety condition averaged slightly fewer errors than those in the non-anxiety condition. See Table 5 for descriptive data on task performance by condition.

Summarizing the above results, significant group differences were demonstrated on DSF, DSB, and WCST. The effect of condition on Stroop performance approached significance. Groups did not differ significantly on their performance on the OST, however data indicate that those receiving supportive instructions averaged approximately three more sets correct than those in the anxiety condition. No group differences were found on the N-back test. These results support Hypothesis 2.

**Hypothesis 3**

It was hypothesized that participants who received anxiety inducing instructions, relative to supportive instructions, would report higher levels of negative self-statements on a measure of cognitive interference. A MANOVA was conducted in which Cognitive Interference
Questionnaire-Task Irrelevant and Cognitive Interference Questionnaire-Task Relevant scores were entered as dependent variables. The multivariate model was found to be significant (Hotelling’s Trace = .09; F(2,94) = 4.03; p < .05). Univariate analyses revealed no group differences CIQ-TI subscores (F(1,95) = 1.54; NS). However, CIQ-TR scores, which is the better indicator of overall negative self-statements, was related to experimental condition (F(1,95) = 5.19; p < .025); see Table 6). In sum, these analyses indicate that the anxiety induction increased a particular form of cognitive interference; CIQ-TR subscores.

Hypothesis 4

It was hypothesized that evaluation anxiety would be positively associated with negative self-statements on a measure of cognitive interference. To test this hypothesis, two linear regressions were conducted in which the CIQ-TI and CIQ-TR subscale scores were entered as dependent variables. The four RTA subscale scores were the used as independent variables.

The first regression, in which the CIQ-TI subscale was entered as the dependent variable, was significant (F(4,92) = 10.46, p < .05). An examination of individual beta weights, which are listed in Table 7, revealed that worry (beta = .50, t(95) = 3.34, p < .01) and irrelevant thoughts (beta = .18, t(95) = 2.06, p < .01) were predictors of the CIQ-TI.

The second regression, in which the CIQ-TR subscale was entered as the dependent variable, was significant (F(4,92) = 3.61, p < .01). Of the RTA subscales, only the irrelevant thoughts subscale was a significant predictor (beta = .37, t(95) = 3.71, p < .01).

In summary, both regression analyses indicated that aspects of evaluation anxiety, particularly the propensity to experience task-irrelevant thoughts, are a predictor of both CIQ subscales.

Hypothesis 5
It was hypothesized that cognitive interference would partially mediate the relationship between evaluation anxiety and central executive performance and phonological loop performance, but not visuospatial sketchpad performance. To test this hypothesis, meditational analyses were conducted using structural equation modeling.

The mediation criteria described by Baron and Kenny (1986) were used to evaluate the degree of mediation. A variable \( M \) is said to mediate the relationship between variables \( X \) and \( Y \) when 1) \( X \) is a significant predictor of \( Y \), 2) \( X \) is a significant predictor of \( M \), 3) \( M \) is a significant predictor of \( Y \) after controlling for the effects of \( X \), and 4) \( X \) no longer significantly predicts \( Y \) when the effects of \( M \) are controlled for.

Bootstrapping techniques suggested by Shrout and Bolger (2002) were used to evaluate the mediation effects of cognitive interference. Bootstrapping techniques are appropriate as they can add predictive validity to small to medium sized samples. The analyses below employed maximum likelihood estimation. As suggested by Shrout and Bolger (2002), 1,000 bootstrap estimations were conducted and confidence intervals were obtained. Both percentile and bias corrected confidence intervals were calculated. Confidence intervals that do not encompass zero are considered significant.

For all models, the initial step entailed entering condition as a predictor of a latent performance variable. This variable was termed "phonological loop performance" and was comprised of the observed variables DSF and DSB for the phonological loop model. The latent variable "central executive performance" was created with the observed variables WCST, OST, and Stroop. The a priori analysis plan called for a latent variable termed “cognitive interference” to be formed by the observed CIQ-TI and CIQ-TR subscales. However, when this model was entered, it was unable to be specified due to a negative error covariance associated with one of
the CIQ subscales. As such, the latent variable of cognitive interference was dropped. Based on results from tests of Hypothesis 3 in which condition demonstrated an effect on CIQ-TR scores, that observed variable was entered as a mediating variable. Thus, condition was simultaneously set to predict CIQ-TR. Finally, CIQ-TR scores were entered to predict performance. Mahalanobis d-squared was used to identify possible outliers. One outlier was identified and removed from the mediation analyses presented below.

Results from the mediation analyses are presented in Table 8. Figures 2-4 depict the mediated models for phonological loop performance, central executive performance, and visuospatial sketchpad performance.

For the phonological loop model, DSF and DSB scores were combined to form a latent variable named “Phonological Loop Performance.” The CIQ-TR subscale was entered as the mediating factor. Data suggest that the CIQ-TR subscale was not a mediator of the condition/phonological loop performance relationship. As can be seen from Table 8, path $c$ (condition predicting performance) was significant, as is path $a$ (condition predicting CIQ-TR). None of the estimation techniques suggested a significant effect for path $b$ (CIQ-TR predicting performance). In addition, the bootstrap percentile estimation technique indicated that path $c'$ (condition predicting performance when the effect of CIQ-TR scores is controlled for) retained significance while the bias corrected estimation technique suggested that it is approached significance. The indirect effect of task relevant thoughts was not significant using either estimation method. An effects ratio was calculated by dividing the indirect effect by the total effect $(a \times b)/c$ to determine the degree to which task relevant thoughts mediate this relationship. An effect ratio of .039 was identified suggesting that CIQ-TR scores mediate approximately 3.9% of this relationship. Taken together, there is little evidence to suggest that the effects of
condition on performance are mediated by CIQ-TR scores. This portion of Hypothesis 5 was not supported.

A similar model was entered for central executive tasks. The CIQ-TR subscale was used as the mediating factor. A latent variable called “Central Executive Functioning” was created with three observed variables: WCST, OST, and Stroop performance.

Data suggested that the CIQ-TR subscale is a partial mediator of the condition/central executive performance relationship. As can be seen from Table 8, path c (condition predicting performance) was significant, as was path a (condition predicting CIQ-TR). The standard estimation method technique yielded a significant effect for path b (CIQ-TR predicting performance). However, this path was not significant using the bootstrap percentile method and approached significance using the bias corrected estimation technique (p = .076). All estimation methods indicated that path c’ lost significance at the p = .05 level when the effect of CIQ-TR scores was controlled for. The indirect effect of CIQ-TR was not significant using the bootstrap percentile method, but approached significance (p = .054) when using the bias corrected estimation method. An effects ratio was calculated to determine the degree to which task relevant thoughts mediated this relationship. An effect ratio of .227 was identified suggesting that CIQ-TR scores mediated approximately 22.7% of this relationship. There is some evidence to support the claim that the relationship between condition and central executive performance is mediated by CIQ-TR scores.

Finally, a path analysis model was created in which performance on the N-back task represented visuospatial sketchpad functioning. Because only one measure of visuospatial sketchpad performance was used in this model, it was unnecessary to create a latent variable for this model. Analyses revealed that this model only met two mediation criteria, and that CIQ-TR
scores did not mediate the condition/visuospatial sketchpad performance relationship. Examining the data more closely, path $a$ (condition predicting CIQ-TR scores) was significant. However, path $c$ (condition predicting performance) and path $b$ (CIQ-TR scores predicting performance) were both not significant. Path $c'$ (condition predicting performance when the effect of CIQ-TR is controlled for) was not significant, which is a mediation criterion. However, this was likely to occur as path $c$ was not significant. The indirect effect of task relevant thoughts was not significant, regardless of the estimation technique used. This portion of Hypothesis 5 was supported as no evidence was found to support the claim that CIQ-TR scores served as a mediator of the relationship between condition and visuospatial sketchpad functioning.

In terms of model fit, standardized root mean residual, root mean square error of approximation, and comparative fit index are reported on Table 9. Cutoffs of .08 for standardized root mean residual, .06 for root mean square error of approximation, and .95 for comparative fit index have been proposed (Hu & Bentler, 1999). Despite well documented problems with the chi square statistic as an indicator of goodness-of-fit (Brown, 2006), it is reported for interpretative purposes. Some fit statistics were not calculated for the visuospatial sketchpad model because both the number of sample moments and the number parameters to be estimated equaled six, which results in zero degrees of freedom. The mediated models appear to fit the data very well, as they meet all recommended cutoffs.

To summarize, condition caused an increase in task-relevant thoughts, not in overall cognitive interference scores. Task-relevant thoughts did not meet the criteria suggesting that they mediated the relationship between condition and performance for phonological loop tasks. Marginal support was found suggesting that task relevant thoughts mediated the effect of condition on central executive performance. Finally, analyses yielded strong support suggesting that task relevant thoughts do not mediate the
relationship between condition and visuospatial sketchpad performance. Overall, partial support was found for Hypothesis 5.

**Hypothesis 6**

It was hypothesized that attentional control would be associated with performance on certain central executive tasks. In particular, inhibition and shifting, but not updating tasks were predicted to be negatively affected by lower levels of attentional control. To test this hypothesis, a series of univariate regression analyses were conducted in which condition was entered in the first block as a control variable and Attentional Control Scale and Cognitive Failures Questionnaire subscale scores were entered in the second block as predictors. Central executive efficiency (e.g., timed performance) and effectiveness measures (e.g., number of errors made) were entered as dependent variables. Results are displayed in Table 10.

Two regression models were used testing WCST data. The first examined effectiveness, using WCST errors as the dependent variable. After controlling for condition, the overall model was not significant (F(6,90) = 1.05, NS). A similar analysis was conducted using reaction time as a predictor. The overall model controlling for condition was found to be marginally significant (F(6,90) = 1.82, NS). However, neither CFQ nor ACS scores were found to have significant effects. Performance on the Stroop task was also examined using similar analyses. The overall model for efficiency was significant (F(6,90) = 2.51, p < .05). The distractibility subscale of the CFQ was found to have a significant effect (beta = -.30, t(96) = -1.96, p < .05) while the effects of the total ACS score (beta = -.17, t(96) = 1.73, p < .10) and the blunders subscale (beta = .27, t(95) = 1.90, p < .10) were found to be marginally significant. The overall model of Stroop efficiency was not significant (F(6,90) = 1.43, NS), however, the CFQ distractibility subscale demonstrated a marginally significant effect (beta = .27, t(96) = 1.67, p < .10). Finally, these analyses were conducted first using OST effectiveness as the outcome variable followed by OST
efficiency. Neither the model using OST effectiveness \(F(6,90) = 1.04, \text{NS}\) nor the model testing OST efficiency \(F(6,90) = .24, p \text{NS}\).

In summary, little evidence was found to support Hypothesis 6. Data indicated that the CFQ distractibility and blunders subscales as well as the total ACS score have some predictive power on errors made on the Stoop task. In addition, the CFQ distractibility score also appeared to have a marginal impact on Stroop reaction time. However, measures of attentional control did not exert an effect on WCST efficiency or effectiveness. Attentional control was unrelated to measures of both OST effectiveness and performance.

**Hypothesis 7**

It was predicted that anxiety would be negatively associated with efficiency and effectiveness on inhibition and shifting tasks, but not updating tasks. Nearly identical analyses to those conducted to test Hypothesis 6 were executed to examine Hypothesis 7. In these analyses, however, the total pre-STAI-S scores and pre-RTA subscale scores were used as predictors. See Table 11 for detailed results.

Neither the model that assessed the effect of anxiety on WSCT effectiveness \(F(6,90) = 1.52, \text{NS}\) nor efficiency were significant \(F(6,90) = 1.58, \text{NS}\). Similarly, neither the Stroop effectiveness \(F(6,90) = 1.21, \text{NS}\) nor the Stroop efficiency \(F(6,90) = 1.64, \text{NS}\) demonstrated significant relationships with anxiety. Finally, analysis of OST effectiveness \(F(6,90) = .78, \text{NS}\) and efficiency \(F(6,90) = 1.21, \text{NS}\) were not significant. However, the RTA Bodily Symptoms subscale was found to be significantly related to OST efficiency (beta = -.23, \(t(96) = 2.13, p < .05\)).

In summary, Hypothesis 7 was largely unsupported. No evidence was found suggesting that anxiety affected any type of central executive performance once the effects of condition
were controlled. Moreover, there did not seem to be a differential pattern of prediction by task type (i.e., inhibition, switching, updating). Finally, there was no evidence to suggest that task efficiency was negatively impacted more than task effectiveness.
CHAPTER V: DISCUSSION

The purpose of this study was to test hypotheses stemming from two explanatory theories of how anxiety negatively may adversely affect test performance. Hypotheses derived from the first theory, CIT, predicted that anxiety-inducing instructions would elicit greater levels of evaluation anxiety, negative self-statements, and poorer performance on phonological loop and central executive tasks. Moreover, greater levels of evaluation anxiety were predicted to be associated with higher levels of negative self-statements. Finally, cognitive interference was predicted to mediate the relationship between instruction condition and performance on phonological loop and central executive tasks. Hypotheses stemming from ACT were also tested. It was hypothesized that greater levels of attentional control would be associated with better performance on central executive tasks that involved inhibition and shifting. Similarly, it was predicted that higher levels of state anxiety would be negatively associated with performance on these central executive tasks.

Cognitive Interference Theory

Findings from this study supported some CIT hypothesis. First, it was found that the instruction condition was effective in generating higher levels of state anxiety and evaluation anxiety (tension and worry subscales from the RTA) immediately after receiving the task instructions and after all experimental tasks were completed. An unexpected interaction effect was also found such that state anxiety decreased in those in the anxiety condition and increased in those in the non-anxiety condition by the experiment’s end. This finding was unexpected and was the only measure of anxiety (either state or evaluation) that followed this pattern. Thus, this aberrant finding may represent a Type I error. In addition, those in the non-anxiety condition may have grown frustrated, restless, or impatient as the experiment progressed. Informal
debriefing interviews that were conducted suggested that a fair number of participants who received non-anxiety instructions correctly guessed that anxiety was being manipulated by the instructions. By knowing that experimenters actually were interested in their performance, participants may have self-generated higher levels of anxiety as the study progressed.

As predicted by CIT, those in the anxiety condition performed less well on phonological loop tasks than those who received non-anxiety instructions. Data also indicated that those in the non-anxiety condition performed better on all three central executive tasks. However, a significant effect was found only for WCST performance whereas a marginally significant effect was found for Stroop performance. Performance on the visuospatial sketchpad task was nearly identical for both groups. Taken together, these data support CIT and are consistent with previous research (Coy et al., 2010).

That those in the anxiety condition reported greater levels of negative self-statements further supports CIT and replicates findings from previous research (Coy et al., 2010; Ganzer, 1968; Hunsley, 1987; Sarason et al., 1986; Sarason & Stroops, 1978). A notable departure from previous work is that the anxiety condition was associated with only an increase in task-relevant thoughts rather than an increase in both task-relevant and task-irrelevant thoughts. In fact, participants receiving non-anxiety instructions reported greater levels of task-irrelevant thoughts. One possible explanation is that the present study included longer questionnaires and more cognitive tasks than most previous research. As a result, participants’ minds may have wandered to various off-tasks topics, regardless of the instructions received.

Additional support for CIT can be garnered from the finding that specific aspects of evaluation anxiety were associated with increased levels of cognitive interference, particularly task-relevant thinking. This is consistent with previous research (Coy et al., 2010; Ganzer, 1968;
Hunsley, 1987; Sarason et al., 1986; Sarason & Stroops, 1978). This study found that evaluation anxiety caused an increase in a specific type of cognitive interference, task-relevant thinking. Though CIT theorists argue that negative self-statements is the type of cognitive interference that should demonstrate greater increases in the face of evaluation anxiety, other researchers have demonstrated increases in both task-relevant and task-irrelevant thinking following anxiety-inducing instructions (Coy et al., 2010). This study used instructions that were almost identical in nature to Coy’s study, so it is unclear why different patterns in cognitive interference emerged, though it is most likely due to methodological differences (e.g., length of the study, administration of tasks).

Cognitive interference, specifically task-relevant self-statements, was tested as a mediator of the instruction condition/performance relationship for phonological loop, central executive, and visuospatial sketchpad tasks. Cognitive interference was not a mediator in the visuospatial sketchpad model and it was a mediator in the central executive model. Both of these findings are consistent with CIT and generally replicate previous findings (Coy et al., 2010). In fact, the present study provided more compelling evidence that cognitive interference is a mediator in the central executive model. All mediation criteria were met in the present study whereas they were not in previous work (Coy et al., 2010), and this study found a greater effects ratio (22.7% versus 15.2%). One possible explanation for this stronger finding is that the present study may have been more thorough in assessing central executive functioning as three tasks were used rather than the single task used by Coy and associates.

However cognitive interference was not found to be a mediator in the phonological loop model, which is an unexpected finding based on previous results. In a similar analysis, Coy and colleagues (2010) found that cognitive interference met all mediation criteria and mediated
approximately 40% of this relationship, whereas very little of the relationship was mediated in
the present study (3.9%). A major methodological difference between the present study and that
study was that tasks were administered by an experimenter in the Coy study whereas tasks were
computer administered in the present study. At least two possibilities arise from this
methodological difference. First, it could be that the interpersonal administration of tasks
intensified the threat and led to markedly worse performance. However, this explanation is
unlikely given that the central executive model was not influenced in a similar way. A more
plausible explanation is that in administering a digit span task using a computer, participants
entered responses on the keyboard. This difference may have reduced the degree to which this
task tapped phonological loop ability by evoking use of the visuospatial sketchpad in generating
responses. That is, participants may have visually pictured the locations of the keys that they
were going to strike rather than maintaining auditory information in the phonological loop. This
possibility was anticipated, and specific instructions were given with the intent of minimizing the
usage of the visuospatial sketchpad. However, no measure of compliance with these directions
was collected. In fact, giving these instructions may have primed participants to use a more
visually-based response strategy.

In this study, participants receiving the anxiety instructions only reported greater levels of
task-relevant thoughts whereas they reported greater levels of both task-relevant and task-
irrelevant thoughts in previous work. This gives rise to the possibility that an increased
frequency of intrusive thoughts may be essential in mediating the relationship between anxiety
condition and phonological loop performance, but fewer intrusive thoughts are required to
mediate the condition central executive functioning relationship.
To summarize, evidence from this study confirms many findings from previous studies that support CIT. Though not each component of every hypothesis was supported, some support was found for every hypothesis. The finding that was most inconsistent with previous work supporting CIT could be due to methodological differences between studies.

Attentional Control Theory

In general, most hypotheses testing predictions from ACT were not supported. Some evidence was found suggesting that measures of attentional control predicted performance on an inhibition task (Stroop) such that more attentional control was associated with lower effectiveness (a greater number of errors) and less efficiency (longer reaction times) on that task. However, no evidence was found suggesting that these measures were predictive of performance on switching or updating tasks as the ACT model predicts. Similarly, neither state nor evaluation anxiety was found to affect measures of efficiency nor effectiveness on inhibition or switching. Both types of anxiety were not predictive of effectiveness on an updating task, but one evaluation anxiety subscale was predictive of efficiency on an updating task. These results are also inconsistent with another prediction of ACT, which suggests that measures of efficiency are almost always negatively impacted by anxiety, even if measures of effectiveness are not.

These findings are largely inconsistent with numerous other studies reviewed by Eysenck and associates (2007). One possible reason is methodological differences. The majority of the studies reviewed experimentally manipulated external threats. That is, external threat stimuli were manipulated by the type of task selected (e.g., emotional Stroop task that uses threat words). Doing so was outside of the scope of this study. Rather, the goal of the present work was to test the tenets of ACT by attempting to manipulate internal threat stimuli (i.e., the number of
worrisome thoughts) by using anxiety inducing instructions, which few studies have done. Thus, it may be that the predictions of ACT are only applicable to external stimuli.

Similarly, most studies using an ACT framework have focused on trait anxiety whereas the present study attempted to increase levels of state anxiety. Another possible explanation for the disparate findings between this study and previous studies may be that there is a fundamental difference in how state anxiety and trait anxiety interact with attentional systems. In fact, a recent study has suggested that this indeed may be the case (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). This study demonstrated a double dissociation such that higher levels of trait anxiety were linked to poorer functioning of the goal-oriented attentional system whereas state anxiety was unrelated to the functioning of this attentional system. They further demonstrated that state anxiety was associated with an over-activation of the stimulus-driven attentional system whereas trait anxiety did not affect this system. Applying these results to the present study, it may be that the goal-oriented attentional system is able to override increased levels of activation in the stimulus driven attentional control system in individuals with low or moderate levels of trait anxiety.

Another possible explanation accounting for the null findings may be measurement issues. The measures of attentional control that were used have been suggested as good measures of attentional control, but they have not been directly tested in an experimental context. Thus, these measures may be poor indicators of attentional control. In particular, attentional control has been described as a trait-like characteristic in the literature and was measured as such in this study. However, a more precise measure that was tailored to assess attentional control during the administration of the tasks may have yielded more support for ACT hypotheses. Additionally, like many self-report measures of psychological phenomena, humans may lack accurate insight
as to how much control they exert over attentional processes. Acknowledging another possible measurement issue, numerous versions of the cognitive tasks have been used in previous studies ranging from in-person to computer administration. The results presented above could be due to a methodological difference in task administration.

Finally, the findings from this study may have been influenced by the unanticipated pattern of state anxiety during the course of the experiment. Perhaps the predictions of ACT would have been supported if levels of state anxiety were held steady throughout the experiment.

To summarize, the present study found little support for the predictions proffered by ACT theorists. However, the theoretical basis for ACT is strong and has been well-tested. Though the results from this study are inconsistent with predictions made by ACT, the most likely and parsimonious explanation for this is a methodological differences in measurement anxiety and attentional control.

Strengths and Limitations

Several strengths of this study should be noted. First, this study contributes to the CIT literature by attempting to replicate previous findings. The results of this study supported many, but not all, of the premises of CIT. It expanded on previous work by assessing several measures of central executive functioning. The findings that were not supported give rise to future research directions. Second, this study comprehensively tested the predictions that various central executive functions would be differentially affected by anxiety. This represents an important extension of the CIT literature. Moreover, this study is unique in that it that it tested ACT hypotheses by manipulating internal threat stimuli rather than employing external threats.

Though this study provides several contributions to the literature, it is not without limitations. First, the sample size is somewhat low, especially considering that SEM data analytic
techniques generally require larger sample sizes. However, as Efron & Tibshirani (1993) have noted, bootstrapping techniques can be used in small to moderate sized samples. Second, though efforts were made to accurately measure psychological variables, all were assessed using only self-report measures. Adding a different form of assessment (e.g., physiological measures) could strengthen the findings of the study. Third, the protocol used for this study took participants a substantial amount of time to complete. The benefit of this is that performance on several tasks was measured. However, it came at the cost of fatigue entering as a potential confounding variable.

Future Directions

In light of these findings, several avenues should be explored in future research. First, the unique contributions of task-relevant and task-irrelevant thoughts in relation to specific types of cognitive tasks should be explored. For example, do different forms of cognitive interference affect specific aspects of working memory differently, and if so, how?

Second, future research should examine the nature of the effect of cognitive interference on phonological loop functioning in a more comprehensive fashion. Most studies examining this relationship have used only one or two indicators of phonological loop functioning, typically digit span forward and backwards. While both of these tasks are valid indicators of phonological loop functioning, a clearer picture could be obtained if a wider array of tasks were used.

Third, the results of this study are contradictory to a corpus of other studies that support many of the underpinnings of ACT. One of the explanations is that there may be a difference between internal and external anxiety cues. Future research should explore if this is the case. Another explanation offered is the notion that state and trait anxiety may affect attentional systems differently. The results of this study support this idea. A line of research that more
closely examines if state and trait anxiety do differentially affect anxiety systems would be a valuable endeavor. If this is indeed found to be the case, ACT theorists should modify the theory to incorporate these new findings.
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Table 1

*Confirmatory Factor Loadings from Miyake et al. (2000)*

<table>
<thead>
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<th>Task</th>
<th>Factor Loading</th>
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<tbody>
<tr>
<td><strong>Inhibition Tasks</strong></td>
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<tr>
<td>Antisaccade</td>
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<tr>
<td>Stop-Signal</td>
<td>.33</td>
</tr>
<tr>
<td>Stroop</td>
<td>.46</td>
</tr>
<tr>
<td>Tower of Hanoi</td>
<td>.37</td>
</tr>
<tr>
<td><strong>Shifting Tasks</strong></td>
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<tr>
<td>Plus-Minus</td>
<td>.59</td>
</tr>
<tr>
<td>Number-Letter</td>
<td>.57</td>
</tr>
<tr>
<td>Local Global</td>
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</tr>
<tr>
<td>WCST</td>
<td>.37</td>
</tr>
<tr>
<td><strong>Updating Tasks</strong></td>
<td></td>
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<td>Keep Track</td>
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</tr>
<tr>
<td>Tone Monitoring</td>
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<tr>
<td>Letter-Memory</td>
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<td>Operation Span</td>
<td>.61</td>
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<tr>
<td><strong>Factor Intercorrelations</strong></td>
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<tr>
<td>Shifting-Inhibition</td>
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<tr>
<td>Updating-Inhibition</td>
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Table 2

*Frequency Demographic Characteristics of the Sample*

<table>
<thead>
<tr>
<th></th>
<th>Anxiety N/M (SD)</th>
<th>Supportive N/M (SD)</th>
<th>$\chi^2/t$ (df)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Female</td>
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<td>28</td>
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<td>.21</td>
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<td></td>
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<td>3</td>
<td></td>
<td></td>
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<tr>
<td>Mixed Race</td>
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<td>4</td>
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<tr>
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<tr>
<td>Freshman</td>
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<td>24</td>
<td>4.50 (4)</td>
<td>.34</td>
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<td>Sophomore</td>
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<td></td>
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<tr>
<td>Junior</td>
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<td>2</td>
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<tr>
<td>Senior</td>
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<td>9</td>
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<td>5th Year or Higher</td>
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<td>4</td>
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<tr>
<td><strong>HS GPA</strong></td>
<td>3.37 (.47)</td>
<td>3.38 (.39)</td>
<td>.01 (95)</td>
<td>.91</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>21.2 (5.2)</td>
<td>20.7 (4.6)</td>
<td>.23 (95)</td>
<td>.64</td>
</tr>
</tbody>
</table>

*Note.* N = 97; M = Mean; SD = Standard Deviation; HS = High School; GPA = Grade Point Average
Table 3

*ACS & CFQ Means, Standard Deviation, and Comparisons by Condition*

<table>
<thead>
<tr>
<th></th>
<th>Anxiety M (SD)</th>
<th>Supportive N/M (SD)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS</td>
<td>46.96 (6.77)</td>
<td>47.27 (7.84)</td>
<td>-.21</td>
<td>.83</td>
</tr>
<tr>
<td><strong>CFQ Subscale</strong></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Memory</td>
<td>18.28 (4.55)</td>
<td>17.29 (5.58)</td>
<td>.95</td>
<td>.35</td>
</tr>
<tr>
<td>Distractibility</td>
<td>26.96 (4.83)</td>
<td>24.25 (5.54)</td>
<td>2.55</td>
<td>.01*</td>
</tr>
<tr>
<td>Blunders</td>
<td>17.91 (3.91)</td>
<td>16.75 (4.34)</td>
<td>1.39</td>
<td>.17</td>
</tr>
<tr>
<td>Names</td>
<td>6.15 (1.92)</td>
<td>6.20 (2.11)</td>
<td>-.11</td>
<td>.92</td>
</tr>
</tbody>
</table>

*Note.* N = 97; M = Mean; SD = Standard Deviation; ACS = Attentional Control Scale; CFQ = Cognitive Failures Questionnaire; df = 95; * indicates significance at p = .05.
Table 4

*Hypothesis 1 – Analyses of the Effect of the Anxiety Inducing Condition on State and Evaluation Anxiety*

<table>
<thead>
<tr>
<th></th>
<th>Anxiety M (SD)</th>
<th>Supportive M (SD)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-STAI-S</strong></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Tension</td>
<td>9.57 (4.27)</td>
<td>7.86 (2.97)</td>
<td>2.23</td>
<td>.03*</td>
</tr>
<tr>
<td>Worry</td>
<td>12.52 (4.08)</td>
<td>9.53 (3.49)</td>
<td>3.90</td>
<td>.00**</td>
</tr>
<tr>
<td>Bodily Sensations</td>
<td>4.33 (1.30)</td>
<td>4.14 (1.58)</td>
<td>.64</td>
<td>.52</td>
</tr>
<tr>
<td>Irrelevant Thoughts</td>
<td>9.46 (2.58)</td>
<td>8.98 (3.40)</td>
<td>.77</td>
<td>.44</td>
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<tr>
<td><strong>Post-STAI-S</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tension</td>
<td>9.52 (3.70)</td>
<td>7.82 (3.25)</td>
<td>2.41</td>
<td>.02*</td>
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<tr>
<td>Worry</td>
<td>11.83 (4.03)</td>
<td>10.16 (3.61)</td>
<td>2.15</td>
<td>.03*</td>
</tr>
<tr>
<td>Bodily Sensations</td>
<td>3.87 (1.24)</td>
<td>4.18 (1.67)</td>
<td>-1.02</td>
<td>.31</td>
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<tr>
<td>Irrelevant Thoughts</td>
<td>7.61 (2.99)</td>
<td>7.31 (3.34)</td>
<td>.46</td>
<td>.65</td>
</tr>
</tbody>
</table>

*Note. N = 97; M = Mean; SD = Standard Deviation; STAIS = State-Trait Anxiety Scale - State; RTS = Revised Test Anxiety Scale; df = 95; * indicates significance at p = .05; ** indicates significance at p = .01.*
Table 5

*Hypothesis 2 – Effect of Condition on Test Performance*

<table>
<thead>
<tr>
<th></th>
<th>Anxiety M (SD)</th>
<th>Supportive M (SD)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonological Loop</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSF</td>
<td>8.59 (2.22)</td>
<td>9.51 (2.12)</td>
<td>4.39</td>
<td>.04*</td>
</tr>
<tr>
<td>DSB</td>
<td>5.24 (2.21)</td>
<td>6.16 (2.28)</td>
<td>4.02</td>
<td>.05*</td>
</tr>
<tr>
<td><strong>Central Executive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WCST</td>
<td>22.96 (10.60)</td>
<td>19.00 (7.17)</td>
<td>4.72</td>
<td>.03*</td>
</tr>
<tr>
<td>Stroop</td>
<td>8.63 (4.74)</td>
<td>6.76 (3.95)</td>
<td>4.46</td>
<td>.04^</td>
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<tr>
<td>OST</td>
<td>42.02 (19.41)</td>
<td>38.71 (16.95)</td>
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<tr>
<td>N-back</td>
<td>28.22 (9.75)</td>
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*Note.* N = 97; M = Mean; SD = Standard Deviation; WCST = Wisconsin Card Sort Task, perseverative errors; DSF = Digit Span Forward; DSB = Digit Span Backwards; DST = Digit Span total; * indicates significance at the Bonferroni-corrected alpha level. ^ indicates marginal significance at the Bonferroni-corrected alpha level.
Table 6

*Hypothesis 3 – Effect of Condition on Cognitive Interference*

<table>
<thead>
<tr>
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<th>Anxiety M (SD)</th>
<th>Supportive M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIQ-TI Subscale</td>
<td>18.17 (4.90)</td>
<td>19.73 (7.08)</td>
</tr>
<tr>
<td>CIQ-TR Subscale</td>
<td>28.76 (6.94)</td>
<td>25.82 (5.75)</td>
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</table>

*Note.* N = 97; M = Mean; SD = Standard Deviation; TI = Task Irrelevant Subscale; TR = Task Relevant Subscale; CIQ = Cognitive Interference Questionnaire; * indicates significance at p = .05; ** indicates significance at p = .01.
Table 7

**Hypothesis 4 – Effect of Evaluation Anxiety on Cognitive Interference**

<table>
<thead>
<tr>
<th>CIQ-TI Subscale</th>
<th>M (SD)</th>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTA-Ten</td>
<td>8.67 (3.72)</td>
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<td>.22</td>
<td>.83</td>
</tr>
<tr>
<td>RTA-Wor</td>
<td>10.95 (4.05)</td>
<td>.50</td>
<td>3.34</td>
<td>.00**</td>
</tr>
<tr>
<td>RTA-Bod</td>
<td>4.23 (1.45)</td>
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<td>-.65</td>
<td>.52</td>
</tr>
<tr>
<td>RTA-TI</td>
<td>9.21 (3.03)</td>
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<td>2.06</td>
<td>.04*</td>
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</table>

<table>
<thead>
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<th>CIQ-TR Subscale</th>
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<th>t</th>
<th>p</th>
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</thead>
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<td>.00**</td>
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*Note. N = 97; M = Mean; SD = Standard Deviation; TI = Task Irrelevant Subscale; TR = Task Relevant Subscale; CIQ = Cognitive Interference Questionnaire; RTA-Ten = Revised Test Anxiety Tension subscale; RTA-Wor = Revised Test Anxiety Worry subscale; RTA-Bod = Revised Test Anxiety Bodily Symptoms subscale; RTA-TI = Revised Test Anxiety Task Irrelevant Thoughts subscale. * indicates significance at p = .05; ** indicates significance at p = .01; RTA data are pre-RTA scores.*
Table 8

Data on the Effect of Condition (X) on Performance (Y) as Mediated Through Cognitive Interference

<table>
<thead>
<tr>
<th>Effect</th>
<th>Estimate</th>
<th>SE</th>
<th>95% Confidence Interval</th>
<th>Bootstrap percentile</th>
<th>Bias-corrected</th>
<th>Bootstrap</th>
<th>M</th>
<th>SE</th>
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</tr>
<tr>
<td>a</td>
<td>-2.976</td>
<td>1.297</td>
<td>(-5.52, -0.43)*</td>
<td>(-5.44, -0.33)*</td>
<td>(-5.43, -0.31)*</td>
<td>-2.976</td>
<td>1.201</td>
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<tr>
<td>b</td>
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<td>0.028</td>
<td>(-0.07, 0.06)</td>
<td>(-0.07, 0.07)</td>
<td>(-0.07, 0.07)</td>
<td>-0.011</td>
<td>0.034</td>
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<tr>
<td>c'</td>
<td>0.846</td>
<td>0.549</td>
<td>(-0.23, 1.92)</td>
<td>(0.08, 1.83)*</td>
<td>(-0.01, 1.67)^</td>
<td>0.846</td>
<td>0.458</td>
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<tr>
<td>a x b</td>
<td>0.034</td>
<td>XXX</td>
<td>(0.22, 0.24)</td>
<td>(-0.17, 0.31)</td>
<td>0.033</td>
<td>0.109</td>
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<tr>
<td>c</td>
<td>0.880</td>
<td>0.432</td>
<td>(0.03, 1.73)*</td>
<td>(0.12, 1.82)*</td>
<td>(0.05, 1.73)*</td>
<td>0.879</td>
<td>0.446</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>-2.976</td>
<td>1.297</td>
<td>(-5.52, -0.43)*</td>
<td>(-5.41, -0.17)*</td>
<td>(-5.57, -0.35)*</td>
<td>-2.976</td>
<td>1.130</td>
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<tr>
<td>b</td>
<td>0.140</td>
<td>0.061</td>
<td>(-0.02, 0.26)*</td>
<td>(-0.03, 0.27)</td>
<td>(-0.01, 0.28)^</td>
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<td>0.074</td>
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<tr>
<td>c'</td>
<td>1.416</td>
<td>0.749</td>
<td>(-2.88, 0.07)^</td>
<td>(-3.09, 0.40)</td>
<td>(-3.12, 0.38)</td>
<td>1.416</td>
<td>0.916</td>
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<tr>
<td>a x b</td>
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<td>XXX</td>
<td>XXX</td>
<td>(-1.07, 0.07)</td>
<td>(-1.27, 0.00)^</td>
<td>-0.417</td>
<td>0.296</td>
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<tr>
<td>c</td>
<td>1.834</td>
<td>0.887</td>
<td>(-3.57, -0.10)*</td>
<td>(-3.61, -0.10)^</td>
<td>(-3.71, -0.08)*</td>
<td>1.833</td>
<td>0.949</td>
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<td>Visuospatial Sketchpad</td>
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<td></td>
</tr>
<tr>
<td>a</td>
<td>-2.976</td>
<td>1.297</td>
<td>(-5.52, -0.43)*</td>
<td>(-5.41, -0.17)*</td>
<td>(-5.46, -0.33)*</td>
<td>-2.976</td>
<td>1.308</td>
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<tr>
<td>b</td>
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<td>0.141</td>
<td>(-1.17, 0.39)</td>
<td>(-1.16, 0.38)</td>
<td>(-1.17, 0.37)</td>
<td>0.110</td>
<td>0.144</td>
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<tr>
<td>c'</td>
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<td>1.826</td>
<td>(-2.66, 4.49)</td>
<td>(-2.58, 4.75)</td>
<td>(-2.44, 4.79)</td>
<td>0.916</td>
<td>1.895</td>
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</tr>
<tr>
<td>a x b</td>
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<td>XXX</td>
<td>XXX</td>
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<td>(-1.78, 0.39)</td>
<td>-0.327</td>
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<tr>
<td>c</td>
<td>0.588</td>
<td>1.784</td>
<td>(-2.91, 4.08)</td>
<td>(-2.84, 4.07)</td>
<td>(-2.81, 4.19)</td>
<td>0.589</td>
<td>1.779</td>
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</tbody>
</table>

Note. N = 97; M = Mean; SE = Standard Error; a = condition predicting CIQ-TR; b = CIQ-TR predicting task performance; c = condition predicting performance; c' = condition predicting performance after controlling for the effect of CIQ-TR; ^ indicates significance at p = .10; * indicates significance at p = .05.
Table 9

*Fit Statistics for Mediated Models*

<table>
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<tr>
<th>Model</th>
<th>df</th>
<th>$\chi^2$</th>
<th>CFI</th>
<th>RMSEA</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonological Loop</td>
<td>1</td>
<td>.47 NS</td>
<td>1.0</td>
<td>.000</td>
<td>.015</td>
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<tr>
<td>Central Executive</td>
<td>4</td>
<td>3.94 NS</td>
<td>1.0</td>
<td>.000</td>
<td>.047</td>
</tr>
<tr>
<td>Visuospatial Sketchpad</td>
<td>0</td>
<td>X</td>
<td>1.0</td>
<td>X</td>
<td>.000</td>
</tr>
</tbody>
</table>

*Note.* df = degrees of freedom; CFA = Confirmatory Factor Analysis, $\chi^2$ = chi-square statistic; CFI = Comparative Fit Index; RMSEA = root-mean-square error of approximation, SRMR = standardized root mean square residual. NS = not significant; X = cannot be computed.
Table 10

Hypothesis 6 – Effect of Attentional Control on Central Executive Performance

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WCST Effectiveness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS</td>
<td>-.04</td>
<td>-.36</td>
<td>.72</td>
</tr>
<tr>
<td>CFQ-M</td>
<td>.11</td>
<td>.73</td>
<td>.47</td>
</tr>
<tr>
<td>CFQ-D</td>
<td>.01</td>
<td>.08</td>
<td>.94</td>
</tr>
<tr>
<td>CFQ-B</td>
<td>-.05</td>
<td>-.37</td>
<td>.72</td>
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<tr>
<td>CFQ-N</td>
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<tr>
<td><strong>WCST Efficiency</strong></td>
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</tr>
<tr>
<td>ACS</td>
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<td>CFQ-M</td>
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<td>CFQ-D</td>
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<td>.11</td>
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<td>CFQ-B</td>
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<td>.18</td>
</tr>
<tr>
<td>CFQ-N</td>
<td>.01</td>
<td>-.01</td>
<td>.92</td>
</tr>
</tbody>
</table>

| **Stroop Effectiveness** |      |      |     |
| ACS                      | -.17 | 1.73 | .09^|
| CFQ-M                    | .17  | 1.12 | .27 |
| CFQ-D                    | -.30 | -1.96| .05*|
| CFQ-B                    | .27  | 1.90 | .06^|
| CFQ-N                    | -.07 | -.62 | .54 |

| **Stroop Efficiency**    |      |      |     |
| ACS                      | -.02 | -.22 | .83 |
| CFQ-M                    | -.08 | -.54 | .59 |
| CFQ-D                    | .27  | 1.67 | .10^|
| CFQ-B                    | -.16 | -1.09| .28 |
| CFQ-N                    | -.06 | -.50 | .62 |

| **OST Effectiveness**    |      |      |     |
| ACS                      | -.13 | -1.20| .75 |
| CFQ-M                    | .09  | .58  | .23 |
| CFQ-D                    | .17  | 1.06 | .56 |
| CFQ-B                    | .01  | .06  | .95 |
| CFQ-N                    | -.10 | -.85 | .40 |

<p>| <strong>OST Efficiency</strong>       |      |      |     |
| ACS                      | .02  | .16  | .88 |
| CFQ-M                    | -.05 | -.31 | .76 |
| CFQ-D                    | .11  | .69  | .50 |</p>
<table>
<thead>
<tr>
<th></th>
<th>.08</th>
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<td>CFQ-B</td>
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<td>CFQ-N</td>
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<td>72</td>
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</tbody>
</table>

*Note. N = 97; ACS = Attentional Control Scale; CFQ-M = Cognitive Failures Questionnaire Memory Subscale; CFQ-D = Cognitive Failures Questionnaire Distractibility Subscale; CFQ-B = Cognitive Failures Questionnaire Blunders Subscale; CFQ-N = Cognitive Failures Questionnaire Names Subscale; WCST = Wisconsin Card Sort Task; Stroop = Stroop Color Word Task; OST = Operation Span Task; ^ indicates significance at p = .10; * indicates significance at p = .05.*
Table 11

Hypothesis 7 – Effect of Attentional Control on Central Executive Performance

<table>
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<td><strong>WCST Effectiveness</strong></td>
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<tr>
<td>RTA-Ten</td>
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*Note.* N = 97; RTA-Ten = Revised Test Anxiety Tension subscale; RTA-Wor = Revised Test Anxiety Worry subscale; RTA-Bod = Revised Test Anxiety Bodily Symptoms subscale; RTA-TI = Revised Test Anxiety Task Irrelevant Thoughts subscale; STAI-S = State Trait Anxiety Inventory - State; WCST = Wisconsin Card Sort Task; Stroop = Stroop Color Word Task; OST = Operation Span Task; * indicates significance at p = .05.
Figure 1

The Tripartite Model of Working Memory
Figure 2

*Phonological Loop Model Mediated by Cognitive Interference Task Irrelevant Subscale with Standardized Estimates*
Figure 3

*Central Executive Model Mediated by Cognitive Interference Task Irrelevant Subscale with Standardized Estimates*
Figure 4

*Visuospatial Sketchpad Model Mediated by Cognitive Interference Task Irrelevant Subscale with Standardized Estimates*
APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE

Subject # ___________

The following questions ask you to provide a wide range of information about yourself. As always, your responses to these questions will be kept completely confidential. We ask that you be as honest as possible throughout.

1) Age:

2) Gender (Circle one): Male Female

3) Which of the following best describes your race or ethnic origin (circle one only):
   
   American Indian
   Asian or Pacific Islander
   African American
   Asiatic Indian
   Caucasian
   Latino/Latina
   Mult-racial

4) Year in school:
   
   Freshman
   Sophomore
   Junior
   Senior
   5th year or higher

5) Do you smoke regularly? Yes No I have in the past
   
   a) If “yes,” or “have in the past,” for how long? ________ months and ________ years
   b) About how many cigarettes per day? ___________
6) Do you use other tobacco products? (Please name and report how frequently)

7) How often do you consume:

<table>
<thead>
<tr>
<th></th>
<th>Daily</th>
<th>2-3/wk</th>
<th>once/wk</th>
<th>once/month</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Wine</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Liquor</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Coffee</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Soda (Pop)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Other Caffeine Sources (e.g., chocolate, tea)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

8) Have you had any cigarettes, other products, tobacco, alcohol, or caffeine in the past 3 hours?
   Yes   No

9) Please describe any regular exercise habits

10) Have you ever sustained an injury that resulted in a loss of consciousness?   Yes   No

   a) If “Yes,” please describe the injury and estimate the approximate length of unconsciousness.

11) Please circle any of the following specific illnesses or conditions, either if you presently have the illness/condition, or if you had the illness/condition in the past.

   Alcohol/Drug Problems   Allergies/Asthma
   Anemia                  Bleeding Tendencies
   Cancer/Tumor            Color Blindness
   Diabetes/Sugar          Epilepsy/Seizures
   Glaucoma                Gout
   High Blood Pressure     Heart Trouble
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Hypo/Hyperthyroid    Sinusitis
Kidney/Bladder Trouble    Flu
Liver Disease    Mental/Emotional Problems
Rhemumatism/Arthritis    Stomach/Duodenal Ulcer
Tuberculosis    Weight Problems
Cold

12) Are you currently taking any medication (prescription or over-the-counter)?  Yes  No

  a) If “Yes,” name the medications and what they’re used for:

13) Have you taken any of these medications today?  Yes  No

  a) If “Yes,” how long ago?

14) What was your high school GPA (please use a 4.0 scale)?  __________

15) What did you score on the ACT or SAT?  __________

16) What is your college GPA (please use a 4.0 scale)?  __________
APPENDIX B

STATE ANXIETY INVENTORY

Directions

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

Please use the following scale in providing your answers:

1-not at all
2-somewhat
3-moderately so
4-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 worrying over possible misfortunes……1  2 3 4
8) I feel satisfied………………………………....................1  2 3 4
9) I feel frightened………………………………..............1  2 3 4
10)I feel comfortable……………………………….............1  2 3 4
11)I feel self-confident………………………………........1  2 3 4
12)I feel nervous………………………………..................1  2 3 4
13)I am jittery………………………………......................1  2 3 4
14)I feel indecisive………………………………..............1  2 3 4
15)I am relaxed………………………………....................1  2 3 4
16)I feel content………………………………...................1  2 3 4
17)I am worried………………………………....................1  2 3 4
18)I feel confused……………………………….................1  2 3 4
19)I feel steady……………………………….....................1  2 3 4
20)I feel pleasant………………………………..................1  2 3 4
APPENDIX C

REVISED TEST ANXIETY SCALE

Directions: Please rate the following statements in regard to the tests that you will be taking (the cognitive tasks, not the surveys) using the scale provided.
1 - strongly disagree
2 - somewhat disagree
3 - somewhat agree
4 - strongly agree

1. I feel very uneasy about how I will perform on these tests.
2. I feel very tense about these tests.
3. I am worrying a great deal about these tests.
4. I wish these tests would not bother me so much.
5. I am anxious about these tests.
6. Thinking about how I am doing on these tests will interfere with my ability to my best on them.
7. I think I will defeat myself while taking these tests.
8. During these tests, I will likely think about the consequences of doing poorly.
9. While taking these tests, I will likely think about how much brighter people are.
10. While taking these tests, I will likely think about how difficult they are.
11. Thoughts of doing poorly will interfere with my concentration during the test.
12. I will likely get a headache during these tests.
13. My mouth will feel dry during these tests.
14. I am trembling while thinking about these tests.
15. I will likely think about things unrealated to the test while taking the tests.
16. I will likely think about current events while taking the tests.
17. I will likely think about being somewhere else while taking the tests.
18. I will likely be distracted by thoughts of upcoming events during the tests.
APPENDIX D

ATTENTIONAL CONTROL SCALE

Here are some different ways that people can feel about working and concentrating. Please indicate how strongly each statement applies to you.

1 = Almost never
2 = Sometimes
3 = Often
4 = Always

1. It’s very hard for me to concentrate on a difficult task when there are noises around. 1 2 3 4

2. When I need to concentrate and solve a problem, I have trouble focusing my attention. 1 2 3 4

3. When I am working hard on something, I still get distracted by events around me. 1 2 3 4

4. My concentration is good even if there is music in the room around me. 1 2 3 4

5. When concentrating, I can focus my attention so that I become unaware of what’s going on in the room around me. 1 2 3 4

6. When I am reading or studying, I am easily distracted if there are people talking in the same room. 1 2 3 4

7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts. 1 2 3 4

8. I have a hard time concentrating when I’m excited about something. 1 2 3 4

9. When concentrating I ignore feelings of hunger or thirst. 1 2 3 4

10. I can quickly switch from one task to another. 1 2 3 4

11. It takes me a while to get really involved in a new task. 1 2 3 4

12. It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures. 1 2 3 4
13. I can become interested in a new topic very quickly when I need to.

14. It is easy for me to read or write while I’m also talking on the phone.

15. I have trouble carrying on two conversations at once.

16. I have a hard time coming up with new ideas quickly

17. After being interrupted or distracted, I can easily shift my attention back to what I was doing before.

18. When a distracting thought comes to mind, it is easy for me to shift my attention away from it.

19. It is easy for me to alternate between two different tasks.

20. It is hard for me to break from one way of thinking about something and look at it from another point of view.
APPENDIX E

COGNITIVE FAILURES QUESTIONNAIRE

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know how often these things have happened to you in the past 6 months. Please circle the appropriate number.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Very Often</th>
<th>Quite often</th>
<th>Occasionally</th>
<th>Very rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Do you read something and find you haven’t been thinking about it and must read it again?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>Do you find you forget why you went from one part of the house to the other?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>Do you fail to notice signposts on the road?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>Do you find you confuse right and left when giving directions?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5.</td>
<td>Do you bump into people?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>Do you find you forget whether you’ve turned off a light or a fire or locked the door?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7.</td>
<td>Do you fail to listen to people’s names when you are meeting them?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>Do you say something and realize afterwards that it might be taken as insulting?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9.</td>
<td>Do you fail to hear people speaking to you when you are doing something else?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10.</td>
<td>Do you lose your temper and regret it?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>Do you leave important letters unanswered for days?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12.</td>
<td>Do you find you forget which way to turn on a road you know well but rarely use?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>13.</td>
<td>Do you fail to see what you want in a supermarket (although it’s there)?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>14.</td>
<td>Do you find yourself suddenly wondering whether you’ve used a word correctly?</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
15. Do you have trouble making up your mind?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

16. Do you find you forget appointments?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

17. Do you forget where you put something like a newspaper or a book?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

18. Do you find you accidentally throw away the thing you want and keep what you meant to throw away – as in the example of throwing away the matchbox and putting the used match in your pocket?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

19. Do you daydream when you ought to be listening to something?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

20. Do you find you forget people’s names?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

21. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

22. Do you find you can’t quite remember something although it’s “on the tip of your tongue”?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

23. Do you find you forget what you came to the shops to buy?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

24. Do you drop things?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0

25. Do you find you can’t think of anything to say?  
   Very Often | Quite often | Occasionally | Very rarely | Never
   4 | 3 | 2 | 1 | 0
APPENDIX F

COGNITIVE INTERFERENCE QUESTIONNAIRE

Instructions. This questionnaire concerns the kinds of thoughts that go through people’s heads at particular times, for example, while they are working on a task. The following is a list of thoughts, some of which you might have had while doing the task on which you have just worked. Please indicate how often each thought occurred to you while working on it by placing the appropriate number in the blank provided to the left of each question.

1=Never
2=Once
3=A few times
4=Often
5=Very often

___ 1. I thought about how poorly I was doing
___ 2. I thought about what the experimenter would think of me
___ 3. I thought about how I should work more carefully
___ 4. I thought about how much time I had left
___ 5. I thought about how others have done on this task
___ 6. I thought about the difficulty of the problems
___ 7. I thought about my level of ability
___ 8. I thought about the purpose of the experiment
___ 9. I thought about how I would feel if I were told how I performed
___ 10. I thought about how often I get confused
___ 11. I thought about other activities (for example, assignments, work)
___ 12. I thought about members of my family
___ 13. I thought about friends
___ 14. I thought about something that made me feel guilty
___ 15. I thought about personal worries
___ 16. I thought about something that made me feel tense
___ 17. I thought about something that made me feel angry
___ 18. I thought about something that happened to me earlier today
___ 19. I thought about something that happened in the recent past (last few days, but not today)
___ 20. I thought about something that happened in the distant past
___ 21. I thought about something that might happen to me in the future

Please circle the number on the following scale which best represents the degree to which you felt your mind wandered off tasks during the task you have just completed.

Not at all 1 2 3 4 5 6 7 Very much
APPENDIX G

INSTRUCTION CONDITIONS

Initial Instructions

Anxiety-Inducing Instructions

As was mentioned earlier, this project involves you performing tests that assess attention, concentration, and memory. These tests have been shown to be highly related to intelligence and ability to do college work. They are also related to success in later life such as earned income and occupational attainment. It’s likely that you have never seen these tests before, so many of them may seem quite difficult. During each test, you will be timed by the computer and notes will be taken regarding your performance. At the end of the session, we will review the results with you and compare your performance with the performance of other college students. Any questions?

Supportive Instructions

As was mentioned earlier, this project involves you performing tests that assess attention, concentration, and memory. Before we begin, though, we want to inform you that we’re mainly interested in determining if these tests would be appropriate for a future project. Therefore, we are not that concerned about your performance, so don’t worry so much about whether you are doing good or bad, but please do the best that you can. We want to remind you that no one will see the results of your performance. So, just relax and follow the instructions as best you can. Before we begin you may just want to take a couple of deep breaths and clear your mind. Do you have any questions?

Instructions before the second, third, fourth, and fifth tests

Anxiety-Inducing Instructions

Remember, this test may seem quite difficult. Again, the computer will time you and I will take notes so I can review the results with you and compare your performance with other college students.

Supportive Instructions

Remember, we are not that concerned about your performance. You are doing fine, so just relax and follow the instructions as best you can.