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The Influence of Cognitive Interference and Anxiety on Working Memory and Performance Validity Tests

Caitlin V. Dombrowski
University of Connecticut, caitlin.dombrowski@gmail.com

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Anxiety disorders and situational anxiety are common in the general population, yet the influence of anxiety symptoms on working memory is poorly understood. Some studies suggest that anxiety may be inversely related to working memory, possibly due to reduced cognitive efficiency and/or interference from worry-based cognitions; however, methodological inconsistencies have undermined generalizability. The high prevalence of anxiety makes further study of its associated neuropsychological deficits and underlying mechanism of action tantamount. Moreover, assessment of performance can induce anxiety in even relatively low anxious individuals, which may also interfere with working memory and performance-based measurement. In this study, undergraduates with low and high levels of subclinical anxiety completed working memory tasks during both low and high situational anxiety phases. Results indicated that although the high anxiety group reported greater anxiety and task interfering cognitions, anxiety level did not predict working memory during either phase. In contrast to theoretical models, working memory performance improved for both groups during the second, high situational anxiety phase. Secondarily, Performance Validity Tests (PVTs) were embedded in the evaluation to determine if low effort—a common confounding variable in assessment—could explain the results of this study. Analyses revealed that 15% of the undergraduate sample failed at least one PVT, suggesting that a lack of significant differences between groups may be, at least in part, attributed to low effort. Implications of these findings and future directions for neuropsychological research with anxious individuals and undergraduates are discussed.

Keywords: anxiety, working memory, cognitive interference, performance validity tests, effort

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Caitlin V. Dombrowski, M.A.

B.S. University of Connecticut, 2010

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The Influence of Cognitive Interference and Anxiety on

Working Memory and Performance Validity Tests

Presented by

Caitlin V. Dombrowski, M.A.

Major Advisor____
Kimberli Treadwell, Ph.D.

Associate Advisor____
Chi-Ming Chen, Ph.D.

Associate Advisor____
Kevin P. Young, Ph.D.

University of Connecticut

2016

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The Influence of Cognitive Interference and Anxiety on Working Memory and Performance Validity Tests

Anxiety disorders are the most commonly diagnosed group of psychological disorders, with even higher prevalence rates than mood disorders (Kessler, Berglund, & Demler, 2005). The lifetime prevalence of anxiety disorders in the United States population is 28.8% and the 12-month prevalence remains high at 18.1% (Kessler et al., 2005). In addition, anxiety disorders are known contributors to heightened disability in cognition, life activities, participation, and social interaction (Hendriks et al., 2014), as well as social and financial burdens (Tolin, Gilliam, & Dufresne, 2009). Not only do individuals with anxiety disorders often have comorbid medical conditions, they are also more likely than others to use medical care services, even when controlling for medical condition (Ford, Trestman, Steinberg, Tennen, & Allen, 2004; Marciniak, Lage, Landbloom, Dunayevich, & Bowman, 2004; Roy-Byrne et al., 2008; Simon, Ormel, VonKorff, & Barlow, 1995). This association between medical conditions and anxiety is likely bidirectional, with worries and anxieties leading to more preoccupation about health, and genuine health problems leading to worries about possible new conditions. Thus, neuropsychologists evaluate many individuals with clinical anxiety and/or transient anxiety in test-taking scenarios.

Elevated anxiety, clinical or situational, is associated with deficits in cognitive performance—namely the central executive component of working memory (Baddeley, 1986)—although findings are mixed. Several theories have been proposed to account for these findings, including the processing efficiency theory (Eysenck & Calvo, 1992), attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007), and cognitive interference theory (Sarason, 1984). The concurrent impact of generalized and state anxiety has not been well examined, nor has effort towards testing in anxious populations. The impact of generalized and state anxiety on attention and working memory will be examined, as will a relevant confounding variable of effort to contextualize findings across studies.

Historical and Theoretical Basis of Anxiety and Cognition

Arousal states and performance ability were first studied in the early 20th century, resulting in the Yerkes-Dodson law, which suggested a U-shaped relationship between arousal and performance (Yerkes & Dodson, 1908), whereby moderate arousal was associated with highest performance. Optimal arousal level was also theorized to be inversely related to task difficulty—best performance on difficult tasks required lower arousal levels. By the mid-century, high arousal states were thought to reduce attentional breadth and increase attentional selectivity (Easterbrook, 1959). During the development and growth of cognitive psychology during the 1960s and 1970s, many researchers investigated the influence of emotional states on performance, as well as the mediation of this relationship by cognitive mechanisms (Derakshan & Eysenck, 2010). Emotionality, particularly from bias towards negative information, tends to interrupt attentional systems (Pallak, Pittman, Heller, & Munson, 1975; see Yiend, 2010 for a review). A recent study found that patients with significant emotional distress who presented for neuropsychological evaluations had more variable performance on attention and concentration tests than a control group (Meyers, Grills, Zellinger, & Miller, 2013). Thusly, individuals with high emotionality might perform efficiently on difficult tasks, despite comparatively lower performance on more simple tasks. Clinically, this discrepancy is often considered a signature neurocognitive profile for individuals with emotional distress. Some studies have also found that individuals in an aroused state, but without clinical psychiatric diagnoses, show disrupted attentional patterns. However, published findings on theorized relationships between arousal states and performance have been inconsistent. Much research has focused on the influence of anxiety on attention and working memory, related cognitive constructs with several component parts. The numerous theories about both of these cognitive functions, as well as the many experimental approaches and measures to assess them, may be contributing to inconsistency of findings.

In the 1980s, Baddeley proposed a multi-faceted model of working memory, an expansion and challenge to the general belief that short-term memory was a unitary mechanism (Baddeley, 1986). He proposed that working memory consists of three parts: the *central executive* controls the processing and allocating of resources between two “slave systems”: the *phonological loop* and the *visuo-spatial sketchpad*. The phonological loop rehearses and temporarily stores verbal information. Analogously in the visual mind, the visuo-spatial sketchpad provides this function for visual information. Frequently, the visual information is also transferred to the phonological loop through language-based description (Baddeley, 1992). Information in either temporary system may be discarded or transferred to long-term memory storage. Baddeley later revised his theory by adding a fourth component of working memory, called the *episodic buffer*, that assists with the temporary storage of information from the slave systems. Notably, all components of working memory have limited storage capacity, the magnitude of which varies both between individuals and within an individual depending on transient factors (e.g., fatigue, motivation).

Subsequently, several competing theories concerning the functions and subcomponents of the central executive emerged. Barrett, Tugade, and Engle (2004) suggested that the central executive's primary task is to allocate attentional resources. Smith and Jonides (1999) theorized that the central executive is composed of five specific functions: switching attention between tasks, planning related tasks towards a unified goal, directing and inhibiting attention, updating and checking working memory storage, and attaching time and place information to working memory representations. Miyake and colleagues' latent factor statistical analysis of actual task performance (Miyake, 2000) led to the proposal of three central executive functions, which overlap considerably with Smith and Jonides' theorized model. Miyake's central executive consists of inhibiting distracting information, shifting attention, and updating and monitoring information within working memory stores. Still more, Fournier-Vicente, Larigauderie, and Gaonac'h (2008), who also used latent variable analysis, identified five executive functions, described as verbal storage, visuospatial storage, strategic retrieval, selective attention, and shifting attention. Indeed, there is general disagreement about the component parts of working memory (Derakshan & Eysenck, 2010). However, attention and speed of processing are consistently regarded as related and integral components to working memory; both of which may also be vulnerable to anxiety, other high arousal states, and effort or motivation towards performance.

Theories and Evidence for an Anxiety-Working Memory Relationship

Many would argue that some anxiety is essential for optimal neurocognitive performance; however, emotional overarousal and/or hypervigilance for threatening stimuli, both associated with anxiety, may lead to reduced neurocognitive performance. Based on Baddeley's conceptualization of working memory, theorists began to examine the possible influence of anxiety on working memory and arousal/attention within the growing fields of experimental and cognitive psychology. There was an expanding body of literature showing an inverse relationship between anxiety and cognitive performance (Derakshan & Eysenck, 2010). Although anxiety may disrupt any component in the working memory system, the central executive is considered the most susceptible to anxious interference (Derakshan & Eysenck, 2010). Based on Baddeley's model of working memory, Eysenck and Calvo proposed the processing efficiency theory, which was later incorporated into Eysenck's attentional control theory, to describe the apparent relationship between trait and state anxiety and cognitive performance within normal populations (Derakshan & Eysenck, 2009; Eysenck, 1979; 1988; Eysenck et al., 2007; Eysenck & Calvo, 1992). The theory posed that efficiency (speed) of mental processing is more likely to be hindered by anxiety than effectiveness (accuracy) of task performance. The phonological loop and visuo-spatial sketchpad remain adequately functional, despite a slowing of information processing within the slave systems (Eysenck et al., 2007)—attributed to the handicapped central executive. The attentional control theory incorporates Miyake's (2000) description of subcomponents underlying the central executive (Derakshan & Eysenck, 2009), and posits that the central executive may be undermined by (1) an anxious focus on task-irrelevant but threat-salient information (poor inhibition); and (2) a constant search for threatening input (overshifting). Eysenck first developed these theories of anxious processing inefficiency and attentional disruption to explain characterological, or trait-like, anxiety in normative samples rather than clinical samples, which has resulted in more research studies of test and trait anxieties.

Working Memory and Trait Anxiety. Despite over a century of research on the influence of emotional states on performance, relatively few studies have directly assessed the relationship between clinical anxiety and working memory components (Stein & Rauch, 2010), yet much research has focused on trait anxiety in normative samples. For example, academically-oriented research has amassed substantial support for a relationship between test anxiety and academic performance; a meta-analytic review found small to moderate associations between test anxiety and several performance indices: intellectual ability, academic achievement testing, and grade point averages (Hembree, 1988). It is unclear, though, whether test anxiety is assessing trait anxiety, state anxiety, or some combination of the two (Eysenck, 2010). High trait anxiety has been found to be associated with slower performance (reduced efficiency) on tasks with both high and low working memory load (MacLeod & Donnellan, 1993; Metzger, Miller, Cohen, Sofka, & Borkovec, 1990). In another study of individuals with high trait anxiety, visual working memory was lower when the central executive was engaged by a secondary task but not when the phonological loop or visuo-spatial sketchpad were otherwise engaged (Eysenck, Payne, & Derakshan, 2005). Young adults with current anxiety disorders showed reduced performance on visual working memory tests compared to controls (Castaneda et al., 2011). Adults with generalized anxiety disorder were found to show reduced attentional control, associated with the frontal, voluntary processes of the central executive, during periods of heightened task demands (Stefanopoulou, Hirsch, Hayes, Adlam, & Coker, 2014). In a recently published study assessing the impact of trait anxiety on shifting ability—a subcomponent of the central executive—within the context of self-reported effort and situational stress, cognitive trait anxiety (anxiety symptoms related to cognitions) was associated with poorer shifting efficiency but not effectiveness (Edwards, Edwards, & Lyvers, 2015); furthermore, the magnitude of this relationship was greater at times of low effort or high situational stress.

Working Memory and State or Situational Anxiety. Working memory deficits have also been associated with state anxiety in undergraduate samples (Coy, O'Brien, Tabaczynski, Northern, & Carels, 2011; Knox & Grippaldi, 1970; Lapointe et al., 2013; Northern, 2010). These results have included state anxiety brought on by specific situational stressors, including fear of threat, testing instructions, and clinician-specific situational factors. For example, male undergraduates in a stress-inducing experimental group performed worse than controls on declarative memory and working memory tasks; additionally, their self-reported state anxiety during the task was correlated with neuropsychological test scores in several domains (Leininger & Skeel, 2012). Structured medical settings with traditional doctor-patient roles and formalized directions for testing, rather than a relaxed environment with more casual, friendly interactions and encouragement, have been associated with heightened state anxiety levels (Etherton & Axelrod, 2013; Greher, 2003). Studies have also used the *threat of shock* paradigm to simulate cognitive states of individuals with clinical anxiety (see Robinson, 2013 for a review of shock studies), resulting in reduced performance on complex or unpracticed tasks (Pyke & Agnew, 1963). Overall, vast methodological differences and disagreements about cognitive constructs undermine consensus about the relationship between state anxiety and working memory. Additionally, few studies have examined the combined effects of transient anxious arousal in clinically anxious individuals—a commonly seen phenomenon in an assessment setting. In an early study of neurocognitive abilities, state and trait anxiety were both associated with lower working memory than verbal reasoning performance (Knox & Grippaldi, 1970). More studies, however, are needed to understand the contributions of differential and specific anxieties on working memory performance.

Cognitive Interference, Anxiety, and Working Memory. Sarason proposed the cognitive interference theory to explain why individuals with anxiety exhibit reduced working memory (1984). He suggested that preoccupying worries about personal performance, described as "obsessive self-preoccupation," unnecessarily raises stress levels (Sarason & Stoops, 1978, p. 107). As a result, attentional resources are siphoned away from task-relevant engagement, thereby undermining the individual's ability to perform efficiently on cognitive tasks involving working memory and executive functions. Individuals with anxiety may require additional effort to complete tasks at the same levels as their peers (Berggren & Derakshan, 2012). Additionally, negative expectations about one's potential performance and abilities, likely brought on by the additional effort dispensed, are thought to further negatively impact their test performance (Lezak, Howieson, Bigler, & Tranel, 2012a). Cognitive distortions have even been shown to fully mediate the relationship between test anxiety and academic achievement in late adolescence (Putwain, Connors, & Symes, 2010). So, although pathological worrying may aid the avoidance of overwhelming emotional content, therefore becoming a basic emotion regulation strategy (Riskind, 2005), it can also reduce working memory capacity (Hayes, Hirsch, & Mathews, 2008). Several studies have shown that worry-driven cognitions contribute to the cognitive impairments seen on neuropsychological testing (Cummings & Mega, 2003; Gualtieri & Morgan, 2008; Leigh & Hirsch, 2011; N. J. Martin & Franzen, 1989; Metzger et al., 1990). Self-induced worry as well as attempts to control worry have also led to reduced working memory capacity (Hallion, Ruscio, & Jha, 2014; Sari, Koster, & Derakshan, 2016). Interestingly, interfering cognitions were shown to mediate the inverse relationship between state anxiety and phonological loop/central executive performance but not visuo-spatial working memory (Coy et al., 2011).

Summary of Anxiety and Working Memory Findings

State and trait anxiety likely disrupt task-relevant processing by the central executive and the larger working memory system with self-focused, preoccupying worry, as suggested by Sarason's cognitive interference theory. However, methodological inconsistencies, particularly differences in population, anxiety type, component of cognition (e.g., shifting or inhibiting), and working memory task, have undermined the ability to draw clinically meaningful conclusions. Moreover, most studies have examined either trait or state anxiety but not both, making it unclear whether potentially lower neurocognitive scores on testing are associated with ongoing anxiety or situational anxiety—which also frequently present together (Eysenck, 2010). It is theorized that sometimes individuals with anxiety simply perform slower than controls but not worse, which can complicate results in cases where time of completion is not assessed or effectiveness is judged by response time. Besides methodological issues, numerous confounding variables remain, including situational factors and motivation/effort. Studies from cognitive psychology, neuroscience, and clinical psychology have also aimed at understanding working memory for “hot” information, or biased cognitions (i.e., attention, interpretation, and memory biases) rather than “cold,” neutrally valenced information, with mixed success (Clarke & MacLeod, 2013; Derakshan & Eysenck, 2010). Additionally, Johnson-Green and Adams have argued that published neuropsychological profiles of individuals with psychiatric disorders would provide useful information to the practicing neuropsychologist regarding expected test profiles (1998). Ongoing neuropsychological research is warranted to investigate the specificity of neurocognitive deficits associated with anxiety symptoms, particularly how interfering cognitions relate to the efficiency or effectiveness of different parts of the working memory system (e.g., shifting, inhibiting).

Validity of Cognitive Assessment in Anxiety

Although much research of the relationship between anxiety and cognitive performance has focused on attentional control, motivation and effort may play an important role in performance for any individual, particularly for anxious individuals as anxiety may produce false positives on effort testing. Many tests of effort rely on an individual’s attentional and working memory capacity to establish good effort (Wise, 2006). As has been discussed, anxiety also reduces working memory, thereby potentially undermining the utility of effort testing in this population. In fact, many individuals with anxiety are highly motivated to perform well, despite behavioral and neurological impediments to cognitive performance (Berggren & Derakshan, 2012). Effort is an important confound to consider when examining neuropsychological underpinnings of anxiety, as the testing situation itself and motivation towards the assessment may conflate results. Indeed, effort has been shown to be more influential than emotional valence type on neuropsychological testing results (Derakshan & Eysenck, 2010). Given that low effort undermines the ability to measure an individual's cognitive functioning, measurement of an individual's effort towards test-taking has become an emerging standard in the field of neuropsychology (Constantinou, Bauer, Ashendorf, Fisher, & McCaffrey, 2005; Larrabee, 2012).

Tests designed to assess effort, or performance validity (PVTs), generally appear to the test-taker to be tests of traditional neuropsychological constructs with high face validity (e.g., attention), despite aiming to assess effort; therefore, they can be readily incorporated into any neuropsychological battery without the examinee's knowledge. Few studies of neuropsychological testing in anxious individuals have incorporated PVT; thus, little is known about anxious individuals' performance on these measures, and the degree to which effort or anxiety contribute to outcomes. Given the prevalence of long-standing anxiety and transient anxious responses to testing, it would be helpful for clinicians to have normative data about the relationship between anxiety levels and effort during assessments.

Preliminary empirical examination of effort and anxiety suggest that individuals with anxiety perform adequately on testing. A study of community-dwelling older adults with state and trait anxiety found that scores on a commonly-used, non-computerized PVT, the Test of Memory Malingering (TOMM), were consistent with the performance of non-anxious controls (Ashendorf, Constantinou, & McCaffrey, 2004). Moreover, none of the high anxiety participants scored below the cutoff during the TOMM Trial 2, which is the standard by which pass/fail rates are typically determined on the measure. The TOMM and the symptom questionnaires were the only measures used in this study. A second study of older adults assessing the relationship between the TOMM Trial 2 and state and trait anxiety also failed to find a relationship (O'Bryant, Finlay, & O'Jile, 2006). Notably, the second study found relationships between TOMM Trial 1 scores and both types of anxiety, suggesting that the affective state of the individual should be considered when deciding to discontinue testing after the first trial (a more recent development suggested to shorten the measure). The second trial may provide differential information about the nature of the individual's failure during the first trial. These findings suggest that cutoffs for pass/fail scores need to be low enough that performance invalidity is detected but also high enough that affective arousal does not cause an individual to fail the measure, i.e., sensitivity and specificity must be balanced.

Both studies presented above suggest that the TOMM provides an effective measure of effort in anxious older adults. Although preliminary results suggest that anxiety is not associated with low effort scoring, only one measure was used. Clinical practice guidelines suggest neuropsychologists use 2-3 tests of effort to note fluctuations in effort across time as well as to tap slightly different types of effort. In sum, research involving multiple tests of effort, as well as other forms of anxiety, is needed to fully evaluate how anxious individuals perform on PVTs, and the potential resulting impact on assessing neuropsychological status in anxiety.

Validity of Cognitive Assessment in Undergraduate Participants

A large portion of the literature examining anxiety and neuropsychological functioning has been conducted in undergraduate samples, which may be a shortcoming in this area of research. Some researchers have called into question the motivational status of undergraduates completing course credit as a basis for generalizing analyses of other constructs to general adult populations. Indeed, few studies with undergraduate samples have controlled for effort, possibly a frequent confound of published results. In a direct examination of undergraduate effort during a testing scenario, An, Zakzanis, and Joordens (2012) reported that over half of their undergraduate sample failed two of three PVTs, the Victoria Symptom Validity Test (VSVT) and the Dot Counting Test (DCT). In contrast, all participants passed the TOMM. Results may indicate that the TOMM is less sensitive to low effort in undergraduate student participants and/or the VSVT and Dot Counting may overestimate failures. Of yet, it is not clear why the TOMM appears to be more easily passed by many individuals. Based on their results, An and colleagues argued that invalidity is a significant concern when using college samples. Although this study raised a red flag in this field of research, there exist significant limitations with their methodology, including a relatively small sample size (i.e., 36), unblinded research assistants, non-standard cutoff used on the VSVT, predominance of female and Asian students, and half of the sample reporting English as a second language.

In contrast, the majority of subsequent studies have supported valid testing conditions for undergraduate samples. These studies have incorporated larger sample sizes, broader representations of ethnicity and gender, and accepted guidelines for pass/fail cutoffs. In the first study published in contradiction to An's findings, archival data from 100 undergraduates with more representative gender and ethnic characteristics indicated that few (under 3%) failed PVTs (Silk-Eglit et al., 2014). Several PVTs were used, including the TOMM, the VSVT, the Word Memory Test (WMT), Reliable Digit Span, the Medical Symptom Validity Test, and the forced-choice subtest of the California Verbal Learning Test-II, across two separate samples. A study of undergraduate performance at a US public university on the WMT found a 6.4% failure rate (Santos, Kazakov, Reamer, Park, & Osmon, 2014). This study also found that negative demand characteristics (i.e., the investigator’s demeanor and treatment of the participant) did not affect WMT scores. In a study using several PVTs, including the DCT, VSVT, and WMT, 8.3% of the undergraduate sample scored below cutoffs on at least one of the PVTs during initial testing (Ross et al., 2016); at approximately one-month follow-up with all participants, just 3.7% failed a PVT. In contrast, to the above presented research on undergraduate participants, one study used embedded, rather than stand-alone, measures of effort within the computerized CNS Vital Signs (DeRight & Jorgensen, 2015). In this study, 12% of the sample failed a validity indicator during baseline testing, and 11% failed one during the repeat administration. In total, 15% of participants failed at least one embedded PVT. Additionally, a computerized study of question responding patterns in a low-stakes testing situation, where there are no apparent repercussions for the participant putting forth suboptimal effort, rapid-guessing behavior were found in less than 7% of participants (Wise, 2006). Despite this relatively low percentage of random responding, the author found that even slight increases in random guessing behavior can have meaningful effects on test reliability.

Based on the above findings, An and colleagues' findings of low effort in undergraduate samples may be an outlier (2012); however, additional studies of testing validity in college populations may help clarify the magnitude of this issue, particularly with non-traditional students or in poorly controlled experimental designs. Should An's results be an anomaly, there is little reason to doubt the appropriateness of utilizing college samples for piloting neuropsychological research.

As well, since none of the undergraduate validity studies examined anxiety in regards to PVTs, it remains important to clarify this issue. This study would be the first to assess PVT performance in a subclinically anxious undergraduate sample. Furthermore, assessing for validity allows a researcher to consider excluding undergraduates who fail to pass these measures, thereby ensuring that their data was validly completed. Therefore, even if failure rates are low, PVT administration may lead to reducing noise in analyses. The practice of using PVTs to confirm performance validity is already commonly considered in clinical research samples and clinical settings; therefore, it appears to be a reasonable consideration in undergraduate populations where performance validity rates appear to vary.

Purpose

Despite the high prevalence of anxiety in the general population and potentially anxiety-provoking experience of attending a cognitive assessment, the influence of anxiety symptoms on components of working memory is poorly understood. Theorists argue that anxiety can contribute to less effective and/or less efficient (slowed) performance. Eysenck's attentional control theory (2007) posits that reduced efficiency may be related to the central executive component of working memory, through reduced inhibitory control and hypervigilant over-shifting of attention. Furthermore, cognitive interference from worries may underlie this effect. The present study examined the impact of state and general anxiety on working memory, including both efficiency and accuracy of performance. Self-reported thoughts during tests were assessed to test the theory of cognitive interference in anxious individuals. Lastly, effort during the experiment was assessed with PVTs to control this as a third variable contributing to diminished working memory performance, and to add to the literature on their measurement in anxious and undergraduate populations.

Hypotheses

Hypothesis 1. Individuals in the high generalized anxiety group will perform worse, and slower, than individuals in the low generalized anxiety group on working memory measures tapping both the central executive and the phonological loop. In contrast, the groups will perform equally on a task tapping the visual-spatial working memory sketchpad.

Hypothesis 2. Any observed association between high generalized anxiety and diminished performance on the central executive and phonological loop tasks will be mediated by cognitive interference (distracting self-talk), consistent with cognitive interference theory (Sarason, 1984).

Hypothesis 3. To disentangle the unique contributions of trait and state anxiety, state anxiety will be manipulated in the high and low general anxious groups, to examine differential effects on performance in working memory. It is hypothesized that after receiving the situation stressor of anxiety-inducing instructions, state anxiety will exert a main effect by reducing working memory on the central executive and phonological loop, but not the visual-spatial loop, as compared to performance prior to the stressor. An interaction effect is also hypothesized, in that high general anxiety and high state anxiety will potentiate the effect of anxiety on working memory, resulting in the high anxious group exhibiting significantly greater deficits in working memory than the low anxious group under the state anxiety induction. Following the stressor, cognitive interference is hypothesized to mediate the inverse relationship between anxiety and performance for both groups.

Hypothesis 4. General anxiety level will not impact effort testing in this anxious, undergraduate sample, consistent with the majority of the literature on undergraduate effort performance. Pass/fail rates of performance validity tests will not differ significantly by group. Since PVTs commonly rely on working memory, attentional control theory suggests that on untimed PVTs, scores will not differ by group affiliation; however, on timed PVTs, high anxious individuals will perform more slowly.

Hypothesis 5. Undergraduate participants are hypothesized to put forth adequate effort during testing. Therefore, performance validity failures will be infrequent in this study, with less than 5% of students failing a measure.

Methods

Participants

Participants were undergraduates attending a large university in the northeast United States, who were recruited from General Psychology courses. During the spring semester, 1077 undergraduates completed prescreening testing. The students were 55% female, and had racial diversity consistent with the overall university: 65.6% Caucasian, 19.7% Asian American, 9.9% Hispanic, 7.5% African American, 2.0% Middle Eastern, 0.7% Native American, and 0.3% Pacific Islander. The vast majority of surveyed students (985) successfully completed a brief anxiety screen to determine group affiliation for this study. These undergraduates were statistically grouped by level of anxiety: high (approximately top 25%), moderate (middle 50%), and low (bottom 25%).

Once grouped, 590 students qualified for the experimental arms of this study by scoring in the highest and lowest quartile on the anxiety screen, thereby forming the high and low anxiety groups, respectively (see Appendices C.1 and C.2). The high anxiety group consisted of 310 (31.5%) students and the low anxiety group consisted of 280 (28.4%) students. Individuals in the moderate anxiety group (i.e., students in the middle two quartiles) were ineligible for study enrollment.

The study continued enrollment until enough participants were enrolled in gender-matched groups to power the study analyses. In total, 90 participants were enrolled in the study: 44 low anxiety (LA; 19 females and 23 males) and 46 high anxiety (HA; 25 females and 20 males) participants, see Table 1. Three participants were excluded due to RA mistakes in administration (2) or failure to complete 50% of study measures (1), resulting in a final total of 87 participants: 43 males and 44 females (50.6% female). No participants self-identified as transgender. Participants ranged in age from 18 to 22 years, with a mean age of 19.17 years (*SD* = .99). The majority of participants completed the experiment during their freshman or sophomore years of college (85.1% of the sample). Participants in the final sample identified as 52.9% European American/White, 39.9% Asian/Asian American, 9.2% Hispanic American/Latino, 2.3% African American/Black, 1.1% North African, and 4.6% biracial. Approximately 1 in 4 participants (26.4%) was born outside the United States. Although 34.5% of the sample learned English as a secondary language, the vast majority (90.8%) listed English as their primary language. A majority of participants (92%) were right-handed and most (83%) have parents with at least some college education.

Measures

Anxiety Screener. ***Generalized Anxiety Disorder-7 Scale*** (GAD-7; Spitzer, Kroenke, Williams, & Lowe, 2006). The GAD-7 was originally created for efficient screening of anxiety in primary care and medical settings (Spitzer et al., 2006) and was subsequently validated in community samples (Lowe et al., 2008). The self-report questionnaire contains seven items targeting symptoms of general, or worry-based, anxiety. Individuals are asked to report the frequency of each symptom over the past two weeks by choosing "*not at all*," "*several days*," "*more than half the days*," and "*nearly every day*," respectively scored 0, 1, 2, and 3. Total scores range from 0 to 21 with anxiety severity cutoffs of >4 (mild), >9 (moderate), and >14 (severe). In varied psychiatric samples, the measure effectively assessed anxiety severity but produced many false positives, likely owing to overlapping symptoms experienced in many psychiatric illnesses (Beard & Björgvinsson, 2014; Kertz, Bigda Peyton, & Bjorgvinsson, 2013). In a community sample, a cutoff score of 10 has shown good sensitivity (89%) and specificity (82%, Spitzer et al., 2006). In psychiatric samples, specificity is reduced by half (Kertz et al., 2013). Therefore, while pragmatic in primary care or community samples, evaluative follow-up is needed for diagnostic specificity. The measure demonstrates good convergent validity with depression, anxiety, stress, and worry (Kertz et al., 2013). Finally, confirmatory factor analysis suggested that the measure best supports a two-factor structure with somatic tension items (4, 5, and 6) and worry cognition items (Beard

& Björgvinsson, 2014). In the present study, the GAD-7 was used to screen for anxiety. A score of 7 or higher at the time of prescreening defined the upper anxiety quartile, and scores of 0 or 1 defined the low anxiety quartile.

Intelligence Measure. ***Wechsler Test of Adult Reading*** (WTAR; Wechsler, 2001). This brief task is designed to assess general intellectual abilities by tapping an individual's vocabulary knowledge, considered an aspect of crystallized intelligence. In this study, it was utilized to provide a measure of intellectual equivalency across both the high anxiety and low anxiety groups. To complete the WTAR, participants read aloud words that are pronounced irregularly. The number of mispronounced words from the list of 50 provides a general approximation of intellectual functioning. The WTAR exhibits excellent internal consistency (.90 to .97) in the US standardization sample. The test was co-normed with the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III; Wechsler, 1997a), and shows high correlations with WAIS-III Verbal IQ (r = .75), FSIQ (r = .73), and verbal subtests. WTAR scores are better than demographic characteristics at predicting IQ scores (Wechsler, 2001). It is considered an adequate measure of estimating verbal IQ in individuals with expected IQs in the average range —like undergraduates at a competitive public university. In addition to the WTAR, participants were asked to self-report SAT scores to obtain another approximate measure of intellectual ability for matching of groups.

Anxiety, Mood and Cognitive Interference Measures. ***Depression Anxiety Stress Scale-21*** (DASS-21; Lovibond & Lovibond, 1995). Symptoms of depression and generalized (trait-like) anxiety were measured with the short-version of the DASS-42, designed to measure the three factors of the tripartite model (L. A. Clark & Watson, 1991): high arousal associated with anxiety (Anxiety subscale), low positive affect (Depression subscale), and negative affect (Stress subscale). The scale consists of 21 items that are rated on a 4-point Likert scale from 0 to 3 with total scores ranging from 0 to 63 points. The DASS-21 has demonstrated good to excellent internal consistency for all three scales (Antony, Bieling, Cox, Enns, & Swinson, 1998; Henry & Crawford, 2011). Overall, the scale appears to be comprised of four latent factors. Each scale comprises separate factors, and together they share a fourth factor of general psychological distress and negative affectivity (Henry & Crawford, 2011). The longer form DASS-42 has acceptable to good test-retest reliability (.71-.81; Brown, Chorpita, Korotitsch, & Barlow, 1997). The DASS is becoming more frequently used in research and clinical settings and is designed to improve upon measurement concerns with the Beck scales (Lovibond & Lovibond, 1995). Furthermore, it provides better discrimination of anxiety and depression items than the trait-version of the STAI (Bieling, Antony, & Swinson, 1998).

State-Trait Anxiety Inventory-Form Y1, State (STAI; Spielberger, 1983). The STAI is a self-report questionnaire designed to measure state and trait anxiety. It was cited by Lezak and colleagues (2012b) as an optimal anxiety measure for use in neuropsychological assessment, although the DASS has been shown to better assess trait level symptoms. In this study, participants completed only the state form (Form Y1) for assessment of current anxiety symptoms. The STAI consists of 20 items scored on a 4-point Likert scale from 1 to 4 with total scores ranging from 20 to 80. A review of published studies using the STAI found that the state questionnaire had a median reported internal consistency of .92 across all studies (Barnes, Harp, & Jung, 2002). As expected, test-retest reliabilities were generally lower on this state-reliant measure, ranging from .37 to .97 with a mean of .70.

Cognitive Interference Questionnaire (CIQ; Sarason & Stoops, 1978; Sarason, Sarason, Keefe, Hayes, & Shearin, 1986). The CIQ is a 22-item self-report questionnaire constructed to assess an individual's negative, off-task self-talk while completing a task (see Appendix B). The measure also assesses how much the individual perceives that these cognitions have distracted from their performance. The scale is broken into subscales of "task-relevant worry" items (e.g., "I thought about how poorly I was doing") and "task-irrelevant thought" items ("I thought about other activities"). Each item is rated on a 5-point Likert scale from "*never*" to "*very often*," except for the last item; item 22 requires the participant to estimate their perception of how much their mind wandered during the task on a 7-point Likert scale. The CIQ Task-Relevant Worry subscale is composed of the total score of ten items (ranging from a possible 10 to 50), whereas the CIQ Task-Irrelevant Thought subscale is composed of eleven items (range of 11 to 55). The analyses were calculated using the total score across all 21 items on these subscales. Total scores ranged from 21 to 105. The internal consistency is good for the 21-item scale (Cronbach's alpha = .85; Lachman & Agrigoroaei, 2011).

Demographic Data. Participants self-reported age, gender and ethnicity, as well as SAT Verbal and Quantitative scores.

Working Memory Tests. *Delis-Kaplan Executive Function System Color-Word Interference Test* (CWIT; Delis, Kaplan, & Kramer, 2001). The D-KEFS CWIT is a task designed to amend an inhibition/switching trial onto the original Stroop task's color naming, word reading, and inhibition trials, and is used in this study to assess the central executive. For each trial, the participant is presented with practice items and scored items. On the stimulus page, there are horizontal rows of the trial-specific items (i.e., words, colors). The participant is instructed to complete the task (e.g., read the words or name the colors) from left to right until he/she has completed all of the rows. The item content is presented in a random fashion, such that the colors do not follow a predictable pattern. The trials are timed and the errors are counted. On the color naming trial, the participant names the colors printed on the stimulus page as quickly as possible. The word reading trial involves the participant reading the names of the same colors presented as words on the page. For the inhibition trial, the participant is presented with the names of colors printed in a different ink color (CWIT Condition 3: Inhibition). The participant is instructed to say the name of the ink color, rather than reading the written color name. Lastly, the inhibition/switching trial appears similar to the inhibition trial, except half of the words are inside boxes (CWIT Condition 4: Inhibition/Switching). For the unboxed words, the participant must say the ink color—like in the inhibition trial—however, for the boxed words, the participant must instead read the written word. Normative data from the D-KEFS manual was used to convert raw data to age-based scaled scores. For this study, both Condition 3 and 4 will be used to assess central executive functioning.

Digit Span (Wechsler, 1997b). The digit span task is composed of both forward auditory digit span and backward auditory digit span from the Wechsler Memory Scale-III. In this study, the Digit Span task will be used to assess the phonological loop capacity of the participant's working memory. This task involves the evaluator reading strings of numbers and then the participant repeating them back in the same order (Digit Span Forward) or saying them back in reverse order (Digit Span Backward). Over the course of the task, the number strings increase in length. The participant's score on the task is calculated by adding together the number of successfully completed number strings for each subtask to form one total score.

Spatial Span (Wechsler, 1997b). The spatial span task is composed of both forward visual working memory span and backward visual working memory span from the Wechsler Memory Scale-III. For the present study, Spatial Span will evaluate the visual-spatial sketchpad component of the participant's working memory. Like the Digit Span task, the Spatial Span task involved both forward and backward subtests. A plastic stimulus with raised, blue blocks is placed between the evaluator and the participant. For each trial, the evaluator taps on the blocks one by one in a specific sequence. Then the participant is instructed to either replicate this sequence exactly (Spatial Span Forward) or reverse the order of the tapping in the sequence (Spatial Span Backwards). The final score is the summation of all correctly completed items on both subtests. Raw scores from both Digit Span and Spatial Span were converted to age-based normative scores with the data available in the test manual.

Trail Making Test: Trail A and Trail B (Army Individual Test Battery, 1944). Trails A and B together form a paper and pencil test of motor speed, attention, and working memory. For this study, Trail B will tap the central executive component of working memory. On Trail A, the participant is instructed to draw lines connecting numbered circles in increasing numerical order. On Trail B, each circle encloses either a number or a letter of the alphabet. The participant is instructed to drawing lines alternating between increasing numerical order and sequential alphabetic order (e.g., 1 to A to 2 to B, etc.). For both trails, the participant's score is determined by their completion time. Trail A should provide an estimate processing speed, assuming intact motor functioning. Normative data for this study was used from a study of undergraduate students (Tombaugh, 2004).

Performance Validity Tests (PVTs). ***Test of Memory Malingering*** (TOMM; Tombaugh, 1996). The TOMM is an untimed forced-choice, visual recognition memory task where the participant is presented with each of the 50 items consecutively for 3 seconds each. Following this learning trial, the participant is then presented with 50 pairs of pictures. Each pair includes one of the items was previously presented to them in the learning trial and one is a novel (distractor) item. The participant must choose which item he/she remembers from the learning trial. The evaluator provides immediate feedback telling the participant if their choice is “correct” or “no, that’s not right. It was this one.” In the original test, there are two learning trials, each followed immediately by a testing trial. A 10-minute delayed retention testing trial may also be administered. For this study, only the two learning trials with respective testing trials will be administered. Scores of 45 and above will be considered adequate performance on this measure (Tombaugh, 1996). Lower scores are uncommon among individuals putting forth good effort.

Rey-15 Item Test (Rey-15; Lezak, 1995). The Rey-15 item is a commonly used untimed performance validity test that does not follow a typical forced-choice paradigm and is easily and quickly given (Reznek, 2005). A card with 15 items, in five rows of predictable patterns of three items, is presented to the participant for ten seconds. Following the learning/recall trial, the participant is instructed to draw as many items as possible on a blank piece of paper from memory. Free recall of fewer than nine items will be considered a failure on the recall trial (Reznek, 2005). Then, the participant is immediately provided with a page of possible items from the learning trial (all 15) as well as 15 distractor items. Participants are instructed to mark which items they remember from the learning trial. The individual's combined score is calculated [recall correct + (recognition correct – false positives)], and a score of 21 and above is suggested for individuals responding validly (Morse, Douglas-Newman, Mandel, & Swirsky-Sacchetti, 2013). In the present study, a score of 20 or below will be considered a failure for the Rey-15 Item Combined score. Even individuals with significant brain injuries or other degenerative disorders often score above the cutoff for this test.

Reliable Digit Span (RDS; Wechsler, 1987). The Digit Span task can be used as an untimed embedded measure of performance validity. Since each length of digit string is repeated twice for both subtests, a reliable digit span can be calculated by observing the highest string length the participant completed for both trials at that length. Then the highest reliable string length is summed for both subtests to determine the reliable digit span. RDS is an effective measure for determining honest responders from simulators of dishonest test performance (Jasinski, Berry, Shandera, & Clark, 2011). Based on the normative data for the WAIS-III RDS, a cut score of 7.1 has been suggested (Jasinski et al., 2011; Schroeder, Twumasi-Ankrah, Baade, & Marshall, 2012). For this study, a score below 7 on the measure will be considered a failure of this validity test.

Dot Counting Test (DCT; Boone, Lu, & Herzberg, 2002). The DCT is a timed test that is easily and quickly administered. The participant is shown 12 consecutive cards with grouped and ungrouped dots. They are instructed to count the dots on each page and announce the total number. Both the time it takes for the participant to complete the DCT as well as the total counting errors are calculated for a total score—"E-score." The manual suggests that a cutoff E-score of 14 is appropriate for non-clinical groups: sensitivity of 88.2% and specificity of 96.1% (Boone et al., 2002). Scores equal to or above 14 are considered evidence of poor effort in non-clinical groups.

Procedure

Prescreening. The study was approved by the university's Institutional Review Board. During the spring semester of 2015, General Psychology students completed a prescreening survey to qualify for experimental studies through the psychology department's participant pool. Qualtrics, a secure internet-based survey software, was used for the prescreening.

Participant Recruitment. Individuals that qualified for this study scored in the upper and lower quartile of generalized anxiety based on prescreening data, and were able to enroll in experimental appointments on the department's experimental pool study sign-up portal. Participants were not informed that prescreening data was used for recruitment in this study. All participants were blind to the existence of experimental groups as well as their group affiliation.

Experimental Appointments. Each participant attended a one-on-one, in-person appointment lasting two hours with an undergraduate research assistant (RA) trained on the study protocol. The appointments began with informed consent, including an explanation of experimental procedures. Participants were asked to confirm abstinence from caffeine for the prior three hours; none reported consuming caffeine. After the consent process, the participant completed baseline questionnaires of anxiety, mood, and demographics on a laptop computer using Qualtrics, except for two instances when the computer did not work, and paper-and-pencil administration was conducted. Then, participants were administered the intelligence screener (WTAR) by the RA.

After overseeing these baseline tasks, the RA began the first of two phases of neuropsychological and effort evaluations for the experiment. First, the RA read the "supportive instructions" (see Appendix A). After which, the participant completed the STAI again. The RA then administered a counter-balanced battery of working memory and performance validity tests, followed by cognitive interference and state anxiety questionnaires. Prior to each test, the RA read aloud a brief reminder of the supportive instructions. For the second phase, state anxiety was induced and then the neuropsychological and effort assessment tasks followed a similar format: the participant heard the "anxiety-inducing instructions" (see Appendix A), filled out the STAI, completed working memory and performance validity tests with abbreviated anxiety-inducing instruction reminders, and then filled out the cognitive interference and state anxiety questionnaires.

For both testing phases, RAs administered the CWIT, Digit Span (including embedded RDS), Spatial Span, TMT, and DCT; therefore, each participant completed these tests twice across the appointment to create a within-subject, repeated-measures design. Each participant also completed the TOMM and the Rey-15 Item Test once during either phase of experiment; order was counter-balanced across participants. The supportive and anxiety-inducing instructions were adapted from Coy and colleagues (Coy et al., 2011).

After completing all study procedures, participants were read and provided with a written debriefing statement (see Appendix A). During the debriefing, the participant was informed that s/he would not receive the results of this testing, despite being told s/he would at the start of the anxiety-inducing instructions earlier in the appointment. Participants were provided with stamped copies of the debriefing statement, with contact information for the study experimenters and the IRB. No participants inquired about further information after leaving the appointment. Each participant received 4 credits towards their General Psychology course for participation.

Administration Training

Seven undergraduate RAs were trained on administration of all study measures. Each RA reviewed the manual-based instructions when provided for measures such as Digit Span, Rey-15 Item and TOMM, and received verbal instruction from the student investigator for those that did not have manuals, such as the DASS and STAI. Additionally, the RAs were provided with *in-vivo* instructions as well as videotaped directions. Following initial familiarity with each measure, the RAs practiced administering the measures to the graduate student investigator, and to each other while observed by the graduate student investigator.

After demonstrating sufficient administration abilities and gaining familiarity with the experimental procedure as judged by the student investigator, each RA practiced the entire protocol with an undergraduate enrolled through the department's participant pool but who did not qualify for either experimental group. These practice appointments were videotaped and reviewed by the graduate student supervisor. In total, 15 practice participants were recruited and filmed for establishing reliable administration procedures; each of the seven RAs completed data collection with at least two practice participants.

The practice participants were informed of their practice designation during the informed consent process. RAs were considered trained when they successfully administered the experiment to a practice participant, as judged by the student investigator.

Procedure Fidelity

Each RA collected data for four to 20 participants, based on scheduling. Each week a review meeting was held with RAs, the student investigator and PI to review procedures and answer ongoing administration questions. Halfway through data collection, each RA completed a second videotaped "practice participant," reviewed by the student investigator, to ensure reliable administration and lack of drift from protocol procedures. All RAs exhibited appropriate administration at this checkpoint. RAs were blind to participant group membership.

Data Analytic Plan

All variables were tested for normality and descriptive statistics were calculated (e.g., mean, total, standard deviations, ranges). T-test comparisons were completed between groups for age, SAT score, and WTAR estimated intellectual score to establish group equivalency. Gender distributions were also matched, using chi-square analyses. To assess groups at baseline, t-tests were completed to assess differences for generalized anxiety (on the GAD-7 and the DASS), state anxiety, stress, and depression.

To assess the first hypothesis, a one-way 2 (group) x 5 (cognitive task) MANOVA was conducted to assess potential group differences on the various working memory tasks during the first phase. In the event of significant results, post-hoc t-tests by cognitive task were planned.

Analyses to assess a mediation model in the second hypothesis were planned. Structural equation modeling (SEM) to assess the potential mediation effect of cognitive interference on the relationship between anxiety level and working memory tasks for the high anxiety group during the first phase would be conducted.

The third hypothesis was analyzed with 2 (group) x 2 (phase) mixed-design ANOVAs for each cognitive measure to assess the main and interactive effects of state anxiety on performance across the HA and LA groups. If these analyses were found to be significant, cognitive interference mediation analysis was planned via SEM.

The fourth hypothesis expanded upon the first by examining performance validity by anxiety group, and then across phases. Percentages and frequency of failures of each group's PVT were reported. For measures failed more than once, chi-squared analyses of pass/fail rates for each measure were conducted by group and phase. When fewer than five cases were found in a chi-square analysis cell, Fisher's exact test was used instead to adjust for the small sample size. In addition to pass/fail rates, continuous scores on all PVTs were assessed. For the TOMM and the Rey-15 Item (both only given once to each participant), t-test analyses were conducted to assess group differences during the phase in which the test was given. For RDS and the DCT, 2 x 2 ANOVA mixed design analyses were conducted to examine effort performance by group and phase.

To address the fifth hypothesis, failures on performance validity tests were determined (using the cutoffs presented in Table 6) and counted to assess effort in the undergraduate sample collapsed across groups. The percentage of individuals with failed PVTs were reported and compared to existing normative data.

Power Section

Power analyses were conducted using G*Power 3.1 for the third hypothesis, several ANOVA, repeated measures, within-between interactions. For each dependent variable, 2 (group) x 2 (phase) mixed-design ANOVAs were planned. Based on Coy and colleagues (2011) study of state anxiety manipulation with similar cognitive tasks, a medium effect size was expected. Test-retest reliability for the cognitive measures ranged from 0.65 to as high as 0.90. The *a priori* sample size calculations were conducted with the most conservative estimates to ensure sufficient power for analyses. For 0.80 power, 0.05 alpha probability, 0.65 test-retest reliability, 0.02 small partial eta squared (estimated total variance in the outcome variable accounted for by the predictor variable) for an effect size of 0.14, a sample size of 70 was suggested (at least 35 per group).

Missing Data

During the recruitment phase, 90 participants were enrolled to ensure adequate sample size in the event of missing data, administration errors, or PVT failures. Of the 90 enrolled, three participants were excluded from all analyses; two resulted from RA administration errors, and one participant failed to complete 50% of questionnaire data. Therefore, the final study sample numbered 87 participants, 42 in low anxiety and 45 in high anxiety. Removal of three participants from the experimental sample did not substantially alter the demographic data (see Table 1). Of the final sample of 87 participants, nine additional participants had missing data, which was determined to be missing at random. Five of these participants skipped questions on the questionnaires. Three were missing a score due to misadministration. Lastly, one participant reported being color-blind; thus, scores on the Color-Word Interference Test were dropped from analyses. For the nine participants with minor amounts of missing data, pairwise deletion was used. No participants discontinued the appointment or asked to be removed from statistical analyses. Based on a final sample size of 87, the study was powered at 88%.

Results

Descriptive Statistics

Baseline anxiety, mood and cognitive interference, reported in Table 1, were within expected ranges for a community sample. Although strong floor or ceiling effects were present on some measures, also due to use of a community sample, the sample size was large enough for the central limit theorem to provide reasonable robustness of proposed statistical analyses. Participants averaged a standard IQ estimate score of 106.05 (SD = 12.24), which is in the average range. Although 13.8% of participants reported receiving speech language interventions, no estimated IQ scores fell below two standard deviations of the mean (WTAR ranged from 71 to 127), indicating sufficient English reading abilities for study inclusion. Only 6.9% of the sample reported currently receiving psychological treatment or psychiatric medication. All participants denied consuming caffeine in the three hours prior to the beginning of the experimental appointment, as was required for study inclusion.

Descriptive Statistics by Group

Groups were evaluated for matching characteristics of gender, age, estimated IQ, and SAT score. As shown in Table 2, no group differences were found for gender ($X^2(1, 87) = 0.93$, $p = 0.336$), age ($t(85) = .38$, $p = .706$), or estimated IQ ($t(85) = .26$, $p = .793$). No group differences were noted for Math or Verbal SAT scores ($t(78) = -1.40$, $p = .165$ and $t(76) = -.29$, $p = .769$, respectively). Descriptive statistics by group for each of the symptoms questionnaires, performance validity measures, and cognitive tests are provided in Tables 2, 3, 4, 5, and 10. All variables were evaluated for normality.

Baseline Symptom Group Comparisons

As expected, based on selective recruitment procedures, pre-screened general anxiety differed by group; the HA group reported more anxiety, $t(56.38) = -11.67$, $p < .001$. Reassessment of general anxiety at baseline indicated that this group difference was maintained over the recruitment period, with the HA group again reporting more symptoms on the GAD-7 anxiety scale, $t(85) = -3.47$, $p = .001$. Additionally, the HA group reported more state anxiety at the beginning of the experimental appointment ($t(85) = -2.56$, $p = .012$; see Table 2).

Manipulation Check

During both phases of the experiment, the participants reported state anxiety prior to and just after receiving phase instructions, which were intended to be either supportive or anxiety-inducing. A 2 (group) x 2 (state anxiety) mixed-design ANOVA was completed for pre- and post-instruction state anxiety for both instruction types. For the supportive instructions, there was a small main effect of group, indicating that the HA group endorsed more state anxiety overall ($F(1, 84) = 5.08$, $p = .027$, $r = .24$). There was no main effect of state anxiety across time ($F(1, 84) = .15$, $p = .696$, $r = .04$), and no interaction effect ($F(1, 84) = 1.97$, $p = .164$, $r = .15$). For the anxiety-inducing instructions, which were always given second, there was a medium main effect, whereby state anxiety was higher after the instructions as compared to state anxiety after phase 1 but right before the second instructions ($F(1, 83) = 22.79$, $p < .001$, $r = .46$). There was not a significant main effect of group, $F(1, 83) = 2.84$, $p = .096$, $r = .18$, nor an interaction effect, $F(1, 83) = .23$, $p = .630$, $r = .05$.

Hypothesis 1: General Anxiety Variability on Working Memory Performance

To assess potential group differences on the various working memory tasks during the first phase, a 2 (group) x 5 (cognitive task) MANOVA was conducted. Using Pillai's lambda, there was not a significant effect of group on working memory performance during the supportive phase, V = 0.07, $F(5, 80) = 1.19$, $p = .321$.

Hypothesis 2: Cognitive Interference as Mediator Between Anxiety and Working Memory

Since there was no relationship between anxiety and working memory during the first phase, cognitive interference mediation analyses were not conducted.

Hypothesis 3: State Anxiety and Working Memory Performance

The impact of state anxiety on working memory performance was assessed with 2 (group) x 2 (phase) mixed-design ANOVAs, with each working memory measure serving as the dependent variable. For speeded central executive functioning on the TMT Trail B, a medium main effect of phase was found: individuals in the anxiety-inducing phase completed the task more quickly, $F(1, 85) = 48.31$, $p < .001$, $r = .60$. Neither the main effect of group, $F(1, 85) = 2.28$, $p = .135$, $r = .16$, nor the interaction of group and phase were significant, $F(1, 85) = .87$, $p = .353$, $r = .10$. On speeded central executive functioning, CWIT Condition 3: Inhibition, there was a large main effect of phase with participants completing the task quicker on the anxiety-inducing phase, $F(1, 84) = 85.19$, $p < .001$, $r = .71$. There was no main effect of group affiliation ($F(1, 84) = .25$, $p = .621$, $r = .05$) or interaction effect ($F(1, 84) = 3.44$, $p = .067$, $r = .20$). On CWIT Condition 4:

Inhibition/Switching, the main effect of phase was again significant with a large effect size ($F(1, 84) = 89.10$, $p < .001$, $r = .70$). There was no group main effect ($F(1, 84) = .01$, $p = .941$, $r = .01$) or interaction effect ($F(1, 84) = .09$, $p = .766$, $r = .03$). Therefore, group did influence the central executive; however, performance was significantly improved during the second phase of induced state anxiety for all measures of the central executive.

For the two untimed cognitive tasks, Digit Span assessed phonological loop capacity and Spatial Span assessed visual-spatial sketchpad capacity. For both, 2 (group) x 2 (phase) mixed-design ANOVAs were completed. On Digit Span, assessing phonological loop capacity, there was a medium main effect of phase, indicating that participants performed better on the second, anxiety-inducing phase, $F(1, 85) = 20.104$, $p < .001$, $r = .44$. There was no main effect of group ($F(1, 85) = .02$, $p = .886$, $r = .02$) and no interaction effect between group and phase ($F(1, 85) = .09$, $p = .764$, $r = .03$). Similarly, on Spatial Span, the measure of visual-spatial sketchpad capacity, there was a medium main effect of phase, with higher performance in the second phase ($F(1, 85) = 15.35$, $p < .001$, $r = .39$). There was neither a main effect of group, $F(1, 85) = 1.08$, $p = .301$, $r = .11$, nor an interaction effect of group and phase, $F(1, 85) = .00$, $p = .986$, $r = .00$. In sum, for both timed and untimed measures of working memory (regardless of component), analyses revealed consistently significant phase effects with faster/better performance occurring during the second phase. Group affiliation was not associated with working memory performance across phases.

It was hypothesized that for both groups during the second phase, cognitive interference would mediate the relationship between anxiety and neurocognitive performance for the phonological loop task (i.e., Digit Span) and the central executive task (i.e., CWIT Condition 3 and 4, TMT Trail B). Although group affiliation determined by level of general anxiety was not associated with working memory performance, state anxiety may have been associated with working memory performance. Therefore, regression analyses investigated this proposed relationship for both groups during the second phase. For the HA group, state anxiety did not predict performance for any of the central executive/phonological loop measures (Digit Span, $R^2 = .01$, $F = .53$, $p = .472$; CWIT Condition 3, $R^2 = .00$, $F = .00$, $p = .951$; CWIT Condition 4, $R^2 = .00$, $F = .05$, $p = .830$; TMT Trail B, $R^2 = .04$, $F = 1.84$, $p = .182$). Moreover, state anxiety did not predict central executive/phonological loop performance in the LA group (Digit Span, $R^2 = .07$, $F = 2.84$, $p = .100$; CWIT Condition 3, $R^2 = .04$, $F = 1.47$, $p = .233$; CWIT Condition 4, $R^2 = .02$, $F = .71$, $p = .403$; TMT Trail B, $R^2 = .06$, $F = 2.35$, $p = .133$). Since the relationship between anxiety and working memory was not found in any of these analyses, the proposed mediator of cognitive interference could not be assessed.

Hypothesis 4: Anxiety Level and Performance Validity

The fourth hypothesis examined whether generalized anxiety or state anxiety impacted effort testing. No participants from either group failed the TOMM Trial 2 or the Rey-15 Item Recall; therefore, analyses of pass/fail rate by group on these tests were not applicable. The most frequently failed PVT was the DCT at 10 failures, with eight failures from the LA group (see Table 7). Notably, individuals in the LA group did not fail any other PVT in this study. For the DCT, individuals from the LA group were more likely to fail this test (see Table 8). RDS was failed five times, all by participants in the HA group. When comparing failures on the RDS and DCT during the supportive instructions phase, Fisher’s exact test revealed that failed test type differed by group status (*p* = .024). If a participant failed RDS, he/she was more likely to be in the HA group, whereas the reverse was true for the DCT.

Finally, to examine failure across PVTs, failure rates were combined across the RDS and DCT. For both the RDS and DCT, there were a total of eight failures (16.67%) in the LA group and seven (13.33%) failures in the HA group. To investigate the possibility that group status might predict failure on either of these two commonly failed PVTs, individuals were sorted into those with RDS/DCT failures and those without failures on either test. Group status was not predictive of a tendency to fail a performance validity test, using the Fisher's exact test (*p* = .342; Table 9).

In addition to dichotomizing PVTs into "failures" and "non-failures," continuous scores can be calculated for all PVTs, and were analyzed for possible group effects. For example, although an individual may not "fail" a PVT outright, overall scores may be lower for a particular group. The TOMM and the Rey-15 were only given once during the experiment, so t-tests were conducted to determine possible group differences during the phase in which the measure was administered to the participant. On the Rey-15 Item, the Recall trial was used to eliminate the outlying Recognition score (described above). There were no group differences for either phase on the TOMM Trial 2 ($t(50) = -1.28$, $p = .206$ for supportive phase and $t(33) = .76$, $p = .450$ for anxiety-inducing phase). Likewise, there were no group differences on the Rey-15 Item Recall trial scores during the supportive instructions phase ($t(33) = .76$, $p = .450$) or the anxiety-inducing instructions phase ($t(49) = -.18$, $p = .858$).

The RDS and the DCT were administered twice to each participant; therefore, 2 (group) x 2 (phase) mixed-design ANOVAs were conducted for each measure. Although not hypothesized to predict performance, there was a medium main effect of phase on RDS scores, which are accuracy and not time-based. All participants performed better on RDS during the second, anxiety-inducing phase, $F(1, 85) = 16.33$, $p < .001$, $r = .40$. There was neither a significant group effect nor interaction effect between group and phase, $F(1, 85) = .66$, $p = .418$, $r = .09$ and $F(1, 85) = .02$, $p = .890$, $r = .02$, respectively.

Performance on the DCT was assessed by integrating accuracy and speed of performance to calculate the E-score. There was a large main effect of phase whereby performance improved during the second phase regardless of group affiliation, $F(1, 84) = 82.01$, $p < .001$, $r = .70$. Although it was hypothesized that the HA group would perform this test more slowly, there was no main effect of group on timed performance ($F(1, 84) = 1.81$, $p = .182$, $r = .15$). A medium interaction effect indicated that although both groups performed the task more quickly during the second phase, the LA group improved to a greater extent from the first phase to the second phase ($F(1, 84) = 4.89$, $p = .030$, $r = .23$; see Figure 1). Pictorial representation of this effect suggests that the LA group had more room for improvement, since they were mathematically but not statistically slower during the first phase than the HA group. Analyses of only timed (without accuracy) components of the E-score on the DCT revealed similar results (all $p > .05$).

Hypothesis 5: Performance Validity in an Undergraduate Sample

Pass/fail cutoff scores for each PVT were reported in Table 6. Following these guidelines, 2.87% of all administered PVTs were failed (15 of 522). However, 13 of 87 participants (14.94%) failed at least one measure (see Table 7). Two participants, one from each group, failed the same measure twice, once during each phase. These participants failed different measures from each other (i.e., the DCT and RDS). Table 11 depicts PVT results for any participant with at least one PVT failure. The majority of the PVT failures (73.33%) occurred during the supportive-instructions, or first, phase (11 of 15). No participants (0%) failed the TOMM. One HA participant failed the Rey-15 Item during the anxiety-inducing instructions phase, with an unusually low score far below the cutoff (-2 out of 21). Despite intact free recall of many items, this participant missed all true positives and made many false positives on the recognition trial, using recall trial only cutoffs, this participant did not fail the measure (Reznek, 2005). In sum, no participants were found to fail the TOMM or the Rey-15 Item, both of which were given just once during each appointment.

Discussion

The current study evaluated the relationship between anxiety and working memory in undergraduates pre-screened for general anxiety level. In addition, the study investigated performance validity failures in the undergraduate sample, including students with low and high general anxiety. Although groups were found to be significantly different in their anxiety level at baseline, few group differences were found when assessing the main hypothesis regarding a relationship between working memory and anxiety. Analysis of performance validity resulted in some group differences and new information regarding invalidity in an undergraduate and sub-clinically anxious sample.

Working Memory and Anxiety

During the supportive instructional phase, the HA and LA groups did not differ on any of the cognitive tasks administered to assessing working memory functions: the CWIT Inhibition or Inhibition/Switching Trials, Digit Span, Spatial Span, or Trail

Making Test: Trail B. For the HA group during the supportive phase, state anxiety did not predict performance on any of the working memory measures, despite the higher endorsement of general anxiety. On both timed and untimed measures of working memory, group affiliation (based on general anxiety) was not associated with performance. These results do not support Eysenck's attentional control theory, which states that anxiety likely interferes with efficiency of working memory but not effectiveness—particularly related to the central executive component of Baddeley's working memory model. Regardless of the working memory component targeted by the tasks in this study (i.e., central executive, phonological loop, or visuo-spatial sketchpad), anxiety level was not predictive of performance.

Notably, both groups performed working memory tasks more efficiently and/or more accurately (depending on the measurement type) during the second administration. These findings may be the result of practice effects and/or elevated effort towards testing (following anxiety-inducing instructions during the second phase). However, state anxiety during the second phase was not predictive of working memory performance in either group. Therefore, if anxiety is presumed to co-vary with motivation (which was not assessed nor conclusively agreed upon by researchers), there is tentative evidence that a practice effect may be the culprit rather than an arousal induction.

In sum, the theorized effect between general anxiety and working memory performance was not supported by the data. As a result, proposed mediation analyses of cognitive interference were neither suggested nor possible. Both Eysenck's theory of attentional control and Sarason's theory of cognitive interference have primarily investigated trait or test anxious community individuals, with less focus on symptoms of generalized anxiety—the type assessed in this study. Alternative anxiety focus (i.e., cognitive worry, arousal, physiological assessment) or symptom measure may have resulted in more support for these theories. More likely, however, the analyses completed in this study were hindered by the low endorsement of anxiety symptoms and resultantly constrained group differences within the community sample. Further exploration of study limitations and future directions is considered below.

Performance Validity

Based on concerns about frequent performance invalidity in undergraduate samples (An et al., 2012), this study assessed performance validity of all participants, using several stand-alone PVTs (i.e., the TOMM, Rey-15 Item, and DCT), and one embedded PVT (i.e., Reliable Digit Span). No participants from either the HA or LA groups fell below cutoffs on the TOMM Trial 2 or the Rey-15 Item Recall Trial. This study adds to the growing literature that undergraduates exhibit adequate effort to pass the TOMM, the most-widely used, stand-alone performance validity measure according to neuropsychologists with expertise in validity testing (Schroeder, Martin, & Odland, 2016). In addition to this study, both prior studies using the TOMM with undergraduates failed to find any failures on the measure (An et al., 2012; Silk-Eglit et al., 2014). The Rey-15 Item, tied for fourth most frequently administered PVT in clinical practice (Schroeder et al., 2016), has not been previously examined in an undergraduate validity study. Only one participant failed the Rey-15 Item Recognition Trial by perfectly reversing target-distractor discrimination; therefore, it is likely that this second language English learner may have misunderstood the recognition instructions, perhaps mistakenly circling new items rather than recognized items. This participant passed the Recall trial, and all other participants in this study passed both trials on the test; therefore, the present study provides preliminary evidence of a useful and robust measure of effort in undergraduate populations. Furthermore, the Rey-15 Item test is quickly administered and is available in the research literature so it can be used without additional cost to the researcher.

Despite the promising results from this study about the utility of the TOMM and the Rey-15 Item in undergraduate samples, nearly 15% of the sample had at least one failure on two other PVTs, the DCT and RDS. Both the LA and HA groups had at least a 13% failure rate. This result is lower than An and colleagues (2012) findings, but is consistent with more recent results found using a battery of embedded computerized indices on the CNS Vital Signs (DeRight & Jorgensen, 2015). Almost three-fourths of the failures occurred during the first administration in the repeated measures design, during the “supportive-instructions” phase. It is possible that a practice effect decreased the effectiveness of using the measures during the second phase. Alternatively, the “anxiety-inducing instructions” phase resulted in a perceived increase in task demands, which may have increased the participants’ motivation to put forth good effort. In neuropsychological research, it is common for participants with two failures to be designated as failing to meet effort requirements. This study had two participants with two failures, one from each group (see Table 11).

Although group affiliation was not predictive of the likelihood of failing any PVT, it was predictive of which PVT was failed. During the supportive phase, when most PVT failures occurred and instructions most closely reflected typical neuropsychology examinations, individuals in the HA group were more likely to fail RDS and individuals in the LA group were more likely to fail the DCT. Overall, the majority of PVT failures in the HA group were on the embedded RDS measure, which is designed to measure working memory ability rather than assess performance validity. Therefore, RDS may be more susceptible to working memory weaknesses seen in individuals with affective states, despite the lack of significant results related to transient anxiety in this study. Many clinicians use embedded measures of performance validity, particularly when pressed for time, when no external incentive is readily identifiable, and/or when monetary funds are not available for stand-alone PVTs. Only two participants in the HA group failed a stand-alone PVT (Table 11). These results suggest that embedded PVTs, specifically RDS, may not be reliable for determining performance validity in individuals with at least subclinical general anxiety. Individuals with clinical levels of general anxiety are at least as likely to fail RDS as those found in this study.

These findings contribute to a small literature on performance validity testing in individuals with anxiety. Two prior studies in older adults found no failures on the TOMM in self-reported high state and trait anxious individuals. The present study adds to this literature by showing that individuals with sub-clinical general anxiety also did not fail the TOMM. Additionally, this study provides additional information about how sub-clinically anxious individuals perform on the Rey-15 Item, DCT, and RDS. In sum, as stated above, the RDS appears to be more sensitive to anxious distress than the other three PVTs administered in this study.

In contrast to looking at PVT failures, continuous scores on PVTs were also inspected. Group affiliation alone did not differentially predict continuous scores on the TOMM, Rey-15 Item Recall Trial, RDS, or DCT. On the DCT and RDS, individuals performed better during the second administration, regardless of group affiliation. For the DCT, the LA group also showed greater improvement over time, although both groups improved. This finding suggests that the “anxiety-provoking,” phase 2 instructions may have been successful at increasing the perceived importance of the task, which in turn increased effort towards task completion. On the other hand, participants may have simply scored better due to a practice effect, as previously noted.

Limitations

Several limitations were identified in this study. The sample was constrained. Study participants were all undergraduates recruited from a community sample, which limits the generalizability of findings to typical neuropsychology referrals. The majority of the patients, even those in the HA group, did not present with clinical levels of anxiety. Overall, the lack for support for hypothesized outcomes in this study are attributed to the community sample used. Not only were the groups both subclinical in anxiety level, there was little variance across the available students in the pool. Students were also pre-screened for anxiety symptoms over a month before baseline testing was readministered and many students showed variability of self-reported symptoms over that time. Some students in the HA group, for example, reported less anxiety at baseline but were still considered part of the HA group, which overall was still significantly higher in self-reported anxiety than the LA group. Those who did have significant anxiety may have been attending psychotherapeutic and medication interventions, which may have lowered the influence of anxiety on working memory. The HA group reported significantly more anxiety symptoms on the general anxiety questionnaire; however, this difference in anxiety may not have reached clinically meaningful levels. Therefore, the study may not have been able to approximate differences found between non-anxious and highly anxious individuals. The theorized conditions used to develop this study may only be valid in individuals with significant anxiety rather than subclinical levels. Additionally, general anxiety was the target of the screening and baseline questionnaires (rather than trait anxiety). Studying different types of clinical levels of anxiety may provide richer information about how these proposed mechanisms (e.g., cognitive interference, poor inhibitory control) might occur for anxious individuals.

The sample also consisted of undergraduates at a public university with selective admissions; thusly, the recruitment pool and final sample were more highly educated than the general public, which may limit the generalizability of this study's findings. Many individuals in this sample learned English as a second language or did not use English as their primary language at present. Therefore, there may have been some difficulty with reading comprehension or understanding the RA's instructions, which may have interfered with potential effects, particularly in a subclinical sample where expected effect sizes are small.

Unfortunately, since the phases were not counterbalanced, practice effects likely account for nearly all improvement seen across time, a rather unlikely finding otherwise that anxiety-inducing instructions related in improved performance for individuals with higher general anxiety. The students in that group, however, would not generally have qualified for clinical levels of generalized anxiety; therefore, their responses may not be the same as expected for individuals with clinical anxiety. Their ability to use motivation to overcome anxious interference may have been greater.

The instructions used in this study are not typical of neuropsychological evaluations. This change, like with any situational factor, can alter the results observed. Many neuropsychologists who use PVTs in their practice will encourage patients to always give their “best effort” and may even let them know that poor effort will be noticeable during testing. These instructions have been developed to encourage individuals with plans to falsely represent themselves and/or individuals with low motivation to provide good, consistent effort for interpretable results. Given that this was a low stakes testing environment, it is possible that by not noting this possibility for the participants, some individuals with low motivation may have invalidated their performance. If accurate, this effect may have undermined the primary hypothesis involved detecting differences in performance between high and low anxious groups; individuals with low anxiety may not have been compelled to put forth high effort and may have appeared more consistent with performance in the HA group.

Many situational or contextual factors can play a role in performance. For example, the majority of RAs were aware, at least to some extent, about the study’s aims and hypotheses. One of the RAs who helped write the IRB was also needed to run participants due to time constraints. Additionally, the focus of the research laboratory on anxiety-related research makes it difficult to blind RAs from the role of anxiety in research questions. All RAs were blinded to group affiliation of the participant, and many RAs were unaware of the existence of different group affiliations, as participants and RAs were blinded to the process of appointment assignments.

Conclusions and Future Directions

In summary, the current study presents new findings related to performance validity in both undergraduate and elevated general anxiety samples. Consistent with prior research, undergraduates and individuals with elevated anxiety symptoms passed the TOMM without issue. Adding to this literature base, the Rey-15 Item was also not failed by anyone from either group, suggesting that this measure may be less sensitive to affective distress. In contrast, the DCT and RDS were failed fairly frequently, resulting in an overall PVT failure rate of approximately 15%. They were also predictive of HA and LA group affiliation. RDS was frequently failed by individuals with sub-clinical levels of anxiety; the DCT was more likely to be failed by individuals with few anxiety symptoms. Future extensions from these findings suggest that additional studies should look at a variety of PVTs with undergraduate students, and consider which PVTs are most informative when working with these participants. Additionally, more research into the types of PVT failures observed in clinically anxious populations is needed, particularly since many PVTs are associated with working memory and attentional factors—possible weaknesses in this population. The confound of internal motivation, commonly seen in anxious high-achievers, is an additional variable that future studies might consider.

Since support for a link between anxiety and working memory functioning has grown, there may be opportunities to clinically intervene to help individuals with anxiety who complain of cognitive problems or who are documented to have reduced working memory abilities (Crocker et al., 2013; Snyder, Miyake, & Hankin, 2015). Over the past several decades, cognitive rehabilitation interventions have gained empirical and clinical support for use with individuals with mild cognitive deficits (Cicerone et al., 2011).

These interventions are presently indicated for individuals with mild cognitive impairment, amnestic type (Hampstead, Gillis, & Stringer, 2014) and executive functioning deficits (Cicerone, Levin, Malec, Stuss, & Whyte, 2006). Cognitive psychotherapy is empirically supported for anxious individuals with distorted self- or world-beliefs; therefore, cognitive rehabilitation techniques targeted at working memory and executive functioning skills may be a natural adjunct to traditional cognitive-behavioral therapy. Providers likely find that their anxious patients frequently complain of difficulties concentrating and completing tasks efficiently, which suggests that the patient would be open to activities geared at rehabbing these difficulties. In fact, a recent pilot study found that a 3-week-long working memory training resulted in improved attentional control, trait anxiety, and resting state EEG (Sari, Koster, Pourtois, & Derakshan, 2015). Research into the effectiveness and feasibility of cognitive rehabilitation for individuals with anxiety is recommended.

Lastly, only a handful of studies have directly investigated the interplay between working memory, anxiety, and biomarkers; however, recent research is promising and may even provide fruitful ways to differentiate between effort and motivation in working memory task engagement of individuals with anxiety (Berggren & Derakshan, 2012; Derakshan & Eysenck, 2010). Future studies are encouraged to use translational research techniques for pursuit of a neurological link with theorized models.

Appendix A

Examiner-Administered Instructions
Adapted from (Coy et al., 2011)

SUPPORTIVE INSTRUCTIONS
Taken from (Coy et al., 2011)

“As was mentioned earlier, this project involves you performing tests that assess attention, concentration and memory. Before we begin, though, we want to let you know that these tests are commonly used to assess abilities in many individuals for psychological experiments. Some tasks will be fairly easy for you to complete whereas some will likely be more difficult. In general, just try to complete the tests to the best of your abilities. At the end of testing, we will be happy to discuss any questions you may have or explain the testing further with you. Any questions?”

ANXIETY-INDUCING INSTRUCTIONS
Adapted from (Coy et al., 2011)

“As was mentioned earlier, this project involves you performing tests that assess attention, concentration and memory. The first round of tests was for practice. Now we will complete the actual testing. You should know, 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. As you likely noticed, many of these tests may seem quite difficult. During each test, you will be timed and notes will be taken regarding your performance. It is important that you do well this time around because at the end of the session, we will review the results with you and compare your performance with the performance of other college students. We will also be able to tell if you have not improved upon your practice scores. Any questions?”

Examiner-Administered Instruction Reminders
Adapted from (Coy et al., 2011)

SUPPORTIVE REMINDER

“Remember, we are not that concerned about your performance, so do not worry so much about whether you are doing good or bad. Please just do your best. We want to remind you that no one will see the results of your performance.”

ANXIETY-INDUCING REMINDER

“Remember, this round is the actual testing. These tests have been shown to be highly related to intelligence and ability to do college work. It is important that you do well this time around because at the end of the session, we will review the results with you and compare your performance with the performance of other college students.”

Debriefing Statement*
Written for this study

“Thank you for completing the study today. Although the tasks completed in this study do inform our understanding of cognitive abilities in undergraduate students and young adults, we will not be informing you about your performance today. We were interesting in learning how different factors, including situational factors impact performance. Today, we investigated how instructions and self-disclosed emotional experiences impact cognitive performance on these tasks. Our findings suggest that it’s possible for our emotional experiences to hinder our performances on these sort of measures. We really appreciate the time and energy you put into completing this experiment and will be looking at performances at the groups level. Your results will be analyzed along with other individuals’ performances who completed the same measures to understand the main study objective. If you have any questions about the study procedures, please contact the graduate student research or faculty members listed on your Debriefing Statement.”

*Participants were read aloud this statement and provided with a written copy, which included study contact information.

Appendix B

Cognitive Interference Questionnaire
(Sarason et al., 1986; Sarason & Stoops, 1978)

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 approximately how often each thought occurred to you while working on it by placing the appropriate number in the blank provided to the left o 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 got 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 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 in the future.

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

1 2 3 4 5 6 7

Not at all Very Much

Appendix C

Tables

Table 1.

Demographic Information of the Overall Sample

Variable Name	Overall Sample (n = 90)	Missing Data
Gender	44 males; 46 females	0
Age (years)	19.18 (1.01), 18 - 22	1
WTAR (SS)	106.12 (12.31), 71 - 127	1
SAT Math	637.60 (88.02), 400 - 800	7
SAT Verbal	595.84 (83.89), 300 - 780	9

Demographic Information of the Experimental Sample

Variable Name	Experimental Sample (n = 87)	Missing Data
Gender	43 males; 44 females	0
Age (years)	19.17 (0.99), 18 - 22	0
WTAR (SS)	106.05 (12.24), 71 - 127	0
SAT Math	637.14 (87.66), 400 - 800	7
SAT Verbal	597.22 (85.16), 300 - 780	9

Note. Data are presented as Mean (SD), Minimum - Maximum values.

Table 2.

Demographic Information, Prescreening, and Baseline Symptoms by Group

Variable Name	High Anxiety Group (n = 45)	Low Anxiety Group (n = 42)	t-value	p-value
Gender (M:F)	20:25	23:19	X^2=0.925	.336
Age (years)	19.13 (1.06) 18 - 22	19.21 (0.93) 18 - 22	0.379	.706
WTAR	105.71 (12.56) 71 - 127	106.40 (12.03) 73 - 127	0.263	.793
Math SAT	650.46 (86.86) 400 - 800	623.13 (87.41) 400 - 800	-1.403	.165
Verbal SAT	600.00 (89.50) 300 - 780	594.29 (81.44) 450 - 730	-.294	.769
Prescreen GAD-7	9.38 (4.68) 0 - 21	.67 (1.72) 0 - 8	-11.666***	< .001
Baseline GAD-7	7.64 (5.54) 0 - 21	4.02 (4.00) 0 - 14	-3.474**	.001
Baseline DASS-21 *Overall Score*	12.60 (11.68) 0 - 50	5.44 (5.93) 0 - 24	-3.633**	.001
Baseline DASS-21 *Depression Scale*	3.38 (3.45) 0 - 14	1.59 (1.99) 0 - 7	-2.986**	.004
Baseline DASS-21 *Anxiety Scale*	3.69 (4.57) 0 - 20	1.56 (2.15) 0 - 11	-2.804**	.007
Baseline DASS-21 *Stress Scale*	5.53 (4.78) 0 - 19	2.29 (2.49) 0 - 9	-3.994***	< .001
Baseline STAI	40.49 (12.81) 20 - 75	34.10 (10.21) 20 - 54	-2.562*	.012

Note. Data are presented as Mean (SD), Minimum - Maximum values.

Note. *p < .05, **p < .01, ***p < .001

Table 3.

Questionnaire Results from Experimental Phases

Variable Name	High Anxiety	Low Anxiety	t-value	p-value
STAI *Post-Supportive Instructions*	39.43 (13.395) 20 - 75	34.79 (10.626) 20 - 55	-1.786	.078
STAI *Post-Round 1 Testing*	38.89 (11.831) 20 - 80	34.59 (11.565) 20 - 57	-1.703	.092
CIQ Total *Post-Round 1 Testing*	45.18 (13.920) 21 - 102	45.02 (14.129) 22 - 97	-.093	.929
CIQ Relevant *Post-Round 1 Testing*	26.71 (7.879) 10 - 47	26.56 (7.513) 11 - 48	-.007	.995
CIQ Irrelevant *Post-Round 1 Testing*	18.48 (8.577) 11 - 55	18.47 (8.675) 11 - 49	-.053	.958
STAI *Post-Anxiety Ind. Instructions*	42.98 (13.172) 20 - 80	38.51 (13.864) 20 - 77	-1.540	.127
STAI *Post-Round 2 Testing*	40.55 (13.651) 20 - 80	35.83 (13.296) 20 - 77	-1.621	.109
CIQ Total *Post-Round 2 Testing*	42.40 (14.175) 21 - 102	42.60 (15.682) 22 - 97	0.64	.949
CIQ Relevant *Post-Round 2 Testing*	25.76 (8.705) 10 - 50	25.14 (10.127) 10 - 50	-.306	.760
CIQ Irrelevant *Post-Round 2 Testing*	16.64 (8.394) 11 - 55	17.47 (8.511) 11 - 47	.455	.650

Note. Data are presented as Mean (SD), Minimum - Maximum values.

Note. +p < .1, *p < .05, **p < .01, ***p < .001

Table 4.
Cognitive Measures by Group, for TMT and CWIT

Variable Name	High Anxiety	Low Anxiety	t-value	p-value
TMT Trail B T-Score *Round 1 Testing*	53.46 (11.63) 34.3 - 91.8	58.05 (16.95) 34.3 - 110.7	1.48	.142
TMT Trail B T-Score *Round 2 Testing*	44.74 (8.78) 31.1 - 72.9	46.63 (9.49) 28.0 - 70.5	.97	.337
CWIT 3: Inhibition Scaled Score *Round 1 Testing*	11.91 (1.83) 7 - 16	12.34 (2.07) 7 - 16	1.02	.309
CWIT 3: Inhibition Scaled Score *Round 2 Testing*	13.38 (1.64) 10 - 16	13.32 (1.77) 9 - 16	-.17	.869
CWIT 4: Inhibition/Switching Scaled Score *Round 1 Testing*	12.02 (1.42) 9 - 15	12.00 (2.80) 2 - 15	-.05	.964
CWIT 4: Inhibition/Switching Scaled Score *Round 2 Testing*	13.53 (1.44) 10 - 16	13.61 (1.46) 10 - 16	.24	.808

Note. TMT = Trail Making Test. CWIT = Color-Word Interference Test.
Note. Data are presented as Mean (SD), Minimum - Maximum values.
Note. *p < .05, **p < .01, ***p < .001

Table 5.
Cognitive Measures by Group, for DS and SS

Variable Name	High Anxiety	Low Anxiety	t-value	p-value
DS Total Scaled Score *Round 1 Testing*	10.51 (2.87) 5 - 17	10.64 (2.42) 6 - 18	.23	.818
DS Total Scaled Score *Round 2 Testing*	11.36 (2.90) 5 - 18	11.38 (2.46) 7 - 18	.04	.965
DS Forward Span z-score *Round 1 Testing*	.01 (.88) (-1.99) - 1.75	.12 (.90) (-1.42) - 1.75	.54	.590
DS Forward Span z-score *Round 2 Testing*	.12 (.90) (-1.24) - 1.75	.12 (.85) (-1.42) - 1.75	-.02	.987
DS Backward Span z-score *Round 1 Testing*	.32 (.94) (-1.40) - 2.03	.17 (.90) (-1.40) - 2.03	-.73	.470
DS Backward Span z-score *Round 2 Testing*	.56 (.98) (-1.40) - 2.03	.41 (.93) (-1.40) - 2.03	-.71	.482
SS Total Scaled Score *Round 1 Testing*	12.58 (2.09) 8 - 17	12.10 (2.65) 5 - 17	-.95	.347
SS Total Scaled Score *Round 2 Testing*	13.47 (2.49) 8 - 18	12.98 (2.42) 8 - 18	-.93	.355
SS Forward Span Scaled Score *Round 1 Testing*	12.27 (2.54) 5 - 16	11.43 (3.57) 5 - 18	-1.27	.208
SS Forward Span Scaled Score *Round 2 Testing*	13.07 (3.02) 5 - 18	12.69 (2.38) 7 - 18	-.64	.523
SS Backward Span Scaled Score *Round 1 Testing*	12.31 (2.41) 7 - 17	12.21 (2.67) 5 - 17	-.18	.859
SS Backward Span Scaled Score *Round 2 Testing*	13.29 (2.57) 7 - 17	12.81 (2.56) 7 - 17	-.87	.386

Note. DS = Digit Span. SS = Spatial Span.
Note. Data are presented as Mean (SD), Minimum - Maximum values.
Note. *p < .05, **p < .01, ***p < .001

Table 6.
PVT Cutoffs Implemented

PVT	Cutoff
TOMM	<45 on Trial 2 (Tombaugh, 1996)
DCT	≥14 E score (Boone et al., 2002)
Rey-15 Recall	<9 for the learning/recall trial (Reznek, 2005)
Rey-15 Combined	<21 for the combined recall and recognition score (Morse, et al., 2013)
RDS	<7 score (Schroeder, et al., 2012)

Note. TOMM = Test of Memory Malingering; DCT = Dot Counting Test; Rey-15 Recall = Rey-15 Item Test Recall Trial; Rey-15 Combined = Rey-15 Item Test Recall and Recognition Combined Score; RDS = Reliable Digit Span.

Table 7.
PVT Failures

Test Name	Total	HA Group	LA Group	SI Phase	AI Phase
TOMM	0	0	0	0	0
DCT	10	2	8*	8	2
Rey-15 Recall	0	0	0	0	0
Rey-15 Combined	1^	1^	0	0	1^
RDS	5	5*	0	3	2
Across all tests	15	7	8	11	4

Note. TOMM = Test of Memory Malingering; DCT = Dot Counting Test; Rey-15 Recall = Rey-15 Item Test Recall Trial; Rey-15 Combined = Rey-15 Item Test Recall and Recognition Combined Score; RDS = Reliable Digit Span.

Note. *One participant failed this measure twice

Note. ^Failure likely related to ESL comprehension issue. The Rey-15 Recall scores were assessed instead.

Table 8.
Group affiliation by DCT or RDS failure during supportive-instructions phase

	High Anxiety	Low Anxiety	Total
DCT failure	1	7	8
RDS failure	3	0	3
Total	4	7	11

Note. DCT = Dot Counting Test; RDS = Reliable Digit Span.
Note. Fisher's Exact Test, $p = 0.024$.

Table 9.

Group affiliation by DCT/RDS failure or pass during supportive-instructions phase

	High Anxiety	Low Anxiety	Total
DCT/RDS failure	4	7	11
Neither failed	41	35	76
Total	45	42	87

Note. DCT = Dot Counting Test; RDS = Reliable Digit Span.
Note. Fisher's Exact Test, $p = .342$.

Table 10.
PVT Scores by Group

Variable Name	High Anxiety	Low Anxiety	t-value	p-value
TOMM Trial 2 *Round 1 Testing*	50.00 (.00) 50 - 50	49.79 (.77) 46 - 50	-1.44	.161
TOMM Trial 2 *Round 2 Testing*	49.95 (.21) 49 - 50	50.00 (.00) 50 - 50	.764	.450
DCT E-score *Round 1 Testing*	9.62 (1.78) 6 - 14	10.57 (2.97) 5 - 22	1.79	.078
DCT E-score *Round 2 Testing*	8.33 (1.75) 5 - 14	8.49 (1.90) 4 - 15	.39	.695
Rey-15 Recall *Round 1 Testing*	14.86 (.64) 12 - 15	15.00 (.00) 15 - 15	.76	.450
Rey-15 Recall *Round 2 Testing*	14.86 (.64) 12 - 15	14.83 (.76) 11 - 15	-.18	.855
Rey-15 Combined *Round 1 Testing*	29.55 (.86) 27 - 30	30.00 (.00) 30 - 30	2.49	.021*
Rey-15 Combined^ *Round 2 Testing*	29.67 (.80) 27 - 30	29.10 (1.68) 22 - 30	-1.43	.506
RDS *Round 1 Testing*	9.60 (2.11) 6 - 15	9.88 (1.64) 8 - 15	.69	.493
RDS *Round 2 Testing*	10.22 (2.01) 6 - 14	10.55 (1.71) 8 - 15	.81	.420

Note. TOMM = Test of Memory Malingering; DCT = Dot Counting Test; Rey-15 Recall = Rey-15 Item Test Recall Trial; Rey-15 Combined = Rey-15 Item Test Recall and Recognition Combined Score; RDS = Reliable Digit Span.

Note. Data are presented as Mean (SD), Minimum - Maximum values.
Note. *p < .05, **p < .01, ***p < .001
Note. ^Excluding outlier described in text

Table 11.
*PVT Failures by Participant**

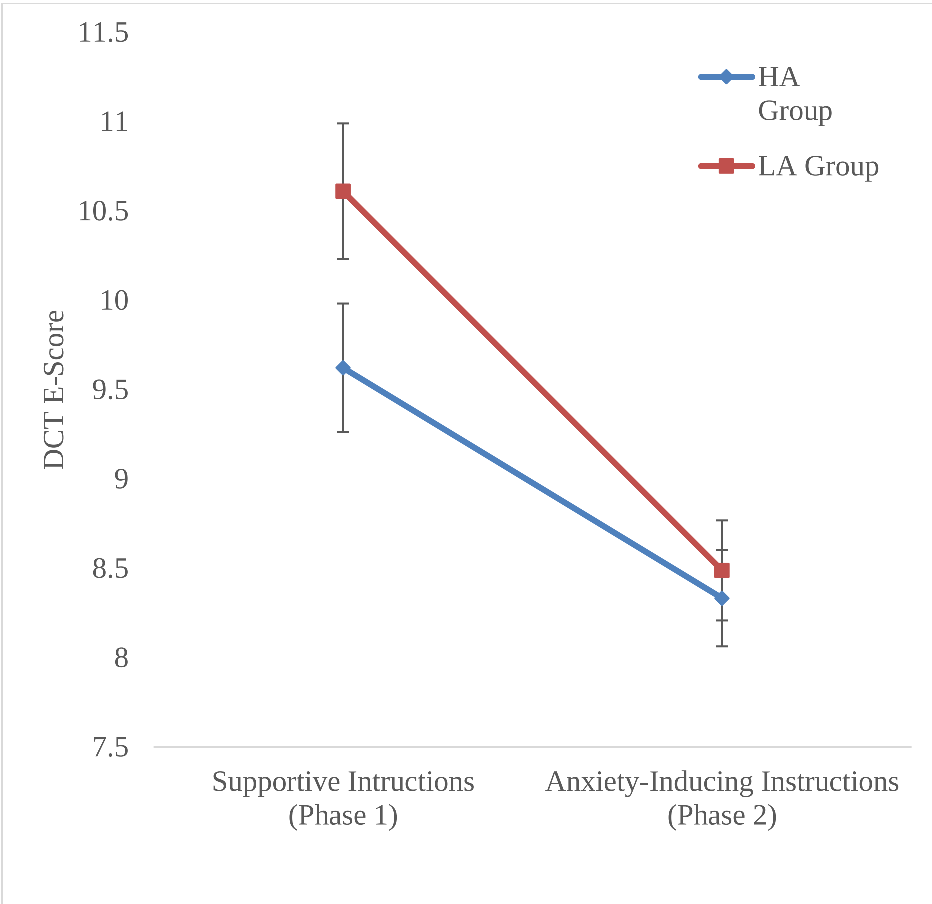
		Phase 1				Phase 2			
ID	Group	TOMM Trial 2	Rey-15 Recall	DCT	RDS	TOMM Trial 2	Rey-15 Recall	DCT	RDS
20	LA	-	Pass	**Fail**	Pass	Pass	-	Pass	Pass
28	LA	Pass	-	**Fail**	Pass	-	Pass	Pass	Pass
53	LA	Pass	-	**Fail**	Pass	-	Pass	**Fail**	Pass
60	LA	Pass	-	**Fail**	Pass	-	Pass	Pass	Pass
62	LA	-	Pass	**Fail**	Pass	Pass	-	Pass	Pass
79	LA	Pass	-	**Fail**	Pass	-	Pass	Pass	Pass
88	LA	Pass	-	**Fail**	Pass	-	Pass	Pass	Pass
3	HA	-	Pass	Pass	**Fail**	Pass	-	Pass	**Fail**
4	HA	-	Pass	Pass	**Fail**	Pass	-	Pass	Pass
5	HA	-	Pass	Pass	Pass	Pass	-	Pass	**Fail**
18	HA	Pass	-	Pass	Pass	-	Pass	**Fail**	Pass
19	HA	-	Pass	**Fail**	Pass	Pass	-	Pass	Pass
51	HA	Pass	-	Pass	**Fail**	-	Pass	Pass	Pass

Note. TOMM = Test of Memory Malingering; DCT = Dot Counting Test; Rey-15 Recall = Rey-15 Item Test Recall Trial; Rey-15 Combined = Rey-15 Item Test Recall and Recognition Combined Score; RDS = Reliable Digit Span.

*Only participants with at least one failure were included.
Note. - means that the test was not given during that phase.

Appendix D

Figure 1.
Dot Counting Test (DCT) Interaction Effect by Group and Phase



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