The relationship between test anxiety and cognitive performance: Mediated by state and trait self-control

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Abstract

Cognitive testing has been largely embraced by present-day society as the primary tool used to gage individual performance. These tests provide an objective means of determining whether an individual is ready to progress within their social, academic, or vocational positions. However, anxiety experienced during testing may lead to impaired test performance, which may have both social and economic implications. It is therefore imperative that a greater understanding of the relationship between anxiety and test performance be obtained. Grounded on the premise of both, the Attentional Control Theory and the Cognitive Interference Theory, this study hypothesised that both trait and state self-control mediate the relationship between test anxiety and cognitive performance. Undergraduate psychology students were matched across four experimental conditions based on their trait self-control scores. These conditions involved the active manipulation of state anxiety (using an adapted version of the Socio-Evaluative Cold Pressor Test for Groups) and state self-control resulting in the following four groups: anxiety absent-self-control depleted (n = 34), anxiety absent-self-control intact (n = 32), anxiety present-self-control depleted (n = 33), and anxiety present-self-control intact (n = 30). Cognitive performance was measured using a free-recall task. Analyses found no significant between-group differences on cognitive performance for state and trait self-control during the anxiety-absent conditions. State self-control significantly affected cognitive performance during the anxiety-present condition. However the nature of this effect was contrary to what was expected (i.e., participants with intact self-control would outperform those with depleted self-control). Furthermore, a hierarchical multiple regression analysis indicated that trait self-control did not affect cognitive performance during the anxiety-present condition. However, alternate analyses successfully showed that trait self-control does affect cognitive performance in anxiety-provoking situations. This novel finding provides a deeper understanding into how self-control improves cognitive performance, and highlights the importance of developing practical ways of strengthening and improving trait self-control.

Keywords: Test anxiety; cognitive performance; state self-control; trait self-control; Attentional Control Theory; Cognitive Interference Theory; State-Trait Anxiety Inventory, Visual Analogue Scale; Brief Self-Control Scale; Beck Depression Inventory-II; Free-Recall

The relationship between test anxiety and cognitive performance: Mediated by state and trait self-control

Contemporary society, motivated by the need to obtain reliable, objective information, has largely embraced a test-taking culture. Test information is often used to make important, life changing, decisions regarding an individual's performance in social, academic and work situations. As a result, test-environments are often stressful and anxiety-provoking (Bertrams, Englert, Dickhäuser, & Baumeister, 2013; Zeidner, 1998). However anxiety experienced during testing may lead to impaired cognitive performance (Eysenck, Derakshan, Santos, & Calvo, 2007). This effect on cognitive performance is particularly relevant for adolescents and young adults, who could consequently face poor educational outcomes such as dropping out of school, or failing to enter university (Owens, Stevenson, Hadwin, & Norgate, 2014). Not only could these outcomes adversely affect an individual's quality of life, but they could also have major social and economic implications (Van Ameringen, Mancini, & Farvolen, 2003). Therefore, investigating the relationship between test anxiety and cognitive performance is crucial, given the range of consequences that this relationship could have.

Anxiety is an emotional state or reaction to an appraised threat, often characterised by high levels of physiological arousal, feelings of apprehension, and worry (Arent & Landers, 2013). The word 'anxiety' is often associated with some degree of ambiguity. For instance, it can be used to describe a fear of physical harm, a fleeting response to a particular situation, or a character trait. Empirical investigations into the conceptualisation of anxiety have identified two distinct factors: (1) trait anxiety and (2) state anxiety (Robinson, Vytal, Cornwell & Grillon, 2013; Spielberger, 1966). *Trait anxiety* is a stable, innate characteristic (i.e., an individual's disposition to become anxious in an anxiety-provoking situation) whereas *state anxiety* refers to a transitory, fluctuating state (i.e., an individual's anxiety level at a given moment in time; Bertrams, Englert & Dickhäuser, 2010; Bertrams et al., 2013; Spielberger, 1966). Following from this two-factor conceptualisation of anxiety, the type of anxiety experienced during testing relates to state anxiety (Başol & Zabun, 2014).

Test anxiety is the heightened emotional state experienced during evaluative situations (Hill & Wigfield, 1984; Stöber, 2004). Emotionality and worry are two components of test anxiety. *Emotionality,* an affective component, is the subjective awareness of the autonomic responses experienced during evaluative situations (e.g., panic, dizziness, and nausea). *Worry*, a cognitive component, is the cognitive expression of the individual's reaction to an evaluative situation (Cassady & Johnson, 2002). Both theoretical and empirical evidence have identified worry as being more detrimental to cognitive performance than emotionality (Cassady & Johnson, 2002; Sarason, 1984).

Worry often manifests itself through the emergence of internal dialogues including: (a) negative self-statements, (b) concerns about failing, and (c) task irrelevant thoughts. These manifestations can occur throughout an evaluative task (Cassady & Johnson, 2002; Liebert & Morris, 1967), adversely affecting cognitive performance on the task. These adverse effect of worry on cognitive performance can be explained by the interference effect that worry has on the attentional resources required in working memory (WM). Worrisome thoughts tend to occupy the restricted attentional capacity of WM leaving a limited capacity available for concurrent cognitive processing that is required for optimal test performance. Due to this effect of 'worry' on WM, it is assumed that the detrimental effects of state anxiety are greater on tasks that require the efficiency and efficacy of WM (Eysenck et al., 2007). One task that heavily depends on the effective processing of WM is test-taking (Bertrams et al., 2013).

Previous studies (e.g., Elliot & McGregor, 1999) have advocated that test anxiety adversely influences cognitive performance. However, inconsistencies exist across the studies. Some studies have reported a debilitative relationship between anxiety and performance (e.g., Cassady, 2004a, 2004b), while others have not (e.g. Bertrams et al., 2010; Zeidner, 1998). Conversely, some studies suggest that moderate levels of anxiety may facilitate cognitive performance (Arent & Landers, 2013; Cassady & Johnson, 2002). Furthermore, a number of studies report an inverted-U relationship between performance and anxiety (e.g., Brockner, Griver, Reed & Dewitt, 1992; Yerkes & Dodson, 1908). These particular studies suggest that: (1) moderate levels of anxiety are necessary to facilitate optimal performance, while (2) anxiety levels below-or above-moderation are debilitative to performance (Muse, Harris & Field, 2003). Given these discrepancies, research has hinted at the possibility of an extraneous variable mediating the relationship between test anxiety and cognitive performance. One such variable is self-control (Bertrams et al. (2013).

Self-control is the capacity to deliberately and consciously alter one's responses by interrupting and refraining from undesired thoughts or actions, in order to achieve an intended goal (Baumeister, Vohs, & Tice, 2007; Tangney, Baumeister, & Boone, 2004). As with anxiety, self-control can be conceptualised as having both state and trait factors (de

Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2011). Empirical investigations suggest that individuals with higher levels of trait self-control are better able to inhibit their impulses, and therefore perform better on cognitive tasks because they can prevent interferences from outside distractions (de Ridder et al., 2011; Tangney et al., 2004). This task-oriented manner of thinking serves to direct attention to the task at hand (Sarason, 1984). Therefore, attention is an important factor in demonstrating the influence that self-control has on the relationship between test anxiety and cognitive performance (Bertrams et al., 2013; Eysenck et al., 2007). Several theories that have been developed to better understand the relationship between test anxiety and cognitive performance discuss attention. Two theories particularly relevant to the current research are the Attentional Control Theory (ACT) and the Cognitive Interference Theory (CIT).

The ACT focuses on the effect of anxiety on attention, and proposes that anxiety arises when a threat to a specific goal is perceived. This increase in anxiety causes attentional resources to be re-allocated in order to detect and remove the perceived threat. This response has significant repercussions for cognitive performance due to *attentional bias,* which is the shift in attention from neutral, task-oriented stimuli to the perceived threat (Eysenck et al., 2007). As a result the attentional resources dedicated to the neutral task become limited, thereby diminishing cognitive performance.

The role of attention in the CIT is not as explicitly stated as in the ACT. The CIT focuses on the effect of anxiety on cognitive performance, and proposes that individuals with high levels of test anxiety perform poorly in test-like situations because they are unable to suppress and filter out task-irrelevant thoughts. These task-irrelevant thoughts interfere with cognition by diverting attentional resources away from the task (Cassady & Johnson, 2002; Northern, 2010). As with the ACT, the CIT entails a shift in attention away from neutral task-oriented stimuli resulting in poor cognitive performance on said tasks.

Parry (2014) used the ACT to investigate the influence of self-control on the relationship between anxiety and performance. Whereas previous studies only focused on state self-control, Parry (2014) also examined the influence that trait self-control has on this relationship. Participants were screened, and matched across four experimental conditions based on their *trait self-control* scores. *State anxiety* (absent/present) and *state self-control* (intact/depleted) were manipulated prior to cognitive testing to set up the experimental conditions. The dependent variables measured in this study were performances on memory and arithmetic tasks. The results showed that while state self-control significantly affected performance in the anxiety-present condition, trait self-control did not significantly affect the relationship between state anxiety and cognitive performance.

One of the biggest limitations of Parry's (2014) was the failure to induce a sufficient level of anxiety during the anxiety manipulation. This meant that the difference in anxiety levels between the anxiety-absent and anxiety-present conditions was minimal. This may have compromised the ability to detect any statistically significant effects of trait self-control on cognitive performance. Future research should build on the foundations of this study by improving the anxiety manipulation technique to one that mimics the anxiety levels experienced during an actual test situation. This would improve the ecological validity, and allow for a greater understanding of the relationship between anxiety, self-control and performance to be attained.

Rationale, Aims, and Hypotheses

Parry's (2014) study did not support the relationship between trait self-control, anxiety and cognitive performance. However, previous literature suggests that individuals with higher trait self-control should show an enhanced ability to regulate their thoughts, emotions, and impulses compared to those with lower trait self-control (de Ridder et al., 2011).

Given the potential for trait self-control to regulate worrisome thoughts associated with test anxiety, it is important to re-assess whether trait self-control has a debilitative or a facilitative effect on cognitive performance in such situations. I attempted to build on the design of Parry's (2014) research by using (a) an alternative, stronger anxiety induction method, which would allow for the effect of anxiety on cognitive performance to be more apparent; and (b) an additional self-report survey to confirm the success of the anxiety manipulation. Given that my study did not use physiological measures of stress induction, an additional self-report measure increased the reliability of the data.

My study examined the effect of state and trait self-control on the relationship between test anxiety and cognitive performance. In addition to the ACT (used by Parry, 2014), my study also drew on the CIT to (a) observe state and trait self-control as particular cognitive processes affecting attention, and (b) determine whether higher levels of trait self-control allow for more efficient processing.

Following Parry's (2014) research, I hypothesised that:

1. During anxiety-absent conditions, participants with depleted self-control would perform similarly to participants with intact self-control on cognitive tasks.
2. During anxiety-present conditions, participants with intact self-control would perform better on cognitive tasks than participants with depleted self-control.
3. During anxiety-absent conditions, trait self-control would have no effect on cognitive performance.
4. During anxiety-present conditions, participants with higher levels of trait self-control would perform better than those with lower levels of trait self-control.

The role of trait self-control as a mediator between test anxiety and cognitive performance is understudied. A better understanding of the role of self-control and its influence on test anxiety and cognitive performance can help in the crafting of measures aimed at improving academic performance (Tangney et al., 2004). This could be accomplished through psychological interventions that teach anxiety management skills and improve self-control in test anxiety-provoking situations (Baumeister et al., 2007; Parry, 2014).

Methods

Design and Setting

Following Parry's (2014) procedure, my study used a quasi-experimental matched-groups design. The independent variables were (a) state anxiety condition (absent vs. present), (b) state self-control condition (intact vs. depleted), and (c) trait self-control (a continuous variable; Tangney et al., 2004). The dependent variable was performance on a free-recall memory task.

I collected the data in two phases. The first phase involved an online screening survey, which I used to screen participants according to the exclusion criteria (outlined under 'Participants' below). The second phase involved group sessions, during which the state self-control and state anxiety of about 6 participants were manipulated to measure the effect of these variables on cognitive performance. These sessions occurred in a private room in the Department of Psychology at the University of Cape Town (UCT). I arranged these sessions between 09h00 and 12h00 to control for the depletion of state self-control that could result from participating in everyday activities (Baumeister et al., 2007).

My study adhered to the ethical guidelines for research involving human participants as outlined by the UCT, and the Health Professions Council of South Africa. I received ethical approval from UCT's Department of Psychology Research Ethics Committee before commencing with data collection.

Participants

A total of 316 participants completed the online screening survey. I invited 228 eligible participants to attend the experimental session, however, only 130 participants (n_{females} = 107; n_{males} = 23) participated. The 98 participants who did not participate either: (1) did not respond to the emailed invitation, (2) were unable to attend any of the available times, or (3) did not arrive for their allocated time slot.

Participants were English speaking males and females, between the ages of 18 and 25 years. I recruited all participants from UCT's undergraduate psychology student population via the Student Research Participation Programme (SRPP). I awarded each participant with 2 SRPP points for their participation.

I pseudo-randomly assigned each participant, based on their trait self-control scores, to one of the four experimental conditions: anxiety-present, self-control depleted (n = 33); anxiety-absent, self-control depleted (n = 34); anxiety-present self-control intact (n = 30); or anxiety-absent, self-control intact (n = 33).

Exclusion criteria. The online screening survey included the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) and the STAI-Trait scale (Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983). This was to avoid including any individuals who were potentially clinically anxious or depressed in my study. Overall, I excluded 88 potential participants: 48 who failed to complete the online survey; 39 who scored highly on either the STAI-State (scores >50) and/or the BDI-II (score ≥ 29); and 1 who exceeded the age exclusion criterion.

Figure 1 depicts the sources of attrition, exclusion, and the assignment of participants to the experimental conditions.

Power analysis. I used the G*Power programme (Faul, Erdfelder, Lang, & Buchner, 2007) to compute the power analysis. For my achieved sample size, I obtained a power of .75. The power of this sample, while relatively high, is still below the optimal statistical power of .80 (Cohen, 1988). Therefore, it may be slightly more difficult to detect a significant effect in the population my sample.

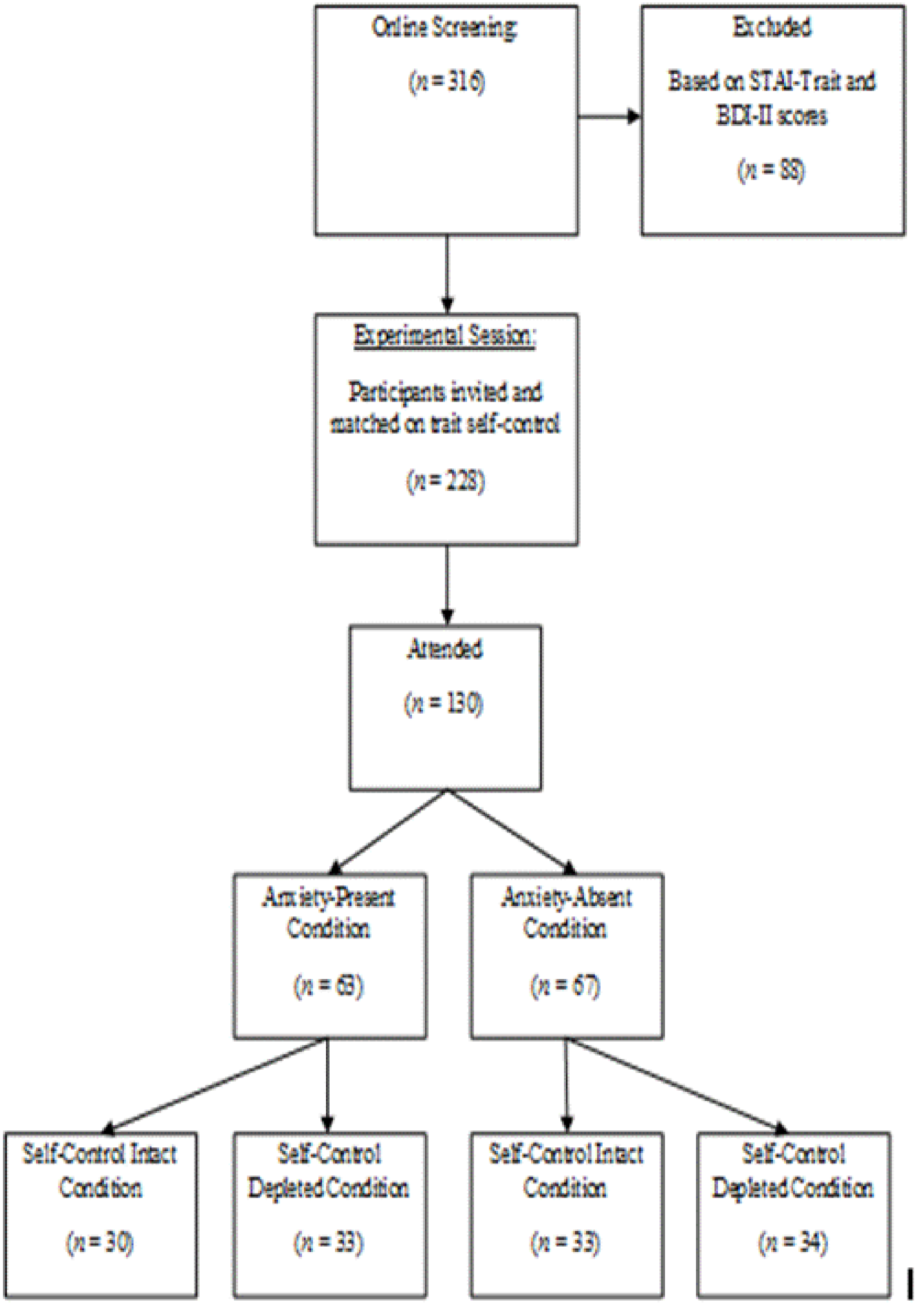

Figure 1. Flow diagram showing participant attrition, exclusion, and assignment to the experimental conditions of the study.

Measures and Materials

Self-report measures.

Beck Depression Inventory-II (BDI-II). The BDI-II is a 21-item scale that measures depressive symptomatology (Beck et al., 1996). Items on this scale assess the typical symptoms associated with depression. Each item provides 4 possible responses of increasing severity. I required participants to select a response that best fitted the way they had been feeling for the two weeks prior to the survey. Scores ranging from 0 – 3 correspond to the four responses. Higher scores are indicative of greater levels of depressive symptomatology.

The BDI-II has a high internal consistency across various populations (α =.89 – .94), and a good test-retest reliability (r = .93; e.g. Beck, Steer & Garbin, 1988). The BDI-II boasts successful employment in various South African studies (e.g. Nel & Kagee, 2012; Plüddemann, Flisher, McKetin, Parry & Lombard, 2010), confirming its cross-cultural application. I used scores from the BDI-II to exclude individuals with higher levels of depressive symptomatology.

State-Trait Anxiety Inventory (STAI). The STAI is used to measure and differentiate between state and trait anxiety in both clinical and non-clinical settings (Spielberger et al., 1983). It is made up of two separate questionnaires: (1) a measurement of state anxiety examining the intensity of anxiety in a given moment, and (2) a measure of trait anxiety which provides a more general assessment of anxiety that is stable across time. Both questionnaires are made up of 20-items that are rated on a 4-point Likert-type scale. Scoring for the STAI is designed to control for response sets by assigning anxiety-present items a direct score of 1 – 4, while assigning anxiety-absent items a reverse score arranged 4 - 1. For both questionnaires, higher scores indicate greater levels of anxiety.

Both of the STAI questionnaires show high internal consistency (α_{State}=.86 and α_{Trait} =.90) and significant levels of construct validity in populations of university students (Hersen, 2004). The STAI has been used in numerous South African studies that confirm its reliability in this diverse population (e.g., Jordaan, Spanenberg, Watson, & Fouche, 2007; Spangenberg, & Theron, 1999). Furthermore, the STAI has been used extensively in research that looks at situation specific anxiety, and is therefore suitable for use in my study (Hersen, 2004).

I used the STAI-Trait questionnaire to exclude individuals with high levels of trait anxiety, and the STAI-State questionnaire to measure changes in state anxiety throughout the study.

Brief Self-Control Scale (BSCS). The BSCS is a 13-item measure of trait self-control (Tangney et al., 2004) which assesses self-regulatory behaviours across four domains: emotions, impulses, thoughts and performance (Duckworth & Seligman, 2005; Maloney, Grawitch, & Barber, 2012). The BSCS uses a 5-point Likert-type scale that ranges from 1 – 5. High scores on the BSCS are indicative of higher levels of trait self-control.

The BSCS has a high internal consistency (α =.84), and a high test-retest reliability (*r* =.87). This scale has been successfully used in the South African context (e.g., Parry, 2014), which confirms its cross-cultural validity. I used the scores from the BSCS to match participants on the variable of trait self-control across the four experimental conditions prior to the experimental session.

Visual Analogue Mood Scale (VAMS). The VAMS is a measure of the participants' subjective stress experience (Folstein & Luria, 1973). It consists of a simple 100 mm horizontal line, with one end representing the "worst" experience, and the other the "best" experience. The use of this scale allows for the measurement of subtle changes in subjective experiences.

I used two separate VAMS. The first posed the question, "How stressful was the activity?", and the second asked, "Do you still feel stressed?"

I required participants to rate their subjective experience by placing a cross on the appropriate point of the line. These VAMS were similarly labelled; the left end (0mm) was labelled "not at all" and the right end (100mm) was labelled "extremely". Scoring occurs by measuring the distance (in mm) from the 0mm mark to the participants cross on the line. This scale is a valid measure of subjective experience with the within-group reliability coefficient ranging from *r* =.61 -.73 (Ahearn, 1997).

State self-control manipulation. For the state self-control manipulation task, I adopted the paradigm used by Parry (2014). Participants in the self-control depleted condition were asked to copy out a typed piece of text ("Stalagmites and Stalactites", 2011; Appendix C) but to omit the letters "a" and "i" so that the word "stalagmite" would then read as "stlgmte". The purpose of this task was to exhaust state self-control resources by inhibiting the impulse to use the letters while copying the text for 6 minutes. For the self-control intact condition, participants were asked to copy out the text, verbatim. The successful manipulation of state self-control was essential to observe its effect on the relationship between state anxiety and cognitive performance.

To determine the effectiveness of this manipulation, participants completed a 4-point Likert-scale consisting of 4 questions about their experience of the task (Appendix D). Each transcription of the depleted group was checked after the session to ensure that the instructions were successfully adhered to.

Socially Evaluated Cold-Pressor Test for Groups (SECPT-G). The SECPT-G combines the Cold-Pressor Test (CPT) with socio-evaluative components to induce significant increases in cortisol (Minkley, Schroder, Wolf, & Kirchner, 2014). This method of stress induction draws on the concept of *social-evaluative threat* (SET). SET occurs when one's self-identity is perceived to be negatively judged by others (Dickerson & Kemeny, 2004). Although the SECPT-G is a relatively new revision of the SECPT, it has been found to successfully induce physiological, endocrinological, and psychological stress responses (Minkley et al., 2014).

Anxiety-present conditions. For social evaluation to have been adequately simulated, the SECPT-G required a degree of deception. Although deception is typically considered to be problematic, due to the fact that it withholds a great degree of information about the study from the participants, the informed consent form explicitly outlined risks present in the study. I also made a considerable effort to correct any negative feelings that arose due to the use of deception, by fully debriefing participants.

The SECPT-G typically uses three forms of SET in its design; (1) the "groups" design itself, (2) a video-camera, and (3) an independent evaluator. I included two additional forms of SET: (1) a general knowledge quiz, and (2) a peer-evaluation component. I told participants that my study aimed to examine facial expressions during an aversive task (like the CPT), to gain insight into the human characteristics of stamina and perseverance. I also told them that these characteristics could then be used to predict performances on cognitive tasks.

The SET of the "groups" design was maintained throughout the study by arranging the desks into a U-formation so that participants faced each other. A video-camera was set up so that each participant had a clear view of it throughout the experiment. However, no footage was actually recorded. In addition, an unfamiliar female confederate was seated at a prime location of the room. I informed participants that both their facial expressions, and overall performance, during the CPT were going to be monitored and evaluated by the video-camera and evaluator.

For the CPT, I asked participants to stand behind their chairs and to immerse their non-dominant hand into ice water for 3 minutes. Prior to immersing their hand, I discussed three main points with the participants. Firstly, I emphasised that should they feel any pain, they were free to remove their hand from the water (the evaluator recorded the times of those who removed their hand before the 3 minutes had elapsed). Second, I notified participants that during the CPT they would be asked general knowledge questions at random, and that the answers needed to be provided as quickly as possible. For the sake of clarity and efficiency, I informed the participants that should they not know the answer to a question, they should say “pass”. Each participant had the chance to answer at least two questions. Finally, for the peer-evaluation component, I informed participants that to complete the up-coming cognitive task, they would each need to select one other participant to work with. This form of peer-evaluation lends itself to possible feelings of rejection, which has been found to bring out a higher stress response (Zoccola, Dickerson, & Lam, 2012).

Anxiety-absent manipulation. For the anxiety-absent conditions, all evaluative stimuli were removed. The SET of the “groups” design was eliminated by arranging the desks linearly so that participants faced the front of the room. There was no video-camera, no general knowledge quiz, and the evaluator, while still present, did not watch the participants. There were also no peer-evaluative elements. I informed participants that the purpose of this study was to gain insight into the human characteristics of stamina and perseverance, and how this relates to cognitive performance. I instructed participants to stand behind their chairs and to immerse their non-dominant hand, up to the wrist, into the warm water.

Cognitive tasks. Although two cognitive tasks were presented to the participants in this study, only one was used to measure cognitive performance. This task was a free-recall task. During the recall task, 15 trigrams (e.g., KOR) were projected onto a screen at the front of the room for 1 minute (Appendix E). Participants were asked to memorise as many of the trigrams as they could before the list was removed from the screen. At the end of the experimental session, the participants had 2 minutes to recall as many of the trigrams as possible by writing them down.

For the second task, which was used as a distracter task, participants had to solve as many of the arithmetic problems (Appendix F) presented on a screen, as they could, in 1 minute.

Procedure

The study procedure is outlined in Figure 2.

Online Survey and Screening. The online screening survey was made up of four main parts; (1) a socio-demographic survey, (2) the STAI-Trait form, (3) the BDI-II, and (4) the BSCS.

The socio-demographic survey obtained information such as age, gender, and race. The self-report questionnaire data were used to exclude individuals who were deemed to have clinically high levels of trait anxiety and depressive symptomatology. I used BSCS scores to match participants across the four experimental conditions.

After processing the online surveys, I contacted eligible participants via email. These emails included a number of available weekday time slots between 09h00 and 12h00. I required participants to indicate their availability for at least two of the indicated times. After I received feedback from all the participants, I combined this information with their trait self-control scores to assign a final time slot (which determined which experimental group they would be part of) for each participant.

A.

Anxiety Induction	Groups Design	Video Camera	Evaluator	CPT	General Knowledge Quiz	Peer-Evaluation
Positive	"U" shape desk arrangement	Present	Attends to Participants	Cold Water	Present	Present
Negative	Linear desk arrangement	Absent	Does not Attend to Participants	Warm Water	Absent	Absent

B.

	Self-Control Manipulation	Self-Control manipulation Check	Display Trigrams	Baseline	Anxiety Induction	Post-Manipulation	Mental Arithmetic Task	Recall Trigrams	Debriefing	Post-Debriefing
Present-Depleted	Copy text omitting "a" and "i"	Likert Scale	*t* = 1 minute	STAI-State (1)	Positive	STAI-State (2) + VAS (1)	*t* = 1 minute	*t* = 2 minutes	*t* = 5 minutes	STAI-State (3) + VAS (2)
Absent-Depleted	Copy text omitting "a" and "i"	Likert Scale	*t* = 1 minute	STAI-State (1)	Negative	STAI-State (2) + VAS (1)	*t* = 1 minute	*t* = 2 minutes	*t* = 5 minutes	STAI-State (3) + VAS (2)
Absent-Intact	Copy text verbatim	Likert Scale	*t* = 1 minute	STAI-State (1)	Negative	STAI-State (2) + VAS (1)	*t* = 1 minute	*t* = 2 minutes	*t* = 5 minutes	STAI-State (3) + VAS (2)
Present-Intact	Copy text verbatim	Likert Scale	*t* = 1 minute	STAI-State (1)	Positive	STAI-State (2) + VAS (1)	*t* = 1 minute	*t* = 2 minutes	*t* = 5 minutes	STAI-State (3) + VAS (2)

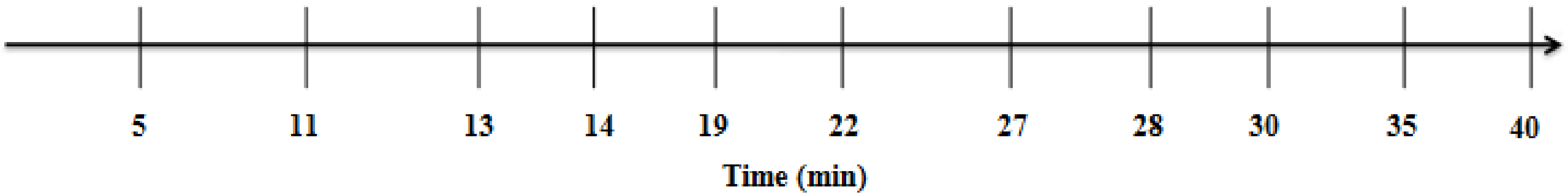

Figure 2. Diagram representing the components of the experimental session. (A) Essential differences between the anxiety induction conditions. (B) Procedure followed in the experimental session.

Experimental Session. The experimental session room was arranged to accommodate six numbered work-stations. Each work station consisted of a desk, chair, bucket and a pack of the relevant forms. Upon arrival I greeted and randomly assigned each participant to a work station. Once all the participants were seated, I provided a brief introduction, before instructing them to read and sign the informed consent form (Appendix A) which contained information relevant to the condition being investigated at the time (i.e., anxiety-present/absent).

Once participants had signed the consent form, I gave them instructions for the self-control manipulation task (intact/depleted; Appendix C). To determine the success of this manipulation, I asked participants to complete the self-control manipulation check Likert-scale (Appendix D). Following this task, I directed the participants' attention to where the list of 15 trigrams was displayed. The list was promptly removed from the screen at the 1 minute mark.

Prior to commencing with the SECPT-G, I required the participants to complete the baseline STAI-State questionnaire. Depending on the condition being investigated, participants then either underwent the anxiety-present or anxiety-absent procedure. To gage the effectiveness of the anxiety manipulation, I had participants complete a second set of self-report surveys (i.e., STAI-State questionnaire and VAMS). Participants then completed the distracter task after which they recalled the trigrams.

Once all these tasks were completed, I debriefed the participants and distributed the debriefing form (Appendix B). Finally, I administered the final STAI-State and VAMS measures to ensure that state anxiety had been successfully diminished.

Statistical Analysis

I used SPSS, version 22.0, for the statistical analyses of all the data collected. The design of my study allowed for between-groups, and where necessary, within-groups analyses. I provide the details about each specific analysis before I present their results.

Unless otherwise stated, all the statistical assumptions were upheld. The level of statistical significance for my study was set at α =.05.

Results

Final sample characteristics. The final number of participants included in the study was 130 (Present-Depleted: n = 33; Absent-Depleted: n = 34; Absent-Intact: n = 33; Present-Intact: n = 30).

I conducted analyses of the final sample characteristics using a series of 2 x 2 factorial ANOVAs with the outcome variables being: (1) age, (2) BDI-II scores, (3) STAI-Trait scores, and (4) BSCS scores (see Table 1 for the descriptive statistics). These variables were analysed to ensure that the participants were sampled from a similar population.

Table 1

Measure	Groups			
	Present-Depleted n = 33	Absent-Depleted n = 34	Absent-Intact n = 33	Present-Intact n = 30
Age	20.55 (1.28)	19.74 (1.31)	19.91 (1.33)	20.57 (1.28)
BDI-II	4.94 (4.88)	9.47 (6.38)	9.21 (7.77)	7.23 (4.61)
STAI – Trait	36.36 (6.90)	38.88 (7.07)	38.15 (7.67)	36.80 (7.69)
BSCS	36.52 (5.71)	38.09 (4.70)	37.70 (6.85)	36.33 (5.63)

Descriptive Statistics for Final Sample Characteristics

Note. The data presented above are means with standard deviations in parentheses.

Age. Participants' ages ranged from 25-18 years (M = 20.18 ±1.34). The analysis showed a statistically significant main effect for the anxiety manipulation, $F(1, 126) = 10.34$, p =.002, η_p^2 =.076. However, there was no statistically significant main effect for the self-control manipulation, $F(1, 126)$ =.182, p =.670, η_p^2 =.001. There was also no statistically significant interaction, $F(1, 126)$ =.112, p =.739, η_p^2 =.001. Although a statistically significant main effect was present for the anxiety manipulation, the absence of a statistically significant interaction indicated that age was equally distributed across the experimental conditions.

BDI-II scores. The BDI-II scores of the participants ranged from 0–28 (M = 7.74 ±6.29). The average BDI-II scores across the experimental conditions showed that the participants fell into the ‘minimally depressed’ category (Beck et al., 1996). The factorial ANOVA showed a statistically significant main effect for the anxiety manipulation, $F(1, 126) = 9.30$, $p = .003$, $\eta_p^2 = .069$. However, there was no statistically significant main effect for the self-control manipulation, $F(1, 126) = .91$, $p = .34$, $\eta_p^2 = .007$. There was also no statistically significant interaction, $F(1, 126) = 1.43$, $p = .23$, $\eta_p^2 = .011$. Although a statistically significant main effect was present for the anxiety manipulation, the absence of a statistically significant interaction indicated that BDI-II scores were equally distributed across the experimental conditions.

STAI-Trait scores. The STAI-Trait scores ranged from 20-50 ($M = 37.58 \pm 7.31$). The factorial ANOVA test showed that there was no statistically significant main effect for either the anxiety manipulation, $F(1, 126) = 2.26$, $p = .14$, $\eta_p^2 = .018$, or the self-control manipulation, $F(1, 126) = .013$, $p = .91$, $\eta_p^2 < .001$. There was also no statistically significant interaction between the two variables, $F(1, 126) = .21$, $p = .65$, $\eta_p^2 = .002$. This indicated that the results of the study were not confounded by the participants’ STAI-Trait scores in the different conditions.

BSCS scores. I matched the groups according to participants’ trait self-control scores, which were obtained using the BSCS. Scores ranged from 20-51 ($M = 31.18 \pm 5.75$). The factorial ANOVA demonstrated that there were no statistically significant main effect for either the anxiety manipulation, $F(1, 126) = 2.10$, $p = .150$, $\eta_p^2 = .016$, or the self-control manipulation, $F(1, 126) = .080$, $p = .778$, $\eta_p^2 = .001$. There was also no statistically significant interaction, $F(1, 126) = .011$, $p = .918$, $\eta_p^2 < .001$. The absence of any statistically significant differences in trait self-control scores across the four experimental conditions indicated that the groups were equally matched on this variable.

Experimental Manipulation

Experimental manipulation checks. I used data from the self-report measures to determine the success of (a) the experimental manipulation in altering the levels of state anxiety (i.e., STAI-State scores and VAMS scores); and (b) the self-control manipulation (i.e., the Likert scale). Table 2 provides the descriptive statistics for each of these self-report measures.

Table 2

Descriptive Statistics for Self-Report Measures

Measure	Groups			
	Present-Depleted *n* = 33	Absent-Depleted *n* = 34	Absent-Intact *n* = 33	Present-Intact *n* = 30
STAI – State				
Baseline	34.55 (8.35)	35.94 (8.22)	34.82 (10.00)	33.93 (9.78)
Post-Manipulation	45.58 (8.31)	32.47 (7.51)	32.76 (10.44)	38.43 (12.49)
Post-Debriefing	37.88 (7.63)	31.47 (6.78)	32.27 (10.51)	31.83 (8.61)
VAMS				
Post-Manipulation	4.06 (2.87)	3.00 (2.76)	1.52 (2.11)	6.79 (3.11)
Post-Debriefing	4.11 (2.29)	3.13 (2.87)	1.24 (1.76)	3.19 (2.83)
Likert Scale				
State self-control score	10.09 (1.49)	10.41 (1.46)	11.76 (1.82)	11.67 (2.10)

Note. The data presented above are means with standard deviations in parentheses.

Anxiety measures: STAI-State. I used a 2 x 2 x 3 (anxiety manipulation [present/absent] x self-control manipulation [intact/depleted] x time [baseline/post-manipulation/post-debriefing]) repeated measures ANOVA to investigate the success of the anxiety manipulation. Preliminary analyses indicated that the assumption of sphericity was not upheld for the analysis. Therefore, I used the values obtained from the Greenhouse-Geisser estimate. The statistical analysis showed a statistically significant main effect for the anxiety manipulation, $F(1.77, 223.08) = 30.11$, $p < .001$, $\eta_p^2 = .19$ (present: $M = 37.14$, ±10.20; absent: $M = 33.\ 29$, ±9.03). However, there was no main effect for self-control manipulation, $F(1.77, 223.08) = 1.83$, $p = .17$, $\eta_p^2 = .01$. The analysis also showed the presence of a statistically significant interaction, $F(1.77, 223.08) = 5.24$, $p = .008$, $\eta_p^2 = .04$. Figure 3 shows the statistically significant fluctuations in state anxiety across the four experimental conditions.

Further analyses using planned contrasts confirmed that the anxiety-present conditions were statistically significantly higher in state anxiety than the anxiety-absent conditions, $t(351.85) = 3.85$, $p < .001$. The analysis also indicated that the present-depleted condition was statistically significantly higher in state anxiety than the present-intact condition post-manipulation, $t(49.73) = 2.64$, $p = .01$, and post-debriefing, $t(126) = 2.83$, $p = .01$.

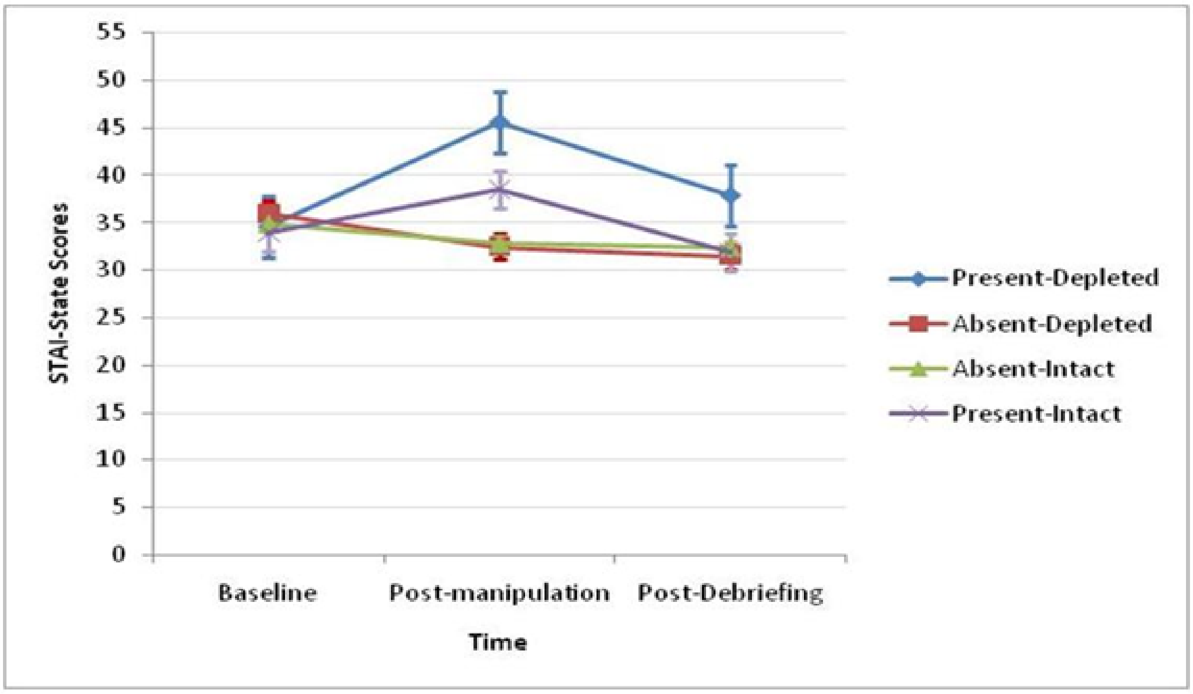

Figure 3. Fluctuations in state anxiety levels across the four experimental conditions. Error bars indicate the standard error of means.

VAMS. I used a 2 x 2 x 2 (anxiety manipulation [present/absent] x self-control manipulation [intact/depleted] x time [post-manipulation/post-debriefing]) to investigate the success of the anxiety manipulation. The analysis showed a statistically significant main effect for the anxiety manipulation, $F(1, 126) = 39.72$, $p < .001$, $\eta_p^2 = .240$. However, there was no significant main effect for the self-control manipulation, $F(1, 126) = 1.14$, $p = .287$, $\eta_p^2 = .009$. There was also no statistically significant interaction effect between these conditions, $F(1, 126) = 12.47$, $p = .001$, $\eta_p^2 = .090$. The analyses indicated that anxiety manipulation was successful, and that the self-control manipulation did not contribute to the differences in state anxiety seen across the experimental conditions.

Self-control measure: Likert scale. I used a 2 x 2 (self-control manipulation [intact/depleted] x anxiety manipulation [present/absent]) factorial ANOVA to investigate the success of the self-control manipulation. The results showed no main effect for the anxiety manipulation, $F(1, 126) = .461$, $p = .498$, $\eta_p^2 = .004$, however the analysis detected a main effect for the self-control manipulation, $F(1, 126) = 23.208$, $p < .001$, $\eta_p^2 = .156$. The analysis indicated that no statistically significant interaction was present between these variables, $F(1, 126) = .144$, $p = .705$, $\eta_p^2 = .001$. These results indicated that the self-control manipulation was successful, and that the anxiety manipulation did not contribute to the differences in state self-control seen across the experimental conditions.

Hypothesis Testing

Hypotheses 1 and 2 focused on the effects of state self-control on cognitive performance at different levels of the anxiety manipulation (absent/present). These hypotheses were analysed using independent samples *t*-tests (self-control manipulation [intact/depleted]), with free-recall scores as the outcome variable. Figure 4 shows the average number of trigrams recalled by participants in each of the experimental conditions.

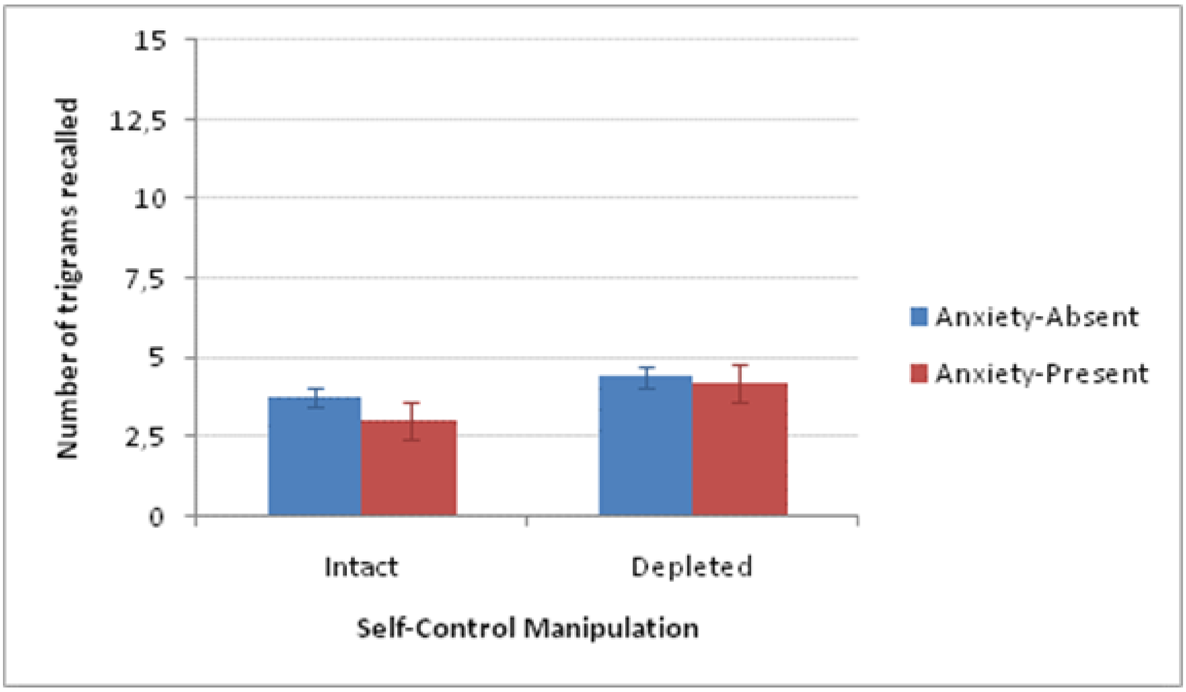

Figure 4. The average number of trigrams recalled by each experimental condition. Error bars indicate the standard error of means.

Hypothesis 1: I predicted that, during the anxiety-absent conditions, participants with intact self-control would perform similarly to individuals with depleted self-control on a cognitive task.

The independent samples *t*-test showed the absence of a statistically significant difference between participants' performance in the absent-intact (M = 4.58 ±1.54) and absent-depleted (M = 3.76, ±2.22) conditions, $t(58.99) = 1.74$, p =.09, d =.45. This result was associated with a moderate effect size, and supported the first hypothesis.

Hypothesis 2: I predicted that, during the anxiety-present conditions, participants with intact self-control would perform better on a cognitive task than participants with depleted self-control.

The independent samples *t*-test showed a statistically significant difference between participants' performance in the present-intact (M = 3.00 ±2.12) and the present-depleted (M = 4.27, ±2.23) conditions, $t(61) = -2.32$, $p = .02$, $d = .59$. Although a statistically significant difference exists between these conditions, the relationship between the two anxiety-present conditions was opposite to what was predicted by the hypothesis. As seen in Figure 4, the present-depleted group outperformed the present-intact group in the free-recall task.

Hypotheses 3 and 4 focused on the effects of trait self-control on cognitive performance at different levels of the anxiety manipulation (absent/present). These hypotheses were analysed using hierarchical multiple regression analyses (MRA), with free-recall scores as the outcome variable.

Hypothesis 3: I predicted that, during the anxiety-absent conditions, trait self-control would have no effect on cognitive performance.

To analyse the hypothesis, I constructed a possible regression model using data from the anxiety-absent conditions alone, with free-recall as the outcome variable. Independent variables age and BDI-II scores were entered into the model collectively in order to control for any possible extraneous effects that they may have on recall. This was followed by the STAI-Trait score. STAI-State and VAMS scores were then entered into the third block, while State Self-Control scores were entered into the fourth. Finally the variable of primary interest, Trait Self-Control, was entered into the fifth block. Table 3 shows the model summary of the analysis.

Table 3

Model summary for anxiety-absent conditions, showing the effect of predictor variables on the dependent variable

Model	R	R^2	Std. Error of Estimate	R^2 Change	F Change	*p*
1[a]	.21	.04	1.93	.04	1.48	.24
2[b]	.25	.06	1.92	.02	1.30	.26
3[c]	.27	.07	1.95	.01	.26	.78
4[d]	.27	.07	1.96	.00	.01	.92
5[e]	.28	.08	1.97	.01	.51	.48

a. Predictors: (Constant), Age, BDI-II
b. Predictors: (Constant), Age, BDI-II, STAI-Trait
c. Predictors: (Constant), Age, BDI-II, STAI-Trait, VAMS, STAI-State
d. Predictors: (Constant), Age, BDI-II, STAI-Trait, VAMS, STAI-State, Self-Control State
e. Predictors: (Constant), Age, BDI-II, STAI-Trait, VAMS, STAI-State, Self-Control State, Self-Control Trait

Table 3 shows that the hierarchical MRA yielded no significant *F change* for any of the predictors. Self-Control Trait, in particular, did not make any statistically significant contribution to the outcome variable. This indicated that variations in trait self-control did not affect cognitive performance during the anxiety-absent condition.

Hypothesis 4: I predicted that, during the anxiety-present conditions, participants with higher levels of trait self-control would perform better on a cognitive task than those with lower levels of trait self-control.

As with Hypothesis 3, a hierarchical MRA was conducted to investigate this hypothesis. A regression model was constructed using the data from the anxiety-present condition alone, with recall as the outcome variable. The predictor variables were entered into SPSS in the same order as in Hypothesis 3. Table 4 demonstrates the model summary of the analysis.

Table 4

Model summary for anxiety-present conditions, showing the effect of predictor variables on the outcome variable

Model	R	R^2	Std. Error of the Estimate	R^2 Change	F Change	Sig.
1[a]	.17	.03	2.25	.03	.89	.42
2[b]	.21	.05	2.26	.02	.97	.33
3[c]	.25	.07	2.27	.02	.62	.54
4[d]	.28	.08	2.28	.01	.65	.43
5[e]	.34	.12	2.25	.04	2.58	.11

a. Predictors: (Constant), Age, BDI-II
b. Predictors: (Constant), Age, BDI-II, STAI-Trait
c. Predictors: (Constant), Age, BDI-II, STAI-Trait, VAMS, STAI-State
d. Predictors: (Constant), Age, BDI-II, STAI-Trait, VAMS, STAI-State, Self-Control State
e. Predictors: (Constant), Age, BDI-II, STAI-Trait, VAMS, STAI-State, Self-Control State, Self-Control Trait

The analysis showed that there was no significant *F change* value for the effect of the predictor variables on the outcome variable. Self-Control Trait, the variable of primary interest, did not bring about a significant change to the dependent variable.

Model Refinement/Adjustment

The low R^2 *Change* values in the model summary indicated that several of the predictor variables included in the regression did not significantly contribute to the model. I conducted further analyses in an attempt to develop a new model that aimed to provide a more accurate representation of the relationship between trait self-control and cognitive performance.

I used the data from the anxiety-present condition, together with the model presented in Table 4 to eliminate predictor variables based on: (a) the R^2 *Change* value, and (b) previously conducted literature (Eysenck & Byrne, 1992). After eliminating a variable, I re-ran the regression to observe the effects that this may have had on the model before moving on to examining the next variable. Predictor variables that were entered into SPSS simultaneously (e.g. age and BDI-II scores) were run hierarchically to evaluate the contribution made by each variable.

Eventually, I obtained a model that appeared to be a more accurate representation of the relationship between trait self-control and cognitive performance. In this model, predictor variables were entered into SPSS in the following order: (1) BDI-II scores, (2) STAI-Trait scores, and (3) Self-Control Trait scores. Using this new regression model, I conducted a re-analysis of Hypotheses 3 and 4.

Hypothesis 3. Table 5 shows the results obtained from the new regression analysis, which used the data obtained from the anxiety-absent conditions.

Table 5

Model summary of the anxiety-absent condition, showing the effect of the trait predictor variables on the outcome variable

Model	R	R^2	Std. Error of the Estimate	R^2 Change	F Change	Sig.
1[a]	.12	.02	1.94	.02	.97	.33
2[b]	.18	.03	1.94	.02	1.12	.30
3[c]	.20	.04	1.95	.01	.42	.52

a. Predictors: (Constant), BDI-II
b. Predictors: (Constant), BDI-II, STAI-Trait
c. Predictors: (Constant), BDI-II, STAI-Trait, Self-Control Trait
d. Dependent Variable: Recall

The results showed no significant *F Change* value for the effect of Trait Self-Control on the outcome variable.

Hypothesis 4. Table 6 shows the results of the new regression analysis, which used the data obtained from the anxiety-present conditions.

Table 6

Model Summary for Anxiety-Present Condition, Showing Effect of Trait Predictor Variables on Recall

Model	R	R^2	Std. Error of the Estimate	ΔR^2	ΔF	Sig.
1[a]	.13	.02	2.25	.02	1.03	.31
2[b]	.19	.03	2.25	.02	1.07	.31
3[c]	.31	.10	2.19	.06	4.0	.05

a. Predictors: (Constant), BDI-II

b. Predictors: (Constant), BDI-II, STAI-Trait

c. Predictors: (Constant), BDI-II, STAI-Trait, Self-Control Trait

d. Dependent Variable: Recall

The results clearly showed a significant *F Change* value for Trait Self-control. Further analysis suggested that Trait Self-Control had greatest influence on recall performance (β =.25), and positively correlated with the outcome variable. Trait self-control also explained 6% of the variance in recall performance, $F(1, 59) = 4.0$, p =.05, η_p^2 =.31. The results from this regression model were associated with a large effect size.

Discussion

My study attempted to build on the premise of Parry's (2014) study to examine the effect of both, state and trait self-control on the relationship between test anxiety and cognitive performance. Parry's (2014) study was unable to conclusively support the findings from existing literature (e.g., Bertrams et al., 2013), regarding the mediating effects of state self-control on state anxiety and cognitive performance. Furthermore, her study was unable to extend the findings of this relationship to include trait self-control. My aims were to: (a) generate new knowledge in the field of test anxiety, self-control and cognitive performance, (b) provide a deeper understanding of the how self-control improves cognitive performance, and (c) highlight the positive contributions to society that could result from this improved understanding. To do so, I followed Parry's (2014) state self-control manipulation protocol. However, I opted for an alternative and more effective state anxiety manipulation technique, in the form of an adapted version of the Socio-Evaluative Cold Pressor Test for Groups (SECPT-G). In this way, I hoped to improve the ecological validity of my study by inducing anxiety levels that mimic those experienced during an actual test situation.

Summary and Implications of Results

Overall the results were successful in confirming the predictions that state and trait self-control did not affect cognitive performance during the anxiety-absent conditions. However for the anxiety-present conditions, although the results indicated that state self-control significantly affected cognitive performance, the nature of this effect was contrary to what was predicted (i.e., participants with intact self-control would outperform those with depleted self-control). Furthermore, the results of a hierarchical MRA were unsuccessful in confirming that variations in trait-self-control affected cognitive performance during the anxiety-present condition. However, secondary analyses based on the results of the initial hierarchical MRAs were able to more accurately predict the relationship between trait self-control and cognitive performance.

Sample characteristics and matching. I conducted analyses to ensure that there were no significant between-group differences across the four experimental conditions. Variables age, BDI-II scores, and STAI-Trait scores were found to be equally distributed across the four experimental conditions. Furthermore, the analysis showed no statistically significant difference in the matching variable, trait self-control, across the four experimental conditions.

Experimental manipulation. Analysis of participant self-report measures clearly indicated that both the anxiety and self-control manipulations were successful.

State anxiety manipulation. Analyses of the STAI-State and VAMS data indicated that state anxiety was statistically significantly different between the anxiety-absent and the anxiety-present experimental conditions. In particular, participants in the anxiety-present conditions scored higher on the self-report measures than participants in the anxiety-absent conditions. This indicates that participants in the anxiety-present conditions experienced elevated levels of state anxiety going into the cognitive tasks.

As previously noted, Parry’s (2014) study was limited by the insufficient effects of the anxiety manipulation. The success of the anxiety manipulation in my study addressed this limitation, and ensured that the experimental conditions were statistically significantly different in terms of the levels of state anxiety at the time of the cognitive task performance. This allowed for the effects of anxiety on cognitive performance to be easily detected.

State self-control manipulation. The analysis of the self-control manipulation check Likert scale data indicated that state self-control was statistically significantly different between the intact and depleted experimental conditions. In particular, participants in the intact condition scored higher on the self-control manipulation check Likert scale than those in the depleted condition. This indicates that participants in the intact conditions experienced elevated levels of state self-control compared to those in the depleted condition.

Parry’s (2014) study was also successful in manipulating state self-control. However, while her manipulation was associated with a moderate effect size, my manipulation was associated with a large effect size. This indicates that there was large difference between participants of the intact and depleted conditions in terms of state self-control.

Hypothesis testing. This study considered 4 hypotheses. Hypotheses 1 and 2 were analysed using independent samples *t*-tests, while Hypotheses 3 and 4 were analysed using hierarchical MRAs.

Hypothesis 1. I predicted that, during the anxiety-absent conditions, participants with intact and depleted self-control would perform similarly on a cognitive task. As expected, the analysis found no statistically significant difference in performance on the recall task between the absent-intact and absent-depleted conditions. This indicated that participants performed similarly on the recall task. Therefore, Hypothesis 1 was successfully confirmed and found to be consistent with the results from previous studies (Bertrams et al., 2013; Parry, 2014).

Hypothesis 2. I predicted that, during the anxiety-present conditions, participants with intact state self-control would perform better on a cognitive task than participants with depleted state self-control. The results successfully showed a statistically significant difference between the present-intact and present-depleted conditions, associated with a moderate effect size. However, the hypothesis was not supported as the present-depleted group outperformed the present-intact group on the recall task, which is the antithesis of the proposed hypothesis.

Although both conditions experienced the same anxiety protocol, the STAI-State scores of the present-depleted condition were statistically significantly higher than those in the present-intact condition. This indicates that although participants in the present-depleted condition experienced higher levels of state anxiety, they performed better on the recall task than participants in the present-intact condition who experienced lower levels of state anxiety. Yerkes and Dodson's (1908) Inverted-U Hypothesis could account for the results obtained for this hypothesis. As mentioned previously, this hypothesis proposes that moderate levels of anxiety, as experienced by the present-depleted condition (Spielberger et al., 1983), facilitate performance on cognitive tasks. Whereas below-moderate anxiety levels, as experienced by the Present-Intact condition (Spielberger et al., 1983), impede performance on cognitive tasks.

Hypothesis 3. I predicted that, during the anxiety-absent conditions, trait self-control would have no effect on cognitive performance. This hypothesis was confirmed, as no statistically significant differences in recall performance were observed when trait self-control was added to the regression model. This implied that participants with varying levels of trait self-control performed comparably during the anxiety-absent conditions. These results support those obtained by Parry (2014). However, my study only managed to attain small effect sizes for the regression model.

Hypothesis 4. I predicted that, under the anxiety-present conditions, participants with higher trait self-control would perform better on a cognitive task than those with lower levels of trait self-control. This hypothesis was not confirmed, as no statistically significant differences in recall performance were observed when trait self-control was added to the regression model. This suggested that participants with varying levels of trait self-control performed similarly on a recall task in the anxiety-present condition. Once again, although I obtained the same result as Parry (2014), I obtained small effect sizes for my regression model whereas she obtained moderate-to-large effect sizes.

Model refinement/adjustment. I conducted several additional hierarchical regression analyses to narrow down the number of predictor variables used in the regression model to only include variables that made significant contributions to the model. Using this new regression model, I re-analysed Hypothesis 3 and Hypothesis 4.

Hypothesis 3. The re-analysis of Hypothesis 3 showed that the addition of trait self-control into the regression model made no significant difference to recall. Compared to the previous regression analysis conducted using the majority of the predictor variables, the effect size for this regression model was halved. Although a lower effect size was associated with this model, the lack of statistical significance indicated that variations in trait self-control during the anxiety-absent condition did not affect cognitive performance. This successfully re-confirmed the third hypothesis.

Hypothesis 4. While the results associated with Hypothesis 3 correlated with that of the previous regression model, the re-analysis of Hypothesis 4 was able to successfully confirm the hypothesis. This meant that participants with higher levels of trait self-control performed better on the cognitive task than those with lower levels. The statistical analysis clearly demonstrated a statistically significant result, once trait self-control was added into the model. This suggests that a number of the predictor variables that were previously included in the regression model, did not significantly influence the relationship between trait self-control and cognitive performance. However, once again this model was associated with small effect sizes, which suggests that the difference in cognitive performance between participants with higher trait self-control compared to those with lower trait self-control was small.

Summary. To definitively conclude that the relationship between test anxiety and cognitive performance was mediated by state and trait self-control, it was imperative that all 4 hypotheses be confirmed. More specifically, Hypotheses 1 and 2 needed to have been statistically significant in order to validate the mediation of test anxiety and cognitive performance by state self-control. Likewise, Hypotheses 3 and 4 needed to have been statistically significant in order to confirm the mediation of test anxiety and cognitive performance by trait self-control.

Although Hypothesis 1 was supported by the results of the present study, Hypothesis 2 was not. Therefore, I cannot definitively confirm that during an anxiety-provoking situation, individuals with intact self-control perform better on a cognitive task than individuals with depleted self-control. This is because: (1) the results obtained in my study directly contradicted the proposed hypothesis, and (2) the study conducted by Bertram et al. (2013) was able to successfully confirm the premise of Hypothesis 2.

The initial regression model was successful in confirming Hypothesis 3, however, it did not confirm Hypothesis 4. Therefore I used a new regression model, based on the design of the previous model. This model successfully confirmed Hypothesis 3, and most importantly, Hypothesis 4. Therefore, I can conclude, quite convincingly, that trait self-control mediates the relationship between test anxiety and cognitive performance.

This study drew on both the Attentional Control Theory (ACT) and the Cognitive Interference Theory (CIT) to better understand the relationship between test anxiety, cognitive performance, and self-control. According to the ACT decreased cognitive performance during an evaluative situation can be explained by attentional bias: when a threat (e.g., worrisome thoughts) to achieving a desired goal is perceived, increased state anxiety causes a shift in attentional resources from a goal-oriented task towards the perceived threat. Based on this theory, this study suggests that trait self-control acts as a mediating factor responsible for redirecting attentional resources away from the perceived threat, back to the goal-oriented task. The results of this study specifically indicate that higher levels of trait self-control are associated with an increased ability to redirect attentional resources back to the goal-oriented task, in this way improving cognitive performance.

According to the CIT, decreased cognitive performance during a goal-oriented task is due to an increase in test anxiety that ultimately results in the inability to filter out and suppress worrisome thoughts. Worrisome thoughts interfere with cognition by diverting attentional resources away from the goal-oriented task. Based on this theory, the results of this study suggest that trait self-control is a factor that consciously and deliberately prevents the interference of worrisome thoughts on cognitive performance. Individuals with higher levels of trait self-control are expected to possess a greater ability to filter out worrisome thoughts and focus on goal-oriented task performance. Therefore, the results of the present study suggest that trait self-control may be an important element of both the ACT and the CIT (Eysenck et al., 2007).

Limitations, and Alternative Explanations

Although efforts were made to limit the effects of extraneous variables, a number of external influences were beyond experimental control. Consequently, there are limitations that may have affected my results.

Sample size. To achieve an adequate power, it is important that the sample be of an optimal size. Typically, larger samples are more representative of the population and allow for the easier detection of statistically significant effects in the data. According to my power calculation, I required a sample size of 144 to obtain a statistical power of .80. However, I was only able to acquire a sample size of 130, which decreased the statistical power to .75. It is possible that the smaller sample size may have compromised my ability to detect a statistically significant effect in the population. Furthermore, this sample size may have been a poor representation of the population, prone to the influence of outliers and extreme cases. Future studies should seek to obtain a larger sample size, as this would: (1) make the sample more representative of the population, (2) reduce the effect of outliers, (3) increase power, and (4) increase the likelihood of detecting a statistically significant effect in the data.

Sampling. My participants were undergraduate psychology students from UCT, recruited using the non-probability sampling technique of convenience sampling. Although this sampling strategy allows for quick and easy access to participants, it introduces several biases and limits the generalisability of the study. For instance, it is a requirement for the psychology students to participate in departmental research investigations. This mandatory participation ensures the attendance of students at studies, but does not take into account the quality of their participation. The results on the STAI-State and the recall task hinted at the fact that although some participants may have chosen to attend sessions, they may not have experienced the full extent of the anxiety manipulation or may not have participated in the cognitive tasks to the best of their ability. This could be attributed to their awareness of the fact that the quality of their participation was inconsequential to their academic performance.

Anxiety manipulation. Recruiting all participants from the undergraduate psychology department increased the possibility of previous participants discussing the nature of my study with their peers, who were yet to participate. This would have reduced the efficacy of the deception used in the study, and limited the effects of the anxiety manipulation. The differences between the two anxiety-present conditions on STAI-State scores and recall may be an indication of this. A large portion of the data for the present-depleted condition was collected during the first half of the semester. Due to the deception I employed, participants who attended the experimental sessions were unaware as to what each element of the study entailed. This reduced their perceived control over the situation, and facilitated the success of the anxiety manipulation. As a result, the present-depleted condition had relatively high STAI-State scores. On the other hand, majority of the data for the present-intact condition was collected during the latter half of the semester. Due to prior knowledge obtained from previous participants about the stress manipulation elements of my study, several of the participants who attended the experimental session may have been prepared for what was to come. This may have compromised the deception and increased the participants' perceived control over the situation. As a result, participants in the present-intact condition scored lower on the STAI-State measure than the present-depleted condition. Future studies aimed at academic institutions should consider sampling participants from a variety of faculties and departments, to: (a) improve the ecological validity of the study, and to (b) control for the biases mentioned above.

Self-control manipulation. State self-control can become depleted by typical daily activities which limit attention to a particular task (e.g., paying attention during lectures). Although experimental sessions were arranged for early in the day to limit state self-control depletion, this was not always possible. Participants often attended early morning lectures or tutorials before arriving at the experimental session. Furthermore, participants could have experienced several situations that may have required the exertion of state self-control en route to the experimental session. Therefore, it is entirely possible that participants may have varied on state self-control prior to completing the state self-control manipulation task. As a result, participants in the self-control depleted groups may have had varying levels of depleted state self-control, which could have affected performance on the recall task. Future studies should include a period of relaxation and deep breathing before commencing with the state self-control manipulation to allow for depleted state self-control levels to rejuvenate (Tyler & Burns, 2008). This will allow for a more accurate self-control manipulation.

Worry. As previously stated, worry is the component of test anxiety identified as being the most detrimental to cognitive performance. Therefore, I expected anxiety to increase worrisome thoughts in participants in the anxiety-present condition. Given that worrisome thoughts occupy WM capacity, cognitive performance in these conditions was expected to be significantly lower than in the anxiety-absent conditions. However, secondary analyses indicated no significant difference between the anxiety-present and anxiety-absent conditions on recall. This could indicate that participants in the anxiety-present condition failed to develop worrisome thoughts post-anxiety manipulation. The absence of worrisome thoughts circles back to the fact that participants were aware that their performance in the study did not amount to any social or academic consequences. Future studies should measure self-reported distraction by worrisome thoughts in the participants. The results of this measure could then be cross-referenced with the STAI-State and cognitive task scores, to determine the relationship between these variables.

Future Directions for Research

In addition to the directions for future research mentioned above, I recommend that future research: (1) improves the ecological validity of the study, and (2) provides a realistic reflection of the relationship between test anxiety, trait self-control, and cognitive performance. One such approach could entail the use of a mixed-design study. Inclusion criteria for this study could include participants' willingness to share the results of their National Benchmark Tests (NBTs). There are a number of benefits that come with using these results to measure cognitive performance: (1) it increases the scope of university students that could be used in the study, (2) standardised test conditions ensures that each participant would have had a similar experience of writing the examination, and (3) these examinations have important consequences for the participants' futures, and are therefore likely to be associated with symptoms of test anxiety. In addition to the NBT results, data collection could include measures of participants STAI-Trait and BSCS scores. The qualitative aspect of the study could entail detailed interviews with participants to obtain relevant subjective information on their experiences of writing the examination. Interview questions could be aimed at uncovering how participants may have felt during the NBT, whether they experienced worrisome thoughts, and other information relevant to their subjective experience of being in that particular anxiety-provoking test situation. This design would allow for a more holistic understanding of the role that trait self-control plays in the relationship between test anxiety and cognitive performance.

Significance of the Present Study

My study examined the effect of both, state and trait self-control on the relationship between test anxiety and cognitive performance. My aims were to: (a) generate new knowledge in the field of test anxiety, self-control and cognitive performance, (b) provide a deeper understanding of the how self-control improves cognitive performance, and (c) highlight the positive contributions to society that could result from this improved understanding.

Previous studies have found that state self-control mediates the relationship between test anxiety and cognitive performance. My study (like Parry, 2014) extended these findings to include trait self-control as a crucial factor mediating cognitive performance during evaluative situations. Furthermore, my study has been able to build on the principles of the ACT and the CIT to explain how higher levels of trait self-control prevents worrisome thoughts from interfering with cognitive processing, thereby allowing for optimal cognitive performance on goal-oriented tasks. The implications of higher levels of trait self-control in successfully combating the worrisome thoughts associated with test anxiety, highlights the importance of developing practical ways of strengthening and improving trait self-control (Baumeister et al., 2007). Such practical applications may provide individuals who are prone to the debilitating effects of test anxiety, with an opportunity to improve their cognitive performance in test-anxious situations by increasing their trait self-control.

By enabling individuals to hinder the debilitating effects of test anxiety, they would be able to perform at their optimal level on cognitive tasks (Bertrams et al., 2013). This can potentially reduce the negative consequences associated with poor performances due to test anxiety such as prematurely leaving school, failing to attain a desired vocational position, or failing to enter university (Owens et al., 2014). Furthermore, improvement over one's innate trait self-control levels during evaluative situations has the potential to spill across into other aspects of behaviour, such as improved self-control over: (a) impulse control, (b) emotions, and (c) interpersonal relationships (Tangney et al., 2004).

Conclusion

Trait self-control appears to mediate the relationship between test anxiety and cognitive performance. This mediatory role involves the deliberate and conscious act of redirecting attentional resources away from interfering worrisome thoughts in order to focus on goal-oriented tasks. My research shows that variations in trait self-control do not affect cognitive performance in anxiety-absent conditions. The analyses did, however, support the hypothesis that higher levels of trait self-control are associated with better performance on a cognitive task than lower levels of trait self-control. Therefore, it is clear that trait self-control does mediate the relationship between test anxiety and cognitive performance.

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Appendix A

Informed Consent Form: Anxiety-Present Groups

The Role of Stamina and Perseverance in Cognitive Performance

What is the purpose of this study?

The purpose of this study is to gain insight into the human characteristics of stamina and perseverance. I am particularly interested in how these characteristics affect cognitive performance.

What does this study entail?

If you agree to participate in this study you will be required to:

(a) take part in a simple writing exercise,

(b) take part in a Cold Pressor Test,

(c) perform simple cognitive tasks, and

(d) complete a few self-report surveys.

For the writing task, you need to copy out a given piece of text, being sure to leave out the letters “a” and “i” as you do so.

The Cold Pressor Test involves placing your non-dominant hand, up to the wrist, into a bucket of ice cold water for 3 minutes. During this time, I will ask you a few general knowledge questions.

For this study, you will need to perform two cognitive tasks, as well as three sets of self-report surveys.

Please note that throughout the study, you will be video-recorded and observed by an independent evaluator.

What are the risks involved in this study?

The Cold Pressor Test may cause you slight discomfort as your hand will be immersed in ice water. You may also feel slightly anxious whilst being observed during this process.

What are the benefits involved in this study?

You will be awarded 2 SRPP points for your participation in this study.

Voluntary Participation

Your participation in this study is entirely voluntary. Should you consent to participate and wish to withdraw your consent, you may do so at any time without any negative repercussions.

Confidentiality

The information you provide in this study will be kept strictly confidential. This information will be stored safely in locked file cabinets at the University of Cape Town, and on a password protected computer.

Your name (including this consent form) will not be associated with any of the cognitive tests or questionnaires that you will complete. Furthermore, this information will not identify you should it appear in any reports or publications.

If you agree to this participate in this study, it is possible that some of the information collected may be used for other research purposes in the future. If this does occur, the data used will not include any information that could identify you.

Questions

If you have any questions about this study, or should any problems arise, please direct them to the following researchers:

Dr. Progress Njomboro (Supervisor)	021 650 3418	progress.njomboro@uct.ac.za
Robyn Human (Co- supervisor)	021 788 5536	robyn.human@uct.ac.za
Victoria Parry (Co-supervisor)	082 657 4174	Vicci.Parry@alumni.uct.ac.za
Rooksaar Amod (Honours Candidate)	072 059 9426	rooksaaramod@yahoo.com

Should you wish to find out more about your rights as a researcher, or if you have any questions, complaints or comments about your study, please contact:

The Department of Psychology

Rosalind Adams

021 650 3417

I have read and understood the purpose, procedure, risks and benefits that are associated with this study. I voluntarily consent to participating in the research study described above.

________________________________ _______________________

Name and signature of the participant Date

Please indicate the course code to which you would like to assign your SRPP points:

__________________________________.

Appendix A

Informed Consent Form: Anxiety-Absent Groups

The Role of Stamina and Perseverance on Cognitive Performance

What is the purpose of this study?

This purpose of this study is to gain insight into the human characteristics of stamina and perseverance. I am particularly interested in how these characteristics affect cognitive performance.

What does this study entail?

If you participate in this study you will be required to:

(a) take part in a simple writing exercise,

(b) immerse your hand in water water for 3 minutes,

(c) perform simple cognitive tasks, and

(d) complete a few self-report surveys.

For the writing exercise, you simply need to copy out a given piece of text as is.

Following this exercise, you will be required to immerse your non-dominant hand in a bucket of warm water for 3 minutes.

For this study, you will need to perform two cognitive tasks, as well as three sets of self-report surveys.

What are the risks involved in this study?

There are no risks involved in participating in this study.

What are the benefits involved in this study?

You will be awarded 2 SRPP points for your participation.

Voluntary Participation

Your participation in this study is entirely voluntary. Should you consent to participate and wish to withdraw your consent, you may do so at any time without any negative repercussions.

Confidentiality

The information you provide in this study will be kept strictly confidential. This information will be stored safely in locked file cabinets at the University of Cape Town, and on a password protected computer.

Your name (including this consent form) will not be associated with any of the cognitive tests or questionnaires that you will complete. Furthermore, this information will not identify you should it appear in any reports or publications.

If you agree to this participate in this study, it is possible that some of the information collected may be used for other research purposes in the future. If this does occur, the data used will not include any information that could identify you.

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Victoria Parry (Co-supervisor)	082 657 4174	Vicci.Parry@alumni.uct.ac.za
Rooksaar Amod (Honours Candidate)	072 059 9426	rooksaaramod@yahoo.com

Should you wish to find out more about your rights as a researcher, or if you have any questions, complaints or comments about your study, please contact:

The Department of Psychology

Rosalind Adams

021 650 3417

I have read and understood the purpose, procedure, risks and benefits that are associated with this study. I voluntarily consent to participating in the research study described above.

______________________________ ____________________

Name and signature of the participant Date

Please indicate the course code to which you would like to assign your SRPP points:

______________________________.

Appendix B

Debriefing Forms: Anxiety-Present Groups

This study is titled: "The Relationship between Test Anxiety and Cognitive Performance: Mediated through the Lens of State and Trait Self-Control". The purpose of this study was to determine whether the effects of stress on cognitive performance can be mediated by state and trait self-control. You were not informed of the true title of the study, or of the variables investigated so as to avoid any response biases in the self-report questionnaires and forms. Furthermore, the true nature of the study was not revealed to you so that I could manipulate your anxiety and state self-control levels.

Social-evaluative techniques along with the Cold Pressor Test (CPT) were used in conjunction to increase your anxiety levels before the cognitive tasks. While the CPT increases your physiological responses, the **idea** of being socially evaluated on a number of levels (by the video-camera, the investigator and your peers) has been found to significantly increase cortisol secretion. Therefore in an attempt to induce anxiety, I told you that you were being evaluated and recorded when you were not.

Self-control is an importance factor in this study. I have hypothesised that high levels of self-control will mediate the effects of anxiety and allow you to perform well on cognitive tasks, while having low-levels of anxiety will allow the effects of anxiety to dominate, therefore yielding poor performances on cognitive tasks.

This study has important implications for improving cognitive performances during test situations. This can be accomplished through psychological interventions and workshops aimed at teaching anxious individuals skills in anxiety management and self-control development. These skills can then be applied in practical situations to improve performance in test anxiety situations.

If you still experience feelings of anxiety following the completion of this study, you may contact the following services:

1. South African Depression and Anxiety Group (SADAG):	0800 21 22 23/ 011 234 4837
2. Student Wellness Services:	021 650 1020/ 021 650 1017

Appendix B

Debriefing Forms: Anxiety-Absent Groups.

This study is titled: "The Relationship between Test Anxiety and Cognitive Performance: Mediated through the Lens of State and Trait Self-Control". The purpose of this study was to determine whether the effects of stress on cognitive performance can be mediated by state and trait self-control. You were not informed of the true title of the study, or of the variables investigated so as to avoid any response biases in the self-report questionnaires and forms. Furthermore, the true nature of the study was not revealed to you so that I could manipulate your anxiety and state self-control levels.

Self-control is an important factor in this study. I have hypothesised that high levels of self-control will mediate the effects of anxiety and allow you to perform well on cognitive tasks, while having low-levels of anxiety will allow the effects of anxiety to dominate, therefore yielding poor performances on cognitive tasks.

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If you still experience feelings of anxiety following the completion of this study, you may contact the following services:

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2. Student Wellness Services:	021 650 1020/ 021 650 1017

Appendix C

Text to Copy

Stalactites and stalagmites are speleothems formed by water dripping or flowing from fractures on the ceiling of a cave.

In caves, stalagmites grow rather slowly (0.00028-0.0366 in/yr [0.007-0.929 mm/yr]), while in artificial tunnels and basements they grow much faster. Soda straw stalactites are the fastest growing (up to 40 mm/yr.), but most fragile stalactites in caves. Soda straw stalactites form along a drop of water and continue growing down from the cave ceiling forming a tubular stalactite, which resembles a drinking straw in appearance. Their internal diameter is exactly equal to the diameter of the water drop. Growth of most stalactites is initiated as soda straws. If water flows on their external surface, they begin to grow in thickness and obtain a conical form. If a stalactite curves along its length, it is called deflected stalactite. If its curving is known to be caused by air currents, it is called anemolite. Petal-shaped tubular stalactites composed of aragonite are called spathites. When some stalactites touch each other they form a drapery with a curtain-like appearance.

When dripping water falls down on the floor of the cave it form stalagmites, which grow up vertically from the cave floor. Any changes in the direction of the growth axis of the stalagmite are suggestive of folding of the floor of the cave during the growth of the stalagmite. If a stalagmite is small, flat and round, it is called button stalagmite. Stalagmites resembling piled-up plates with broken borders are called pile-of-plates stalagmites. Rare varieties of stalagmites are mushroom stalagmites (partly composed of mud and having mushroom shape), mud stalagmites (formed by mud) and lily pad stalagmites (resembling a lily pad on the surface of a pond). A calcite crust (shelfstone) grows around a stalagmite if it is flooded by a cave pool and forms a candlestick.

When a stalactite touches a stalagmite it forms a column. Usually, stalactites and stalagmites in caves are formed by calcite, less frequently by aragonite, and rarely by gypsum. Fifty-four other cave minerals are known to form rare stalactites. Sometimes calcite stalactites or stalagmites are overgrown by aragonite crystals. This is due to precipitation of calcite that raises the ratio of magnesium to calcium in the solution enough that aragonite becomes stable.

Rarely, elongated single crystals or twins of calcite are vertically oriented and look like stalactites, but in fact are not stalactites because they are not formed by dripping or flowing water and do not have hollow channels inside. These elongated crystals are formed from water films on their surface.

In some volcanic lava tube caves exist lava stalactites and stalagmites that are not speleothems because they are not composed of secondary minerals. They are primary forms of the cooling, dripping lava.

The internal structure of stalactites and stalagmites across their growth axis usually consists of concentric rings around the hollow channel. These rings contain different amounts of clay and other inclusions, and reflect dryer and wetter periods. Clay rings reflect hiatuses of the growth of the sample. Stalagmites may be formed for periods ranging from a hundred years up to one million years. Stalactites and stalagmites in caves have such great variety of shapes, forms, and colours that almost each of them is unique in appearance. At the same time, their growth rates are so slow that once broken, they cannot recover during a human life span of time. Thus, stalactites and stalagmites are considered natural heritage objects and are protected by law in most countries, and their collection, mining and selling is prohibited.

Source: http://science.jrank.org/pages/6432/Stalactites-Stalagmites.html#xzz3Y2V65s3m

Appendix D

Manipulation Check Likert-type Scale

1 Very much so	2 Moderately so	3 Somewhat	4 Not at all

1. How difficult did you find this task? 1 2 3 4
2. How effortful did you find this task? 1 2 3 4
3. How tired are you after completing this task? 1 2 3 4
4. How well do you think you did on the task? 1 2 3 4

Appendix E

Nonsense Syllables (Trigrams)

1. KOR
2. FIW
3. HAQ
4. JOH
5. DES
6. PEQ
7. DIH
8. LOM
9. TIG
10. NEF
11. SAL
12. KOD
13. SIW
14. WEJ
15. XIZ

Appendix F

Arithmetic Task

a. 5 x (7 - 1)

b. 6 + 9 x 2

c. 2 + 9 + 35

d. 19 - 85

e. 4 x 6 x 9

f. 25 – 9 + 15 x 0

g. (12 + 5) x 6

h. 9 + 8 -16

i. 22 + 31 x 4

j. (94 +9) x 2

k. 51 – 42 +100

l. 9 x 2 x 9

m. 99 – 21 x 3

n. 52 + 52 -19

o. (31 -9) x 8