The Influence of Cognitive Test Anxiety on Heart Rate Variability

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Abstract
Chronic anxiety and stress are on the rise among students and have been of growing concern to mental health professionals, as they have been linked to mental and physical health issues (Eisenberg, 2007; Furr, 2001; Gotlib, 1984; Holroyd, 1978; Irwin, 1990; Yokus, 2012). Cognitive test anxiety in particular is detrimental to mental health and academic performance, regardless of a student’s degree of exam preparation (Cassady, 2002; Cassady, 2004). There are few empirically validated non-chemical therapies shown to alleviate test anxiety in students, and greater treatment diversity is needed to moderate levels of test anxiety. The purpose of this study is to develop a method of comparing the efficacy of potential test anxiety therapies in a realistic testing environment.

A two-block cognitive task similar to the Graduate Record Examination (GRE) was programmed to represent a timed college examination. Aggressive feedback was displayed after each correct, incorrect, and unanswered trial, and participants were given one minute to read and respond to each question. There were two sets of 15 questions separated by a short break. The total exam duration was approximately 32 minutes.

The task was piloted on a sample of undergraduate students (n=19) alongside physiological recording equipment to determine its effectiveness in eliciting an anxiety response. Questionnaires measured self-reported cognitive test anxiety. A blood volume pulse (BVP) sensor and a respiration sensor were used with the NeXus-II Mark 10 system to record the average heart rate variability (HRV) of each participant at baseline and during both test blocks. HRV is defined as the variation in time interval between heart beats and represents the ability of the human body to adjust heart rate and respiration frequency in response to environmental conditions (Hittig, 2013). High HRV is considered an indicator of low levels of anxiety and good health, while low HRV is an indicator of high anxiety and is associated with a heightened risk of cardiovascular disease, heart attack, and stroke (Hittig, 2013).

A significant drop in HRV was seen during the first exam block compared to baseline. Interestingly, the HRV drop in the second exam block was not significant, suggesting that anxiety dropped on average over the course of the exam. These results suggest that the modified GRE task does effectively raise state anxiety levels in the short term, but that the effect is time-sensitive. Therefore, using an abbreviated version of the modified GRE task may be a good method of inducing and measuring cognitive test anxiety in order to compare the efficacy of potential anxiety therapies.

Introduction
Although moderate levels of state anxiety can increase arousal and motivation and are correlated with higher exam performance in college students, high levels of chronic cognitive test anxiety have been associated with procrastination, low test scores, and high levels of generalized anxiety, worry, and depression (Cassady, 2002; Holroyd, 1978). These findings seem to be independent of gender (Cassady, 2002; Yokus, 2012). Anxiety is typically associated with physiological arousal—often measured via heart rate variability (HRV)—and can also detrimentally influence cognition (Holroyd, 1978). High levels of self-reported cognitive test
anxiety correlate with strong helplessness attributions, which can lead to self-defeating behaviors such as procrastination and the pursuit of ineffective studying techniques (Cassady, 2004). Cognitive test anxiety can contribute to generalized anxiety, which can cause more widespread problems by decreasing immune function and increasing risk of depression, suicide, heart attack, and stroke (Eisenberg, 2007; Furr, 2001; Gotlib, 1984; Irwin, 1990). It is of particular concern that the typical undergraduate student may not yet have developed the executive control necessary to regulate cognitive processes involved in rumination by the time s/he enters college, as executive function is largely attributed to the prefrontal and anterior cingulate cortices (Kelly, 2009). Neither of these regions are fully developed until the mid- to late-twenties (Fuster, 1988).

In order to create new therapies for cognitive test anxiety, it is important to be able to induce it in a research environment and measure it quantitatively so that the efficacy of anxiety therapies be determined. This can be challenging, as many of the cognitive tasks currently used to elicit anxiety are artificial and may not be representative of a real college testing environment. In the current study, an original cognitive task was programmed to mimic a computerized multiple choice exam. It was piloted on a group of undergraduate students alongside physiological recording equipment to determine whether it elicited cognitive test anxiety.

Materials & Methods

Participants

Participants (n=19; 10M, 9F) were recruited via email in a convenience sample of undergraduates from a liberal arts college in the Western United States. All participants fell between the ages of 18 and 24, with an average age of 21.0 years. Participants were informed that they would be entered into a drawing for a gift card for each correct response on the modified GRE task to motivate them to answer each question to the best of their ability.

Measures

Each participant filled out a demographics survey, which included questions regarding age, gender, race, ethnicity, birthplace, and class standing. The Spielberger Test Anxiety Inventory (TAI) and the State-Trait Anxiety Inventory (STAI) were proctored to collect data on self-reported levels of anxiety (Spielberger, 1970; Spielberger, 1980). The NeXus-10 Mark II biofeedback system manufactured by Stens Corporation was used alongside blood volume pulse (BVP) and respiration (RSP) sensors to monitor HRV at baseline and during each exam block.

Procedures

After each participant completed the demographics survey and the TAI, the BVP sensor was placed on the non-dominant index finger and the RSP sensor was wrapped around the waist near the xiphoid process of the sternum. Baseline HRV readings (SDNN) were taken through the BioTrace+ software package while each participant sat quietly and watched an unstimulating 90 second video.

Each participant then completed an original cognitive task programmed in E-Prime 2.0. The task was a 30 minute computerized verbal and mathematics exam composed of two 15-minute blocks. Multiple-choice questions from publicly accessible Graduate Record Examination (GRE) practice tests were used. To increase time pressure, only 60 seconds were given to respond to each question. Scrap paper and a pen were provided if desired. Participants
responded to each question by pressing one of four keys on a response box. Appropriate feedback of “CORRECT” in large green letters and “INCORRECT” in large red letters was shown after each response. HRV was recorded separately during blocks 1 and 2. Participants sat quietly for approximately 2 minutes between the two blocks.

Results

Statistical analyses were carried out to compare HRV at baseline and during blocks 1 and 2, and to correlate self-reported cognitive test anxiety (TAI score) and state/trait anxiety (STAI score) levels with task accuracy (number of correct answers). No significant difference in HRV based on questionnaire scores was found. A statistically significant ($p=.034$) drop in HRV occurred between baseline and testing block 1. The drop between baseline and testing block 2 was not significant.

![HRV Changes During Exam](image)

*Figure 1. Repeated measures ANOVA: F(2,15)=5.567, p=.016
Paired contrasts: Baseline vs. Testing Block 1, $p=.034^*$
All other comparisons, n.s.*

Discussion & Conclusions

The statistically significant HRV drop in block 1 suggests that the modified GRE task did successfully induce cognitive test anxiety in participants. However, because the drop was no longer significant during block 2, the task may have been too long. Participants may have become more comfortable with the exam after block 1, experienced practice effects, and/or become fatigued and demotivated. Therefore, it is likely that an abbreviated version of the modified GRE task would be more successful in eliciting consistent cognitive test anxiety.

A limitation of this study may have been that participants were not compensated for participation aside from the single gift card drawing. Therefore, participants may not have been
sufficiently motivated to produce correct responses on the cognitive task. This lack of motivation could have decreased cognitive test anxiety, as performing poorly had no negative repercussions.

Future research will utilize the modified GRE task alongside HRV recording equipment to determine the efficacy of canine companionship in moderating cognitive test anxiety. Because anxiety levels induced by the modified GRE task appear temporally sensitive, the task may be abbreviated in future research to minimize practice effects and fatigue.
References


