Journal of Integrated Social Sciences
www.JISS.org, 2025 - 15(1): 1-25

Original Article:

NULL BUT NOT VOID: LESSONS FROM AN EXPERIMENTAL STUDY ON THE PSYCHOPHYSIOLOGY OF STRESS

Anna Minor, B.S.
Murray State University, USA

Megan St. Peters, Ph.D.
Murray State University, USA

Abstract

Stress impacts our emotions, cognition, behavior, and health. Although stress is abundant and unavoidable, recent research suggests our perception of stress can strongly influence its outcomes. The Biopsychosocial Model of Challenge and Threat (BPS) states that we appraise a stressful scenario in one of two ways: challenge or threat. A challenge appraisal involves a positive perception of stress while a threat appraisal involves a negative perception of stress. The current research employed an experimental design to randomly assign participants to receive either threat or challenge-based instructions prior to completing the Stroop task, a well-established cognitive control task sensitive to stress and fatigue. Grounded in the BPS framework, this manipulation aimed to explore how contextual appraisals influence cognitive performance, physiological stress, anxiety, and ego depletion, as well as explore the potential role of one's inherent (trait) self-control. Several psychophysiological measures were taken both pre- and post- completion of the Stroop task: heart rate variability, state anxiety, and change in grip strength to assess ego depletion. Trait self-control and cognitive appraisal of the task were assessed post-test. Results confirmed the threat condition instructions were perceived as more threatening. Females were more likely to appraise the challenge condition as more threatening than males. However, task performance, anxiety, physiological stress, and ego depletion were unaffected by the experimental manipulation. Trait self-control was also not predictive of any of these measures. Although largely non-significant, this study provides insights to consider in future studies exploring the psychophysiology of stress.

Keywords: stress, anxiety, self-control, cognitive appraisal, ego depletion

AUTHOR NOTE: Please address all correspondence to Dr. Megan St. Peters, Murray State University, Department of Psychology, 203 Wells Hall, Murray, KY 42071, USA. Email: mstpeters@murraystate.edu

INTRODUCTION

Stress remains the top factor affecting adult mental health (American Psychiatric Association, 2025). Stress is the physiological or psychological response to internal or external stressors. It is associated with negative moods like anxiety (Bolger et al., 1989) and has negative social implications such as withdrawal, irritability and hostility, and ultimately, taxes an individual's psychological resources (August et al., 2007). Consistent with the General Adaptation Syndrome (Selye, 1946), stress has immediate and long-term effects on physical health. Chronic stress serves as a risk factor for physiological disorders including obesity and cardiovascular disease, psychiatric disorders such as depression, anxiety, and acute stress disorder, and neurodegenerative disorders such as Alzheimer's (Ross et al., 2017). In college specifically, stress is negatively correlated with psychological well-being (Barbayannis et al., 2022), psychological flexibility (Koppenborg et al., 2022), academic performance, motivation, and increases the risk of school dropout (Pascoe et al., 2020).

Although the negative consequences of stress have long been documented, research suggests that one's perspective, or cognitive appraisal, of stress has the potential to mitigate these effects. The first formal studies examining cognitive appraisals involved participants watching silent videos – a neutral video or one depicting a primitive ritual involving a crude operation called "subincision," in which a young boy is restrained by several older men while his penis is cut with a sharpened flint (e.g., Lazarus et al., 1962; Speisman et al., 1964). Compared to a neutral film, viewing this film resulted in both self-report and physiological changes consistent with a stress reaction (Lazarus et al., 1962). However, both self-report and physiological stress reactions by watching the subincision video could be reduced by hearing a neutralizing narrative or soundtrack (e.g., about how the operation was not harmful but rather a joyous rite of passage, or if it were presented as a scientific film) (Speisman et al., 1964). Such work laid the framework for the Transactional Model of Stress and Coping developed by Lazarus and Folkman in 1984. Central to this model is the proposed process by which individuals evaluate and interact with their environment – a primary appraisal determines if the event is harmful and a secondary appraisal assesses ability to cope with a perceived threat.

The Biopsychosocial Model of Challenge and Threat (BPS) refined this framework to explore how cognitive appraisals influence self-report and physiological measures of stress during goal-relevant performance (Blascovich & Tomaka, 1996; Blascovich & Mendes, 2000). According to the BPS, when an individual enters a potentially stressful situation, they evaluate how demanding the situation is and whether they have the necessary resources to cope with those demands. If the individual believes they have sufficient internal and external resources to meet the demands, the situation is viewed as a "challenge" whereas if the individual believes their resources are insufficient to meet the demands, the situation is viewed as a "threat." The BPS rests on the "identity thesis" in that

it seeks to answer questions by pursuing, developing, and validating physiological indices of psychological constructs.

For instance, in one study, cognitive appraisals and physiological stress were measured while participants performed a mental arithmetic task (Tomaka et al., 1997). They were randomly assigned to hear one of two audio-recorded sets of instructions: threat (emphasizing accuracy of task performance and potential evaluation) or challenge (emphasizing effort and doing one's best). Consistent with previous studies and Lazarus and Folkman's theory of stress (1984), self-reported cognitive appraisal was assessed as a relative balance between demands and resources. Specifically, they asked participants two questions on a 6-point Likert scale to assess self-report cognitive appraisal – "How threatening.." and "How able are you to cope with…," and examined each question individually as well as calculated an overall appraisal index as a ratio. Physiological data included systolic and diastolic blood pressure (measured at baseline, 1, 3, and 5 minutes), and electrocardiographic indices - pre-ejection period, heart rate, cardiac output, and total peripheral resistance – recorded every minute via electrodes. Reactivity scores were calculated by subtracting baseline from task values. The cognitive appraisal ratio differed based on instruction type, validating the manipulation. There was no difference in task performance (number of responses, number and percentage of correct responses) or blood pressure; however, three of the four electrocardiographic measures differed (all but heart rate).

Though originally unexamined, affect and related psychological constructs likely interact with cognitive appraisals and have since been integrated into the BPS model (Blascovich & Mendes, 2000). These interactions are thought to occur both consciously and unconsciously, prompting calls for further research to clarify their involvement. Porter and Goolkasian (2019) explored how threat and challenge instructions affect cardiovascular and emotion outcomes when playing video games. Participants were randomly assigned to hear challenge or threat instructions before playing Mortal Kombat or Tetris. Measures included two Likert-based questions (0 – 6) to assess primary ("How demanding..") and secondary ("Do you feel you had the necessary skills…") cognitive appraisals, although the researchers did not use a ratio. They found that threat instructions were associated with higher demand and lower skill ratings compared to the challenge condition, validating the study's paradigm. Participants were asked to rate game characteristics (e.g., violent, boring, difficult) on a 5-point Likert scale, and the threat group rated the games as more difficult. Participants also rated emotions (e.g., worried, fearful, happy, proud) on a 9-point Likert scale, and, consistent with BPS, the threat appraisal instructions resulted in higher ratings of "fearful," "worried," and "anxious." Physiological stress was measured using systolic and diastolic blood pressure and heart rate variability (using RMSSD). No effect of instruction type was found related to blood pressure although Mortal Kombat was associated with an increase regardless of instruction type. This appears inconsistent with the hypothesis and review of research by Blascovich and Mendes (2000)

in which they suggest changes in blood pressure should be observed in threat but not challenge conditions (p. 79). Porter and Goolkasian (2019) did find that heart rate variability (using RMSSD) was higher in the threat groups, but only for the first five minutes of game play compared to the challenge groups (regardless of video game type), which may be more consistent with the General Adaptation Syndrome in that online monitoring of the situation segued from the "alarm" phase to the "maintenance" phase when being faced with a stressor (Selye, 1946).

High trait self-control is a personality type associated with a wide range of positive behaviors, such as being able to better control one's thoughts, emotions, and impulses (Baumeister et al., 1998; de Ridder et al., 2012). It is predicted that individuals who exhibit high trait self-control are more likely to perceive a stressor as a challenge as opposed to a threat (Blascovich & Tomaka, 1996, p. 13). To date, only one study was found to have examined the relationship between trait self-control and cognitive appraisal, though it employed a correlational design. Wieringa (2020) explored whether cognitive appraisal mediated the link between trait self-control and healthy eating behavior using a vignette-based approach. While trait self-control was associated with both cognitive appraisal and healthy eating, mediation was not supported – both showed direct effects. Notably, lower self-control was linked to appraising the vignette as more threatening. However, no research has yet experimentally tested the role of trait self-control within the BPS framework.

Although stable individual differences are captured by trait theories, another perspective views self-control as a limited resource that can be temporarily depleted – a phenomenon known as *ego depletion* (Baumeister et al., 2007). This model suggests that individuals with high trait self-control may have greater regulatory resources, potentially buffering them from ego-depletion effects (Baumeister et al., 2007; Hagger et al., 2010). Although several studies have explored the relationship between trait self-control and ego depletion, results are mixed (e.g., Englert & Bertrams, 2021; O'Brien et al., 2021).

A meta-analysis of 83 studies supports that ego depletion impairs self-control task performance (Hagger et al., 2010). For example, Ciarocco et al (2001) examined how avoiding a conversation – or acting as an ostracizer – impacted ego depletion. They used both behavioral (persistence on an unsolvable anagram task) and physical (handgrip strength) measures, finding consistent declines in ego depletion. Drawing on the BPS model, Ciarocco et al (2001) concluded that handgrip duration measures ego depletion as it requires sustained mental and physical persistence. A substantial body of research links stress to ego depletion (Baumeister & Tienery, 2011; Duckworth et al., 2013; Gokalp et al., 2024; Hagger et al., 2010; Maier et al., 2015; Oaten & Cheng, 2005; Park et al., 2016). For instance, Goldberg and colleagues (2017) found that longer baseline handgrip duration was associated with lower perceived stress and other psychological factors (e.g., neuroticism, anxiety sensitivity, mindfulness). However, despite these findings, no studies to date have experimentally examined ego depletion within the BPS framework.

Couched in BPS framework, the current study experimentally manipulates instructions to induce threat or challenge conditions before completing a Stroop task to better understand the interplay of this context on physiological stress, state anxiety, ego depletion, and trait self-control. Additionally, given that one previous study reported that female participants were more likely to appraise situations as more threatening compared to men (Wieringa, 2020), differences between males and females will be explored. Thus, the four sets of hypotheses are as follows:

Hypothesis 1: *Randomly assigned instruction type (threat or challenge) given prior to the Stroop task will result in different cognitive appraisals of the task.*

Hypothesis 2: *Participants randomly assigned to the threat instructions will perform worse on the Stroop task and report higher levels of state anxiety, exhibit more ego depletion, and exhibit impaired physiological functioning compared to those who are assigned the challenge instructions*.

Hypothesis 3: *Trait self-control will be related to Stroop task performance, cognitive appraisals, anxiety, ego depletion, and physiological stress responses.*

Hypothesis 4: *Females will appraise the Stroop task as more threatening than males.*

METHOD

Participants

Of the 106 students who began the study at Murray State University, three were excluded due to significant data loss or recording errors. Thus, the final sample for data analysis consisted of 103 undergraduate students (26 male, 75 female, 2 unanswered). Ages ranged from 18 - 39 (M = 20.13, SD = 2.47). Most participants were White (86.4%), followed by Biracial (5.7%), Black (3.9%), Hispanic (1.9%), Asian (1%) and American Indian (1%). For college classification, 34% were Freshmen, 15% Sophomore, 21% Juniors, and 32% were Seniors. Participants were recruited via the following: flyers hung in public locations on campus and SONA, a research site hosted by the psychology department where students complete studies for research exposure and/or extra credit. The study was reviewed and approved by the local Institutional Review Board.

Materials

Physiological Measures

A Polar H10 heart rate monitor chest strap (Schaffarczyk et al., 2022) was used to collect heart rate measures which were analyzed with Kubios software (Tarvainen et al., 2002), similar to previous BPS research (e.g., Porter & Goolkasian, 2019). A range of measures were selected based on previous research which analyzed heart rate measures with respect to the BPS (Uphill et al., 2019) and/or are recommended measures of heart rate variability when examining stress (Kleiger et al., 2005; Malik et al., 1996). The following heart rate measures were observed and reported: PNS Index, SNS Index, Mean RR, Mean HR, SDNN, RMSSD, NN50, pNN50, RR triangular index, TINN, SI (Stress Index), HFnu, and LF/HF ratio. PNS Index refers to the parasympathetic nervous system, and higher levels of the PNS Index indicate decreased heart rate and lower stress levels while the SNS Index refers to the sympathetic nervous system, and higher levels of the SNS Index indicate increased heart rate and elevated stress levels. Mean RR refers to the amount of time between heartbeats, and a longer mean indicates a lower heart rate and higher parasympathetic activity, thus indicating the challenge state. Mean HR indicates an individual's average heart rate throughout the task, and a higher heart rate is associated with the threat state. SDNN, RMSSD, NN50, pNN50, RR triangular index, TINN, and HFnu all indicate greater heart rate variability and stronger parasympathetic activity, consistent with a lowered stress response, or challenge state. Conversely, the Stress Index and LF/HF ratio indicate a heightened stress response (a threat state) and is associated with sympathetic activation.

Anxiety

The state anxiety subscale of the State-Trait Inventory for Cognitive and Somatic Anxiety-State (STICSA-S; Ree, 2008) was used in the current study. The 21 items are rated on a scale of 1 (not at all) to 4 (very much so). Subscales for state anxiety (cognitive Cronbach's $\alpha = .85$; somatic Cronbach's $\alpha = .85$) and overall (Cronbach's $\alpha = .92$) were used for analyses.

Ego Depletion

Modeling previous research, handgrip duration was measured at baseline and post-task to assess ego depletion as a function of self-regulation (Goldberg et al., 2017). Briefly, participants were given the commercially available handgrip (Gold's Gym HHG-GG001) and asked to squeeze the handgrip a few times to assess tension and familiarize themselves with the handgrip. For pre-test and post-task data collection, a one-inch thick block of wood was placed in the center of the handgrip and participants were instructed to hold the block of wood with the handgrip for as long as they could. The amount of time participants held the block was recorded in seconds by the researcher. This initial amount of time was used as a pre-test measure and a difference score was calculated by subtracting pre-test from

post-test duration to examine the grip strength differed based on the manipulation, consistent with previous research (Ciarocco et al., 2001; Goldberg et al., 2017).

Cognitive Appraisal

The Cognitive Appraisal Scale used by Mendes and colleagues (2007) was used to validate whether the manipulated instructions resulted in differences in perceptions of the Stroop Task. The scale consists of 11 items rated on a scale of 1 (strongly disagree) to 7 (strongly agree). Six questions assess demand appraisals (e.g,, "this task is demanding," "…is stressful," "…is distressing," "…is threatening"). Five questions assessed resource appraisals (e.g., "I have the abilities to perform well," "performing well is important to me"). Although Mendes and colleagues (2007) reported acceptable Cronbach's alphas for both subscales and analyzed each independently as well as a ratio in their study, the current study only yielded an acceptable Cronbach's alpha for the demand subscale (Cronbach's α = .79). Internal reliability was unacceptable for both resource items (Cronbach's α = .63) and the ratio (Cronbach's α = .69).

Self-Control

The Brief Self-Control Scale (Tangney et al., 2004) is a 13-item scale which assesses trait self-control. Items are rated on a scale of 1-(not at all like me) to 5 (very much like me). Negatively phrased items were recoded and all scores were then summed such that higher scores indicate higher levels of self-control (Cronbach's α =.86).

Stroop Task

The Stroop task is a cognitive task that involves executive attention and involves inhibitory control (Baumeister & Tierney, 2011; Engle, 2002). This study utilized the Color Stroop with adaptive response deadline version of the task (Draheim et al., 2023). Participants were presented with the words "red," "green," and "blue" one at a time on the computer screen, and each word was either presented in the same font color as the word (i.e. "red" in red font; congruent trial) or an interfering font color (i.e. "red" in a blue font color; incongruent trial). Participants were instructed to choose the font color of the word for every trial, which was indicated by pressing a red, green, or blue computer key. This version of the task adjusted based on participant's performance on the incongruent trials. Visual and audio feedback were also automatically given when the response deadline was not met. Performance on this task was measured by participant's overall reaction time and overall accuracy.

Manipulation (Stroop Instructions)

Instructions to the Stroop task were created to promote threat or challenge cognitive appraisals based on previous research (Porter & Goolkasian, 2019). The instructions were

shown on the screen and read aloud by the researcher before the participant started the Stroop task. They were as follows:

> **Challenge Condition**. "Research shows that physiological changes when faced with a challenging task are to prepare your body to help you be successful. Attempt to do your best on this task. Think of it as an opportunity to help you overcome a challenge, endure personal growth, and succeed with continued effort. Think of the task as a challenge to be met and overcome, and that you are capable of meeting that challenge."
>
> **Threat Condition. "**Research suggests performance on this task is related to intelligence and success in life. Attempt to get every question correct as quickly as possible. It is very important that you perform this task as quickly and efficiently as possible. You will be evaluated based on the speed and accuracy of your responses. Wrong answers will count against you."

Procedure

The study took place in a research lab on the college campus. Participants selected a thirty-minute appointment time to participate in an individual session with either the primary student experimenter or a student research assistant. After reviewing informed consent, participants completed baseline measures for state anxiety, heart rate variability, and grip strength. Next, participants were randomly assigned to one of the two conditions– threat or challenge– which involved instructions tailored toward cognitive appraisals before taking the Stroop test. Instructions were read aloud and shown on a screen. Participants then completed the Stroop test. Afterwards, post-task measures were collected for state anxiety, heart rate variability, and grip strength. In addition, trait self-control, cognitive appraisal, and demographic questions were assessed (post-test only). Each session took approximately 30 minutes.

Analyses

Independent t-tests were conducted to examine whether cognitive appraisals differed between the conditions (challenge and threat) and between biological sexes (male and female). Pearson's *r* correlations were used to examine relationships between scale variables. When multiple measures were used to examine a single variable (i.e. state anxiety and physiological anxiety), Bonferroni adjustments were used.

RESULTS

Preliminary Analyses

To ensure individual differences between groups did not differ before being randomly assigned to see challenge or threat instructions, independent samples *t*-tests were conducted. These preliminary analyses revealed no difference in pre-test scores between the two conditions (challenge vs threat) ($p > .129$; see Table 1), enabling the use of difference scores (post – pre), consistent with previous studies (e.g., Ciarocco et al., 2001; Goldberg et al., 2017; Tomaka et al., 1997).

Table 1. Results of Independent Samples t-test for Pretest Measures

	t	*df*	Sig (2-tailed)	Cohen's *d*	95% CI
Ego-Depletion: Handgrip	1.13	101	.262	0.22	-5.92, 21.51
Anxiety: Somatic	-0.81	101	.419	-0.16	-3.31, 1.39
Anxiety: Cognitive	0.19	101	.850	-0.04	-1.82, 2.21
Anxiety: Total	-0.36	101	.717	-0.07	-4.95, 3.42
PNS Index	-1.53	99	.129	-0.31	-8.65, 1.11
SNS Index	-0.25	99	.804	-0.05	-1.27, 1.00
Stress Index	-0.01	99	.996	0.00	-4.28, 4.26
Mean RR	0.10	99	.921	0.02	-66.20, 73.21
Mean HR	-0.68	99	.157	-0.14	-9.17, 4.51
SDNN	-1.43	99	.501	-0.28	-205.86, 33.76
RMSSD	-1.60	99	.113	-0.32	-313.59, 33.57
NN50	-1.03	99	.307	-0.20	-12.23, 3.89
pNN50	-0.91	99	.366	-0.18	-13.02, 4.94
RR Tri Index	-0.92	99	.358	-0.18	-2.27, 0.83
TINN	-1.40	99	.164	-0.28	-838.48, 144.11
Hfnu	-0.26	99	.794	-0.05	-8.92, 6.84
LF/HF Ratio	-0.39	99	.697	-0.08	-1.93, 1.29

Experimental Validation

The first hypothesis was to examine whether randomly assigned instruction type ("threat" or "challenge") resulted in different cognitive appraisals of the Stroop task. Given the Cognitive Appraisal Scale (Mendes et al., 2007) failed to yield acceptable internal reliability for the index (overall) and resources subscale, only the demand subscale was examined to validate the manipulation used in the current study. Participants randomly assigned to the "threat" instructions reported a significantly higher perception in demand compared to the "challenge" instructions: $t(101) = -1.68$, $p = .048$, $d = 0.33$, 95% CI (-0.72, 0.06). As shown in Figure 1, those in the threat condition displayed an increase in perceived demand compared to the challenge condition, consistent with the manipulation of the instructions.

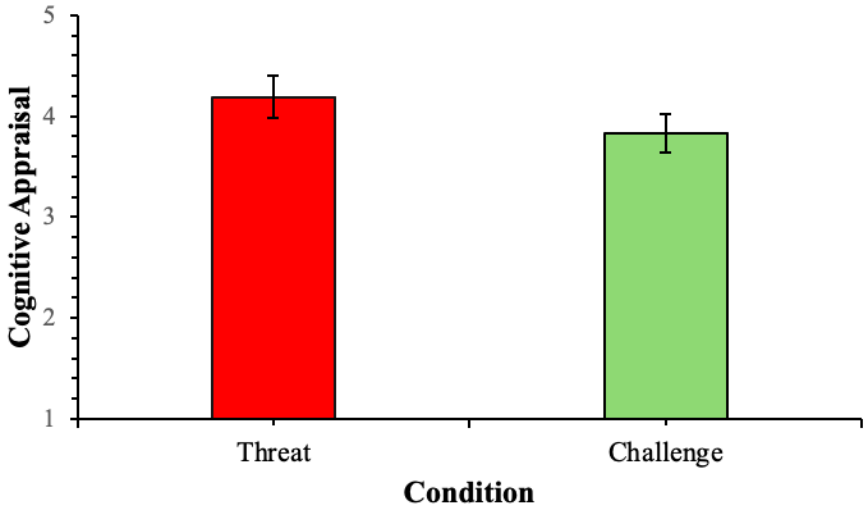

Figure 1. *Cognitive Appraisal Varies Based on Instruction Type*

Note: The threat condition was appraised as more demanding, validating the study design. Error bars represent 95% confidence intervals.

Given quite a bit of previous research had used single questions (one for demand, one for resource, then an index), and the scale in the current study was not internally reliable, exploratory independent samples *t*-test analyses were conducted to examine whether threat and challenge conditions differed in answers on the 11 individual questions. Given the multiple comparisons with Bonferroni adjustments, none reached significance. One question had a large effect size and confidence intervals that warrants consideration - the threat condition had higher ratings for "This task required a lot of effort" $t(101) = -2.34$, $p = .011$, $d = 0.46$, 95% CI (-1.47, -.122). Two questions approached significance but should be interpreted with even more caution given the multiple comparisons. The threat

group reported higher ratings for "This task was stressful" $t(101) = -1.67$, $p = .049$, $d = 0.33$, 95% CI (-1.15, .10) and lower ratings for "This task was a positive challenge" $t(101) = -1.74$, $p = .042$, $d = 0.34$, 95% CI (-0.06, 0.89). The discussion explores concerns and considerations related to assessing cognitive appraisal.

Hypothesis 2 stated *Participants randomly assigned to the threat instructions will perform worse on the Stroop task and report higher levels of state anxiety, exhibit more ego depletion, and exhibit impaired physiological functioning compared to those who are assigned the challenge instructions*.

Independent samples *t*-tests were used to statistically compare the threat and challenge conditions on accuracy and reaction time in the Stroop task. Both were non-significant: accuracy $t(101) = 0.31$, $p = .378$, $d = 0.06$, 95% CI (-0.03, 0.02); reaction time $t(101) = 0.10$, $p = .466$, $d = 0.02$, 95% CI (-37.96, 41.39).

Ego depletion was measured using grip strength. To be consistent with previous research, a difference score was calculated. An independent samples *t*-test yielded no difference between threat and challenge groups: $t(101) = 0.51$, $p = .305$, $d = 0.10$, 95% CI (-4.80, 25.70).

Difference scores were calculated for state anxiety (somatic, cognitive, and total) as well as 13 indices of physiological stress. Each was examined using an independent samples t-test to see if differences varied between challenge and threat conditions. None were significant (see Table 2).

Hypothesis 3 stated *Trait self-control will be related to Stroop task performance, cognitive appraisals, anxiety, ego depletion, and physiological stress responses.* Pearson's *r* correlations were used to assess the relationship between trait self-control and each of the following dependent variables: Stroop task, cognitive appraisal, state anxiety, grip strength, and heart rate variability. Given the 13 measures selected for heart rate variability, a Bonferroni adjustment was needed, and no results were thus significant (see Table 3). It may be worth mentioning that without an adjustment for multiple comparisons, there was a weak positive relationship between trait self-control and pNN50: $r(98) = .200$, $p = .048$ (two-tailed). As stated earlier, pNN50 indicates stronger parasympathetic activity and is associated with relaxation and resilience to stress.

Table 2. No Difference Between Challenge and Threat Instructions

	t	*df*	Sig (2-tailed)	Cohen's *d*	95% CI
Ego-Depletion: Handgrip	0.51	101	.610	0.10	-7.63, 12.95
Anxiety: Somatic	0.65	101	.520	0.13	-0.99, 1.95
Anxiety: Cognitive	-0.60	101	.549	-0.12	-1.70, 0.91
Anxiety: Total	0.07	101	.943	0.01	-2.25, 2.42
PNS Index	1.64	61.53	.106	0.33	-0.91, 9.18
SNS Index	-0.26	72.63	.795	-0.05	-1.02, 0.78
Stress Index	-0.23	75.94	.819	-0.04	-4.04, 3.21
Mean RR	1.11	97	.272	0.22	-27.36, 96.11
Mean HR	-0.19	97	.848	-0.04	-81.03, 66.69
SDNN	1.48	62.80	.143	0.30	-31.83, 214.64
RMSSD	1.65	61.71	.105	0.33	-31.62, 327.54
NN50	0.94	97	.349	0.19	-3.84, 10.76
pNN50	1.86	71.80	.064	0.38	-0.43, 15.19
RR Tri Index	0.35	71.91	.731	0.07	-1.41, 2.01
TINN	1.42	74.24	.159	0.29	-144.14, 863.26
Hfnu	-0.99	97	.327	-0.20	-73.05, 24.59
LF/HF Ratio	0.76	97	.450	0.15	-1.17, 2.62

Table 3. Relationships between Trait Self-Control to Performance and Psychophysiological Measures

	Pearson coefficient	*r* N	Sig (2-tailed)
Cognitive Appraisal	-.111	102	.267
Stroop: Accuracy	.023	102	.822
Stroop: Reaction Time	-.004	102	.966
Ego-Depletion: Handgrip	-.043	102	.671
Anxiety: Somatic	.055	102	.582
Anxiety: Cognitive	.022	102	.830
Anxiety: Total	.047	102	.640
PNS Index	.182	100	.070
SNS Index	-.117	100	.248
Stress Index	-.090	100	.375
Mean RR	.171	100	.089
Mean HR	-.137	100	.173
SDNN	.179	100	.075
RMSSD	.173	100	.086
NN50	.177	100	.078
pNN50	.200	100	.046*
RR Tri Index	.116	100	.251
TINN	.109	100	.279
Hfnu	-.014	100	.892
LF/HF Ratio	-.038	100	.673

*Note: with a Bonferonni adjustment, this is non-significant

Hypothesis 4 stated *Females will appraise the Stroop task as more threatening than males.* An independent samples *t*-test found that females viewed the Stroop task as more threatening $t(99) = -2.02$, $p = .023$, $d = 0.46$, 95% CI (-0.99, -0.01). To explore whether this sex difference exists in both challenge and threat conditions, additional independent samples t-tests were conducted using a Bonferroni adjustment ($p = 0.05 / 2 = .025$ necessary to achieve significance). Interestingly, as shown in Figure 2, females perceived the challenge condition to be more threatening $t(48) = -2.13$, $p = .019$, $d = 0.71$, 95% CI (-1.35, -.04). However, there was no difference between male and female appraisals in the threat condition $t(49) = -0.97$, $p = .169$, $d = 0.30$, 95% CI (-1.08, 0.38).

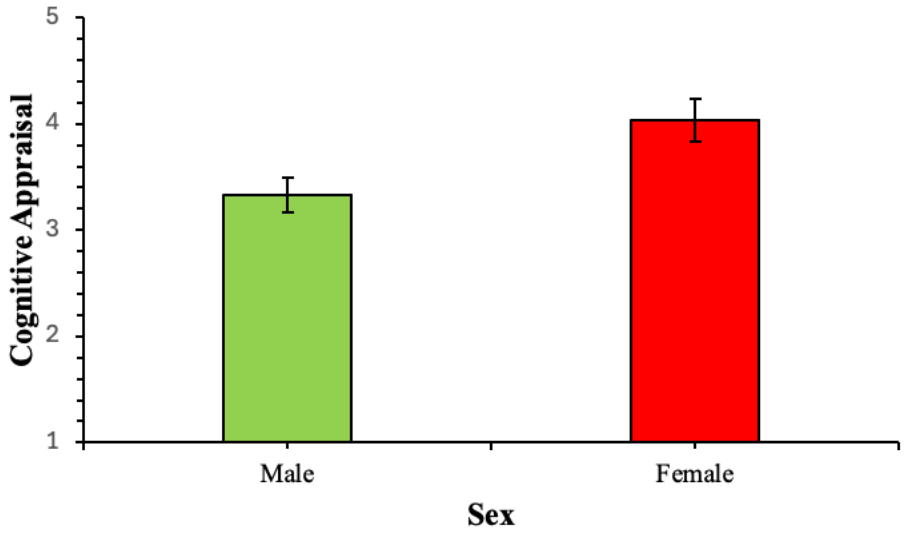

Figure 2. *Females Appraised the Challenge Condition as More Threatening*

Note: Females appraised the challenge condition as more threatening than males ($p = .019$). Error bars represent 95% confidence intervals.

DISCUSSION

The current study used an experimental design to manipulate appraisal type (challenge or threat) before completing the Stroop task, a common cognitive task sensitive to stress and fatigue. Grounded in the BPS framework, the manipulation aimed to explore how contextual appraisal influences physiological stress, anxiety, and ego depletion. Although the manipulation was validated as it was viewed as more threatening by participants, no other measure was affected. Trait self-control was also not related to Stroop task performance, cognitive appraisals, anxiety, ego depletion, or physiological stress.

Females did appraise the Stroop task as more threatening than male participants, particularly in the challenge condition, which is further explored below.

Although the primary hypothesis was not supported, this study yields valuable insights for the field and future studies, particularly within the framework of the BPS. Indeed, the authors felt it was important to publish these findings to draw attention to the concerns and criticisms raised, with the goal of promoting more rigorous methodological and theoretical approaches in future research. Moreover, in a field suffering from a replication crisis, reporting null findings is essential to fostering transparency, refining theoretical models by testing their validity, and encouraging sound research as a whole (Englert & Bertrams, 2021).

Lesson 1: Delivery of Instructions

Previous BPS literature varies with respect to the manner in which the threat and challenge conditions are assigned and/or observed. That is, some participants were read aloud instructions by the experimenter (Feinberg & Aiello, 2010), some participants were presented with an audiotape of instructions (Tomaka et al., 1997), some participants were presented with additional instructions throughout the task (Porter & Goolkasian, 2019), and some were provided with positive or negative feedback (Gog et al., 2024). It was decided in this study that instructions should be read aloud while shown on the screen as a way to ensure they had been reviewed in their entirety. However, five research assistants assisted with data collection; four female, one male. Previous research reveals that men's voices are perceived as more threatening than female voices (Tompkinson et al., 2024) and various vocal qualities may influence how the personality of the speaker is perceived (Pearsell & Pape, 2023). Also, a more thorough review revealed that although not mentioned in the original research article, Blascovich and Mendes (2000) state that the audiotaped vocal tones used for the threat and challenge instructions in the Tomaka et al study (1997) likely contributed "greatly" to the differences in appraisal between the two conditions. Both read by a male, the "threat" instructions were read in a "staccato and stern tone" whereas the challenge instructions were read in a "much more pleasant way." In fact, they state "in retrospect, however, we doubt it would have worked without the difference in affective vocal tone" (Blascovich & Mendes, 2000, p. 75). Thus, it is recommended that future studies that use audio recording ensure all participants read the instructions under uniform conditions. And, while different methods of delivering (and in some cases, emphasizing) challenge and threat conditions exist, future research systematically examining these experimenter methods can reveal important insights into factors that influence perceived threat.

A related and seemingly unexplored area in the BPS literature are studies that employ repeated measures designs so that participants respond to both challenge and threat conditions. This would enable more clear comparisons of how individual factors of the participants, such as trait self-control, differentially influence appraisals.

Lesson 2: Assessing Cognitive Appraisal

This leads to another lesson – how to assess cognitive appraisals. In the original studies there was no measure of cognitive appraisal, rather the manipulation itself was used to differentiate groups (e.g., Speisman et al., 1964). However, Tomaka and colleagues (1997) introduced having participants self-report their cognitive appraisal of the situation. For instance, they asked participants two questions related to how the participant viewed a mental arithmetic task after hearing instructions but before completing the task ("how threatening…" and "how able are you to cope…") to create an overall appraisal index and found it differentiated the two groups. Other researchers also only used two questions but focused more on the BPS concept of overall threat appraisals consisting of both demand and ability. Thus, one question was used to assess demand (e.g., "this task is very demanding") and one related to ability (e.g., "I have the resources to perform [task] successfully"), and then use those responses to create a ratio (e.g., Mendes et al., 2001; O'Brien et al., 2021; Porter & Goolkasian, 2019). These results were less consistent. Porter and Goolkasian (2019) found that their manipulation of assigning people to threat and challenge conditions resulted in different self-report appraisals. In this study, the two questions were examined individually. Mendes et al. (2001) found no difference in perceptions of demands, but did report a difference in perceived resources ($p < .01$) and in the ratio of the two ($p < .04$), but did not adjust for multiple comparisons. The current study used an 11-item cognitive appraisal scale originally employed by Mendes and colleagues (2007). However, unlike their findings, the scale in the current study did not demonstrate acceptable internal reliability for the overall index or the "resource" subscale. Blascovich and Mendes (2000) discussed the need to expand and reframe appraisals to acknowledge the complexity and interplay between demand and resource appraisals, the additional factors that likely contribute (e.g., perceptions of danger, affective cues, cognition), and that both non-conscious and conscious appraisals may occur in parallel. More research is needed exploring ways to measure both conscious and non-conscious cognitive appraisals in a reliable manner consistent with BPS.

Further, Blascovich and Mendes (2000) discuss the iterative nature of the appraisal process in that it occurs before and during the actual task performance and can change throughout. The current study only assessed conscious cognitive appraisal at the end of the Stroop task. It is recommended that future studies assess self-report cognitive appraisals do so at more than one time point – for instance, at the beginning (immediately after being told the threat or challenge instructions) and at the end of task at a minimum. Future work aimed to outline "best practices" for assessing self-report cognitive appraisals of BPS manipulations is essential to promoting consistency and replication in the field.

Lesson 3: Physiological Measures

It should be noted that physiological responses have several advantages over self-report stress responses and appraisals as they can be continuous, covert (portions of the appraisal process may not occur consciously) and there is less room for error (reduces expectancy effects of investigators and demand characteristics of participants) (Blascovich & Mendes, 2000; Mendes et al., 2001). Also, a recent experimental study using prospective teachers found that a social-evaluative threat (having to keep one's hands in cold water while being video-taped) did not change self-reported negative affect but did elevate saliva cortisol (Becker et al., 2023), suggesting that physical stress responses may not always be supported by self-report.

That being said, additional research is needed to better understand which physiological measures most reliability predicts challenge and threat states. Results from a number of studies suggest that heart rate, heart rate variability, skin conductance, and blood pressure produce differential physiological response profiles for threat and challenge appraisals (for a review see Blascovich & Mendes, 2000). However, results have been inconsistent. For instance, Tomaka and colleagues (1997) reported no difference in blood pressure (systolic or diastolic). Further, Porter and Goolkasian (2019) found that participants who received threat appraisal instructions had more sympathetic activity (lower RMSSD) but only in the first 5 minutes of the game – activity returned to similar levels to that of the challenge group after the first five minutes. Such results align with the more nuanced view that cognitive appraisals are an ongoing process that can adjust throughout a single situation, and also aligns with other parallel theories of stress, such as Selye's General Adaptation Syndrome (Selye, 1946), by suggesting that some changes may only occur in the early stages of confronting a stressor (in the "alarm") stage, and that the body then adjusts in the adaptation stage. Thus, based on current results and a thorough review of the literature, a recommendation for future research when measuring stress responses to a situation, both self-report cognitive appraisals and physiological indices should be measured throughout the task when possible, not just at the beginning or end.

Due to concerns raised by Uphill and colleagues (2019) that BPS research relies too heavily on sympathetic markers, a variety of both sympathetic and parasympathetic markers were measured in the current study. The use of numerous measures required an adjustment for the multiple comparisons and yet, the only measure to approach significance was a parasympathetic indicator. Examining and refining which biomarkers best differentiate physiological responses to challenge and threat states can lead to more consistent research and a more informed understanding of how perceptions of stressors can differentially affect our stress response systems.

Lesson 4: Other Factors to Consider

Along these lines, the current study found that females viewed the overall task and the challenge instructions in particular, as more threatening than the male participants. This

is consistent with previous research by Wieringa (2020) who found that females were more likely to appraise a vignette as more threatening compared to men, although they admitted their sample was predominantly women and should be interpreted cautiously. Most of the other BPS research failed to examine potential sex differences. Given that 72.8% of participants in the current study were female, future studies should consider examining sex differences in cognitive appraisals and stress responses.

Lesson 5: General Methodological Considerations

In hindsight, several flaws in our research design are apparent. One is that pre-test physiological data was taken approximately 5 minutes upon entering the lab. This protocol was determined in an effort to reduce the total amount of time required of participants, as no monetary compensation was provided and recruiting adequate numbers of participants has been a notable concern at the university. Participants' physiological output may have been elevated due to a variety of reasons (such as climbing three sets of stairs to get to the lab, having difficulty finding the lab, initial anxiety about participating in an in-person study, etc), which could have served as a confound for the study. A longer resting period may provide a more consistent baseline.

Another area that deserves more careful consideration is in the task selected. Ego-depletion studies have varied widely and researchers acknowledge there is no broad consensus for what constitutes a valid self-control task (for a review see Englert & Bertrams, 2021). The Stroop task was selected as a result of its ego-depleting nature and implementation in previous BPS research (Jamieson et al., 2012; Turner et al., 2012). The particular variant used in the current study with an adaptive response deadline version was chosen due to its accessibility. This version adjusts based on participant performance in the form of reaction time and accuracy. Moreover, if the participant response deadline was not met (i.e. the color was not selected quickly enough), then an audio tone would play and the following was presented onscreen in red letters: TOO SLOW! GO FASTER! Considering the fact that negative feedback was implemented according to participant performance as opposed to condition, it is possible that this could have interfered with the intended challenge and threat manipulation. As a result, future studies are encouraged to select a task that does not modify feedback based on performance for better experimental control. In this case, utilizing a Stroop task version which is either consistent across groups or provides negative feedback only in the threat condition is recommended. On a broader level, the discrepancies in variations, length, and number of trials used in the Stroop task make replication difficult. As stated by previous researchers (e.g., Englert & Bertrams, 2021), there is a need to operationalize experimental methods when using the Stroop task for consistency in the field.

Another consideration related to using the Stroop task is the general concern of using a task in a research lab with only a student researcher as it does not share the same characteristics as other mental stressors. Similar to concerns raised by Porter and

Goolkasian (2019), the current study was conducted in a lab setting with no real "consequence" of performance (e.g., no one beyond the student researcher or participant would know and it did not impact their grade in a class, et cet). Along that same vein, there is controversy in the ego depletion literature as some worry about the lack of consideration for alternative explanations and moderators in understanding results (e.g., Hagger et al., 2010).

It is recommended that future studies select tasks that involve social or self-evaluation related to task performance, as outlined by Blascovich and Tomaka (1996). Yet, previous research emphasizes the importance of varying task type to examine the applicability of BPS (Feinberg & Aiello, 2010). Thus, future studies could compare the various methodological approaches, such as having participants deliver a speech or take an arithmetic task as opposed to (or in addition to) taking the Stroop task. Indeed, using a variety of tasks specific to college student expectations can be used to provide converging insights into this particular population, as can tasks and situations more similar to workplace experiences. And, although random assignment to conditions provides greater experimental control, how BPS is evidenced in perception of non-manipulated measures provides yet another lens for understanding applicability in the real world.

Conclusions

This study found minimal evidence of any psychophysiological indices being impacted by an experimental manipulation that induced threat or challenge conditions. Stroop task performance, ego depletion, anxiety, and physiological stress were unaffected. Trait self-control was not related to any of these measures. Females did appraise the challenge condition as more threatening, which is insightful given a large body of the current BPS literature failed to explore sex differences. While this study produced mostly non-significant results, it offers important considerations that lay the groundwork for future research aimed at addressing the broader stress crisis in society.

Stress affects a large portion of the population and has been linked to declines in academic performance, workplace productivity, and overall health (Barbayannis et al., 2022; Sohail & Rehman, 2015). Although grounded in psychological theory, the findings of this study hold relevance for the broader social sciences, particularly how we conceptualize and measure the impact of stress on human functioning. The BPS offers a framework for understanding how individuals interpret stressful situations – either as opportunities for growth (challenge) or as harmful threats. This interpretive lens is not exclusive to psychology; it intersects with fields such as education, sociology, business, healthcare, and public policy, where the stakes of stress and performance are often high. Whether examining students taking exams, employees navigating deadlines, or communities responding to crisis, understanding how people appraise stress can offer insights into motivation, well-being, and decision-making across social contexts. Importantly, the study underscores how individual and situational factors – from sex

differences to the tone of instructions – likely shape stress appraisals and resulting behaviors.

Moreover, the challenges and methodological lessons learned from this study serve as a call for greater interdisciplinary dialogue in designing and interpreting stress research. Inconsistent results in physiological and cognitive stress measures point to a larger issue that spans disciplines: the need for robust, replicable methodologies that consider the complexity of human experience. As stress continues to affect populations globally, interdisciplinary research informed by psychological frameworks like the BPS model can help the social sciences develop more precise interventions and policies that support human resilience and performance. By critically examining how stress is framed, measured, and experienced, we can better equip educators, leaders, and healthcare providers with tools that empower individuals – not only to manage stress, but to potentially reframe it in ways that enhance functioning and reduce harm.

REFERENCES

American Psychiatric Association. (2025, May). *Annual mental health poll reveals Americans anxious about current events; 40% of employed worried about job security.* [News release]. https://www.psychiatry.org/News-room/News-Releases/Annual-Mental-Health-Poll-2025

August, K. J., Rook, K. S., & Newsom, J. T. (2007). The joint effects of life stress and negative social exchanges on emotional distress. *The Journals of Gerontology: Series B, 62*(5), S304-S314. https://doi.org/10.1093/geronb/62.5.s304

Barbayannis, G., Bandari, M., Zheng, X., Baquerizo, H., Pecor, K. W., & Ming, X. (2022). Academic stress and mental well-being in college students: Correlations, affected groups, and COVID-19. *Frontiers in Psychology, 13.* https://doi.org/10.3389/fpsyg.2022.886344

Becker, S., Spinath, B., Ditzen, B, & Dorfler, T. (2023). Psychological stress = physiological stress? An experimental study with prospective teachers. *Journal of Psychophysiology 37*(1), 12 - 24. https://doi.org/10.1027/0269-8803/a000301

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*(5), 1252–1265. https://doi.org/10.1037/0022-3514.74.5.1252

Baumeister, R. F., & Tierney, J. (2011). *Willpower: Rediscovering the greatest human strength.* Penguin Press.

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science, 16*(6), 351-355. https://doi.org/10.1111/j.1467-8721.2007.00534.x

Blascovich, J., & Mendes, W. B. (2000). Challenge and threat appraisals: The role of affective cues. In J. P. Forgas (Ed.), *Feeling and thinking: The role of affect in social cognition* (pp. 59–82). Cambridge University Press.

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental and Social Psychology, 28,* 1-51. https://doi.org/10.1016/S0065-2601(08)60235-X

Bolger, N., DeLongis, A., Kessler, R. C., & Schilling, E. A. (1989). Effects of daily stress on negative mood. *Journal of Personality and Social Psychology, 57*(5), 808–818. https://doi.org/10.1037/0022-3514.57.5.808

Ciarocco, N. J., Sommer, K.L., & Baumeister, R. F. (2001). Ostracism and ego depletion: the strains of silence. *Personality and Social Psychology Bulletin, 27*(9). https://doi.org/10.1177/0146167201279008

Draheim C., Tshukara J. S., & Engle, R. W. (2023) Replication and extension of the toolbox approach to measuring attention control. *Behavior Research Methods, 56*(3), 2135-2157. https://doi.org/10.3758/s13428-023-02140-2

Duckworth, A. L., Kim, B., & Tsukayama, E. (2013). Life stress impairs self-control in early adolescence. *Frontiers in Psychology, 3*(608). https://doi.org/10.3389/fpsyg.2012.00608

Engle, R. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science,11*(1), 19-23.

Englert, C., & Bertrams, A. (2021). Again, no evidence for or against the existence of ego-depletion: Opinion on "A multi-site preregistered paradigmatic test of the ego depletion effect." *Frontiers in Human Neuroscience, 15*. https://doi.org/10.3389/fnhum.2021.658890

Feinberg, J.M., & Aiello, J.R. (2010). The effect of challenge and threat appraisals under evaluative presence. *Journal of Applied Social Psychology*, *40*(8), 2071-2104.

Gog, T. V., Janssen, E., Lucas, F., & Taheji, M. (2024). A motivational perspective on (anticipated) mental effort investment: The biopsychosocial model of challenge and threat. *Educational Psychology Review, 36* (54). https://doi.org/10.1007/s10648-024-09861-6

Goldberg, S., Flook, L., Hirshberg, M., Findley, D., Kesebir, P., Schaefer, S., & Davidson, R. (2017). Getting a grip on the handgrip task: Handgrip duration correlated with neuroticism but not conscientiousness. *Frontiers in Psychology, 8*, 1367. https://doi.org/10.3389/fpsyg.2017.01367

Gokalp, Z. S., & Haktanir, A. (2024). The mediating role of self-control between stress and procrastination among adolescents: Examining the ego depletion theory. *Psychology in the Schools, 61*(8), 3359-3372. https://doi.org/10.1002/pits.23217

Hagger, M., Wood, C., Stiff, C., Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin, 136*(4), 495-525. https://doi.org/10.1037/a0019486

Jamieson, J. P., Nock, M. K., & Mendes, W. B. (2012). Mind over matter: Reappraising arousal improves cardiovascular and cognitive responses to stress. *Journal of Experimental Psychology: General, 141*(3), 417-422. https://doi.org/10.1037/a0025719

Kleiger, R. E., Stein, P. K., & Bigger, J. T. (2005). Heart rate variability: Measurement and clinical utility. *Ann Noninvasive Electrocardiology*, *10*(1), 88-101. https://doi.org/doi:10.1111/j.1542-474X.2005.10101.x

Koppenborg, K. A., Garnefski, N., Kraaij, V., & Ly, V. (2022). Academic stress, mindfulness-related skills and mental health in international university students. *Journal of American College Health*, *72*(3), 787-795. https://doi.org/10.1080/07448481.2022.2057193

Lazarus, R. S. & Folkman, S. (1984). *Stress, Appraisal, and Coping.* Springer.

Lazarus, R. S., Speisman, J. C., Mordkoff, A. M., & Davison, L. A. (1962). A laboratory study of psychological stress produced by a motion picture film. *Psychological Monographs: General and Applied, 76*(34), 1-35. https://doi.org/10.1037/h0093861

Maier, S. U., Makwana, A. B., & Hare, T. A. (2015). Acute stress impairs self-control in goal-directed choice by altering multiple functional connections within the brain's decision circuits. *Neuron, 87*(3), 621–631. https://doi.org/10.1016/j.neuron.2015.07.005

Malik, M., & the members of the Task Force of the European Society of Cardiology, the North American Society of Cardiology, & the North American Society of Pacing Electrophysiology (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *Circulation, 93*(5), 1043-1065. https://doi.org/10.1161/01.CIR.93.5.1043

Mendes, W. B., Blascovich, J., Major, B., & Seery, M. (2001). Challenge and threat responses during downward and upward social comparisons. *European Journal of Social Psychology, 31,* 447-497. https://doi.org/10.1002/ejsp.80

Mendes, W. B., Gray, H. M., Mendoza-Denton, R., Major, B, & Epel, E. S. (2007). Why egalitarianism might be good for your health: Physiological thriving during stressful intergroup encounters. *Psychological Science*, *18*(11), 991-998. https://doi.org/10.1111/j.1467-9280.2007.02014.x

Oaten, M., & Cheng, K. (2005). Academic examination stress impairs self-control. *Journal of Social and Clinical Psychology, 24*(2), 254–279.

O'Brien, J., Parker, J., Moore, L., & Fryer, S. (2021). The effect of ego depletion on challenge and threat evaluations during a potentially stressful public speaking task. *Anxiety, Stress, and Coping, 34*(3), 266-278. https://doi.org/10.1080/10615806.2020.1839732

Pascoe, M. C., Hetrick, S. E., & Parker, A. G. (2020). The impact of stress on students in secondary school and higher education. *International Journal of Adolescence and Youth. 25*(1), 104-112. https://doi.org/10.1080/02673843.2019.1596823

Park, C. L., Wright, B. R., Pais, J., & Ray, M. (2016). Daily stress and self-control. *Journal of Social and Clinical Psychology, 35*(9), 738-753. https://psycnet.apa.org/doi/10.1521/jscp.2016.35.9.738

Pearsell, S., & Pape, D. (2023). The effects of different voice qualities on the perceived personality of a speaker. *Frontiers in Communication, 7*, 909427. https://doi.org/10.3389/fcomm.2022.909427

Porter, A.M., & Goolkasian, P. (2019). Video games and stress: How stress appraisals and game content affect cardiovascular and emotion outcomes. *Frontiers in Psychology, 10,* 967. https://doi.org/10.3389/fpsyg.2019.00967

Ree, J. M., French, D., MacLeod, C., & Locke, V. (2008). Distinguishing cognitive and somatic dimensions of state and trait anxiety: Development and validation of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA). *Behavioral and Cognitive Psychotherapy, 36*, 313-332. https://doi.org/10.1017/S1352465808004232

de Ridder, D. T. D., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2012). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. *Personality and Social Psychology Review, 16*(1), 76–99. https://doi.org/10.1177/1088868311418749

Ross, J. A., Gliebus, G., & Bockstaele, E. J. V. (2017). Stress induced neural reorganization: A conceptual framework linking Depression and Alzheimer's disease. *Progress in Neurobiology, 85*, 136-151. https://doi.org/10.1016/j.pnpbp.2017.08.004

Schaffarczyk, M., Rogers, B., Reer, R., & Gronwald, T. (2022). Validity of the Polar H10 Sensor for heart rate variability analysis during resting state and incremental exercise in recreational men and women. *Sensors 22*(17), 6536. https://doi.org/10.3390/s22176536

Selye, H. (1946). The general adaptation syndrome and the diseases of adaptation. *Journal of Clinical Endocrinology, 6,* 117-231.

Sohail, M. & Rehman, C. A. (2015). Stress and health at the workplace - A review of the literature. *Journal of Business Studies Quarterly, 6*(3). 94-121.

Speisman, J. C., Lazarus, R. S., Mordkoff, A., & Davison, L. (1964). Experimental reduction of stress based on ego-defense theory. *Journal of Abnormal and Social Psychology, 68* (4), 367-380.

Tangney, J. P., Baumestier, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72,* 271-324. https://doi.org/10.1111/j.0022-3506.2004.00263.x

Tarvainen, M. P., Ranta-aho, P. O., & Karjalainen, P. A. (2002). An advanced detrending method with application to HRV analysis. *Institute of Electrical and Electronics Engineers, 49*(2), 172-175. https://doi.org/10.1109/10.979357.

Tomaka, J., Kibler, J., Blascovich, J & Ernst, J. (1997). Cognitive and physiological antecedents of threat and challenge appraisal. *Journal of Personality and Social Psychology. 73*(1), 63-72. https://doi.org/10.1037/0022-3514.73.1.63

Tompkinson, J., Mileva, M., Wyatt, D., & Burton, A.M. (2024). Perception of threat and intent to harm from vocal and facial cues. *Quarterly Journal of Experimental Psychology, 77*(2), 326-342. https://doi.org/10.1177/17470218231169952

Turner, M. J., Jones, M. V., Sheffield, D., & Cross, S. L. (2012). Cardiovascular indices of challenge and threat states predict competitive performance. *International Journal of Psychophysiology, 86*(1), 48–57. https://doi.org/10.1016/j.ijpsycho.2012.08.004

Uphill, M.A., Rossato, C. J. L. , Swain, J., & O'Driscoll, J. (2019). Challenge and threat: A critical review of the literature and an alternative conceptualization. *Frontiers in Psychology, 10,* 1255. https://doi.org/10.3389/fpsyg.2019.01255

Wieringa, I. (2020). What is the relationship between trait self-control, threat or challenge appraisal, and healthy eating behavior? (Master's thesis). *Utrecht University Student Theses Repository.*

AUTHOR INFORMATION:

Anna Minor received her B.S. in psychology from Murray State University in Murray, Kentucky in May of 2025. She plans to complete her M.A. in Industrial-Organizational Psychology at the University of Tennessee at Chattanooga. She hopes to continue research and pursue a career in consulting.
Address: Anna Minor, Graduate Student, Psychology Department, The University of Tennessee at Chattanooga, 615 McCallie Ave., Chattanooga, TN 37403
Email: dxb794@mocs.utc.edu

Megan St. Peters is an Associate Professor of Psychology at Murray State University in Murray, Kentucky. She earned her B.S. at the University of the Ozarks and her M.A. and Ph.D. in Psychology: Neuroscience and Behavior at Northern Illinois University. She completed a three-year postdoctoral research fellowship at the University of Michigan. Dr. St. Peters' research centers on the complex relationships between stress and cognitive processes like attention and memory. In her lab, she works closely with students to investigate the mind-body connection using diverse physiological methods. She also enjoys providing mentorship for undergraduate and graduate theses research.
Address: Dr. Megan St. Peters, Murray State University, Department of Psychology, 203 Wells Hall, Murray, KY 42071, USA.
Email: mstpeters@murraystate.edu