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PREDICTORS OF ACADEMIC PERFORMANCE: THE ROLES OF SELF-COMPASSION, COPING, MENTAL TOUGHNESS, GRIT, AND SELF-REPORTED STRESSORS ON PHYSICS FINAL EXAM PERFORMANCE

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Abstract

The intersection of stress, persistence and success in college-aged students is progressively gaining attention in research. Analyzing how students succeed and what factors contribute to their success, failure, and ultimately the completion of their degree, is vitally important for educators and administrators in higher education to understand. Historically utilized factors such as grade point average (GPA), standardized test scores (college admissions and Advance Placement (AP) exams), and previous academic achievement (pre-requisite courses) are not the only predictors of academic performance. This study aimed to quantify contributions and inter-relationships of student perceptions, coping style, stress, mental toughness (MT), and other potential factors that correlate with academic performance. Thirty-five Physics I students provided baseline and day-of final exam self-reported assessments of such factors. Exploratory analysis, utilizing multiple regressions, suggests that self-reported stress is a reliable predictor of academic performance on a Physics I final exam and additional constructs such as MT, self-compassion, stress appraisals, coping strategies and grit contribute as well. Implications for the findings of this study can inform higher education's approach to admissions, retention, and stress mitigation of college students.

Introduction

U.S. institutions are on the brink of transformation, the demographic profile of students at our universities will look vastly different in forty years. According to a report from the US Census Bureau (Vespa et al., 2020), population projections from 2020 to 2060 will change significantly. For example, non-Hispanic Whites will shift from 199 million to 179 million people (the only population decreasing in size). The report further clarifies that among the fastest growing Races in the United States are individuals of two or more Races (projected to grow by 200 percent by 2060) and the Hispanic populations (projected to double in the next 4 decades). Generally, the U.S. educational system has heavily depended on recruitment and retention strategies catering to the needs of non-Hispanic Whites. The traditional admissions criterion is said to be racially, gender, culturally, and socioeconomically biased, and to reduce bias many institutions of higher education are shifting to becoming test optional (Elsesser, 2019). With the changing faces of our population, a new approach is necessary to address the needs of our growing minority student enrollment in the coming decades. Aside from that, admissions standards need a major overhaul anyway! No longer can we simply depend on standardized test scores, AP (Advanced Placement) Exams, and/or high school GPA to admit (and not admit) prospective students.

As a former college admission recruiter, I can distinctly remember an instance when a student who was not admissible was accepted in error. Based on their test scores and GPA they were statistically not projected to successfully complete their first year at the institution. Nonetheless, after a frank and sincere conversation with the student and their single mother, the student had the mindset (growth mindset), a strategy (utilizing

campus resources such as learning centers, success programs, DEI (Diversity, Equity, and Inclusion) centers, and academic advisors), and psychological constructs (such as determination and how he addressed failure) in place to succeed. Ultimately the student not only completed his undergraduate degree, but a master's program as well. I can speak first-hand how impactful the educational opportunity affected his life, career, and future. The student possessed and developed psychological characteristics that resulted in academic success even when his ACT score and GPA said otherwise. I believe that there are many more prospective students like this who are not given an opportunity of higher education because of existing admissions standards and retention approaches. This research will explore alternative factors such as mental toughness (MT), coping strategies, grit, stress management, and self-compassion as potential recruitment standards and mitigators of academic failure. Understanding how these factors are interrelated and able to predict academic performance may lead to more effective support for a growing diverse population of college students.

I will address how non-performance factors (i.e., personal attributes of characteristics) may be equally important to the traditionally used performance-based indicators of student success, such as GPA, writing samples, or standardized test scores. Paul Tough's (2012) *Character Hypothesis* suggests that U.S. children from a variety of socioeconomic backgrounds can develop their character by confronting and coping with failure. I will investigate that assumption by exploring non-performance predictors of success. The intent of this research is to investigate how these non-performance, or cognitive factors such as MT, self-compassion, and grit may predispose success when

students are subjected to competitive performance environments such as career fairs, examinations, presentations, or senior capstone projects. Specifically, this research assessed these non-performance constructs to understand their role in predicting performance measures of physics students enrolled at a mid-sized technological university located in the Midwestern United States. Obtaining a deeper understanding of how students perform under stress and how to support diverse (culturally, mentally, and emotionally) learners is at the foundation of this research. My literature review aided this study in the development of the outlined hypotheses with the goal of identifying cognitive factors (and instruments) that admissions offices and institutions could administer during the recruitment and early years of the college student's career to predict and develop academic performance persistence.

Literature Review

Academic Performance and Admissions Standards

Attempting to select the best candidates for universities and colleges across America is comprised of stiff competition based on screening processes rooted in achievement exams, class rank, writing capabilities, past academic performance, and glowing letters of recommendation. Duckworth et al. (2007) found confirming results that over and above high school rank and SAT scores, grit is a retention predictor. According to Witkin (1973), understanding a student's cognitive style (their approach to both perceptual and intellectual activities) is more advantageous than standardized tests. This approach allows institutions of higher education to consider a more comprehensive way of identifying one's strengths, weaknesses, and individuality instead of categorizing them based on their IQ (Witkin, 1973). So, what does this new and different approach look like and how do we begin to transform the systematic way we've admitted and supported students in the past several hundred years? An approach to consider is the *Benjamin Banneker Scholars Program (BBSP)* which was established in 2008 at Central State University, a historically black college and university (HBCU) in south-central Ohio, to examine an alternative strategy to underrepresented minority (URM) retention and graduation in the STEM fields (Kendricks et al., 2019). The program addressed seven challenging areas, which were 1) academic preparedness, 2) low self-efficacy, 3) assurance of belonging within the discipline, 4) environmental isolation, 5) financial support, 6) lack of supportive network, and 7) impractical expectations of themselves and their college experiences. Over the initial 5-year period of the program, students were

retained in the BBSP program and at the institution at a rate of 88% in comparison to 39% for all other students majoring in STEM programs (Kendricks et al., 2019). The researchers of the BBSP program cited creating a supportive family-type environment, a sense of belonging, and metacognitive self-regulation as contributing factors to increased retention and academic performances (Kendricks et al., 2019). I am realistic in understanding that colleges and universities will continue to use measures such as high school GPA, ACT, and SAT for college admissions decisions in the near future. However, these measures do not paint a full picture, and they can potentially limit our ability to create culturally rich and academically diverse learning environments. Factors such as persistence, stress mitigation and self-compassion are not accounted for in predicting a student's academic ability and could be applicable supplements for academic success.

Stress and Academic Performance Factors

The higher education experiences of future generations of students will require special attention to unique and out-of-the-box strategies for student success and support. Having sensitivity and empathy for the wide variety of basic needs, accommodations, and even more basic needs such as food insecurities must be instituted now to allow time for the development of faculty, staff, and administrator training of the future. Wing and Lee (2017) conducted a study of community college students in Hong Kong pursuing their associate degree. The researchers' goal was to make sense of the intersection of failure, academic performance, grit, and stress. Specifically, they wanted to determine if differences existed between stress levels associated with anticipatory failure and those

associated with documented performance. One of their overarching conclusions states that understanding the psychological influence of grit and how it can effectively combat academic stressors is important. Wing and Lee (2017) reported that perceived academic failure was positively associated with stress even when actual academic performance and perceived academic failure were not correlated (Wing & Lee, 2017). In other words, a student's perception of their own abilities is an important factor to consider and incorporate into academic interventions. This notion of increasing students' beliefs in their abilities is the hallmark of Dweck's (1975) work on Growth Mindset. Therefore, it is advisable for universities and students alike to devise interventions such as a growth mindset more broadly (i.e., the belief that personal characteristics and abilities can be developed) in students (Yeager & Dweck, 2012).

Although my study was conducted in a more naturalistic setting, a very similar study by Satterwhite (2016) was conducted in a laboratory setting at a small liberal arts institution. The goal of that laboratory study was to analyze the intersectionality of stress and constructs such as MT, resilience, self-efficacy, and grit. A baseline salivary cortisol collection (a predictor of stress) was obtained from each of the 63 (49 women and 14 men) participants as they entered the lab. The researchers collected saliva by instructing the participants to chew on a cotton pad for 30 seconds then storing the pads in a salivate plastic tube. Thereafter, participants completed three questionnaires; 1) The Dispositional Resilience Scale; 2) The General Self-Efficacy Scale; and 3) Grit Scale as well as some demographic information. After the surveys, the participants were introduced to two stressors. First was a physical task which required them to hold two fingers (pointer and

middle) in a bowl of 39.2-degree Celsius water for 5 minutes or however long was feasible for each participant. Secondly, participants were given 17 cognitively challenging puzzles. They had 10 minutes to complete as many puzzles as they could. Once the 10 minutes expired, participants ranked their current stress level on a 5-point Likert scale. After the two tasks were completed a second cotton pad salivary collection was taken to compare to the baseline cortisol measure. The results of the Satterwhite (2016) study led to the following conclusions relevant to my research (a) grit and MT are two different, but necessary constructs for college students; and (b) participants who reported lower stress levels over the course of the study also reported a sense of internal control (a defining factor of MT). Satterwhite (2016) concluded that MT could potentially alter one's perception of stress and result in an adaptive use of their high cortisol levels. Having excessive stress can produce negative effects on one's physical body, but moderated stress can be a motivator and increase one's focus/performance helping to energize and direct their motivation (Satterwhite, 2016). Another distinction discussed in Satterwhite's (2016) study were the individual differences in the participants' cortisol responses to both cognitive and physical stressor tasks, suggesting that individuals may respond differentially between different types of stressors. Additionally, the competitive nature of the stressors could also potentially explain Satterwhite's (2016) findings regarding varying cortisol levels. Finally, Satterwhite (2016) clarifies that the laboratory setting was a limitation in generalizing results from the study, and that a naturalistic setting may result in different patterns of findings related

to cortisol and emotional responses to stressors. Thus, the more naturalistic setting of my research served to validate and extend Satterwhite's (2016) findings.

Mental Toughness (MT)

Characterized by having high self-esteem and self-confidence, individuals who are mentally tough are motivated and can sufficiently manage their locus of control (Satterwhite, 2016). Additionally, mentally tough individuals typically possess a positive outlook on life. In fact, MT has a positive correlation with optimism (Nicholls et al., 2008). Mentally tough individuals have mastered coping methods to manage stress levels and difficult situations. Thus, the way in which one can cope during opposition is at the forefront of MT research. Loehr (1982) defines MT as one's ability to regularly produce peak performance in a wide range of competitive conditions. However, researchers are still at odds regarding whether MT is innate in one's personality or whether one demonstrates MT based on psychological factors that are unique to a person's external forces. For example, some researchers question whether challenging issues such as family problems, stress, or approval from others causes one to have a range of mentally tough responses based on the situation they are challenged with (Gucciardi, et al., 2008; Guillén & Laborde, 2014). Other literature suggests that MT is an aspect of one's personality just like extraversion, conscientiousness, or neuroticism (Clough & Strycharczyk, 2012). Satterwhite (2016) suggests that the construct of MT does not function as an absolute, while Clough et al (2002) theorized a construct of MT that is applicable to anyone, regardless of their personality characteristics or profession. Clearly, the debate over whether MT is a state-like or trait-like characteristic exists. Despite this

debate, which could implicate applied efforts to increase one's mental toughness, the evidence exists supporting the importance of mental toughness in higher education.

MT is often compared to the concept of hardiness. Kobasa (1979) proposed that hardiness consists of three C's: commitment, control, and challenge. In describing MT, Clough et al. (2002) added another C - confidence - to Kobasa's three C's of the hardiness construct, creating a differentiation between MT and hardiness. Thus, the Four C's of MT theory are that MT includes (a) control, (b) commitment, (c) challenge, and (d) confidence. Furthermore, Satterwhite's (2016) research found that those with high levels of control also produced more cortisol. Additionally, Kaiseler and Polman (2009) found that higher MT measures were associated with lower levels of stress intensity (independent of stressor type), but perceived control levels were higher. Given these implications of coping on cortisol and stress perception, I will also assess coping with an instrument that measures factors associated with one's stress appraisal.

Grit

Grit is defined as the ability to maintain effort and passion toward a long-term goal; gritty individuals see achievement as a marathon and not a sprint (Duckworth et al., 2007). Within an academic setting, individuals who are actively engaged in their success have a behavioral tendency to be grittier versus individuals who are pleasure oriented (Culin et al., 2014). Pleasure oriented behaviors include (a) immediate hedonically positive activities; (b) altruistic activities; and (c) engagement in activities that are attention consuming such as scrolling on social media, hours of video games or YouTube videos. Possessing grit, self-discipline and perseverance have been found to be more

reliable predictors of academic success in comparison to one's IQ or standardized test scores (Duckworth & Seligman, 2005). Grit and MT are often considered different words with the same meaning. The current study indirectly explored whether grit and MT are synonymous within an academic setting. If synonymous, they should correlate highly, and have overlapping predictions of exam performance (and/or stress). Satterwhite (2016) suggests that MT and grit are different, and that grit is long-term perseverance and MT can mitigate stress in the short-term. Analyzing grit and the ability to persist when confronted with short-term setbacks, Satterwhite (2016) found that stress was detrimental and derailed students' ability to persist and found that exposure to an acute stressor differentially affected participant's later views of themselves as gritty depending upon whether the stressor was controllable or not (Bhanji et al., 2016). Satterwhite (2016) found that actual grit, as measured by persistence, may differ from self-reported general grittiness such that an acute stressor may lower one's perceived grittiness, but may not affect one's actual grit.

At the nucleus of MT is control, especially when attempting to manage a temporary stress in life. However, grit may require an individual to relinquish control in situations that may be a hindrance to one's long-term goal (Satterwhite, 2016). Satterwhite (2016) assessed control using the *Dispositional Resilience (Hardiness) Scale* (DRS; Bartone, 2007), which is composed of questions assessing an individual's perceived sense of commitment, control, and challenge in their life. Price (2019) concluded that MT and grit are not mutually exclusive and suggested that researchers are often confused over how these constructs differ and how to utilize them in retention or

other applied methods. January (2016) argument is similar, suggesting that resilience, MT, grit, and hardiness have subtle differences, more similarities, and proof of overlapping dimensions. Price (2019) found that when examining total scores, the constructs appear to be redundant in predicting stress. However, using confirmatory factor analysis on the individual items from the MT and Grit instruments (and 2 others) Price (2019) found evidence of a General Resiliency Factor consisting of items from across instruments (i.e., suggesting some redundancy) and several sub-factors consisting of 9 residual dimensions corresponding to the individual constructs. However, a 2017 study to understand the interrelationship between coaching behaviors, grit, mental toughness, and motivation found a significantly weak relationship between grit and mental toughness (Scharneck, 2017). In sum, it appears that grit and mental toughness do have some redundancy, but each also consists of unique features. I propose that they are two distinct constructs that are both valuable for college students to develop and maintain. Having a balance of both grit and MT may adaptively allow students to utilize their cortisol production to control and manage the stressful situations within an academic environment more proficiently.

Coping

Coping is a psychological behavior which protects an individual from problematic life strains (Pearlin & Schooler, 1978). The concept of coping assumes that people are responding in an active way to challenges they face. In the context of academia, what students do and do not do when confronted with challenges can make a difference to their well-being. Struthers et al., (2000) found that the relationship of a student's stress level

and grade in their psychology class is qualified by motivation and the coping resources they access. According to Endler (1997) there are three basic coping styles when an individual is faced with stress, (a) task-oriented, (b) emotion-oriented, and (c) avoidance-oriented. In task-oriented coping, one seeks to solve the problem at hand. Task-oriented coping is typically used when one can see the problem as controllable or solvable. Emotion-oriented coping, most often used when the problem is perceived as uncontrollable, focuses one's efforts on the emotional distress that stems from the problem. Avoidance-oriented coping is the least effective, and involves attempts to avoid, distract, or divert problems.

Struthers et al. (2000) explored the relationship between (a) coping, (b) academic stress, and (c) motivation on the performance of 203 college students enrolled in an Introduction to Psychology course. Students represented a variety of majors, including psychology, engineering, nursing, and physical education. They reported a significant regression model in which college student stress at the beginning of the semester positively predicted their use of PFC, EFC, and their motivation to succeed in their psychology course, and negatively predicted their course grade at the end of the semester ($R^2 = .08$). In a 2009 study to understand the interrelationship of MT, stress appraisal, coping (strategies & effectiveness) among athletes they found that athletes with higher mental toughness had a positive correlation with PFC strategies and a negative correlation with EFC strategies (Kaiseler & Polman, 2009). These findings motivated me to explore coping in my study. I incorporated the SCOPE instrument that was utilized in

the Struthers et al. (2000) research to assess the coping strategies and their interrelationships with stress and appraisal perceptions of Physics I students.

Self-Compassion

Self-compassion involves being empathetic, understanding, kind and non-judgmental with one's failures or perceived deficiencies (Neff, 2003a). It entails managing negative self-talk as it relates to one's own limitations, missteps, and failures - especially during stressful events or when situations do not go as planned. Utilizing mindfulness (one aspect of self-compassion), researchers found that self-compassion and perceived stress improved across a pre/post manipulation (Bluth et al., 2015). Self-compassionate individuals can assess stress in their lives and reframe it as non-threatening. This cognitive reframing aids in the regulation of cognitive resources, rather than letting these limited resources be monopolized by an adverse self-perception (Hallett & Hoffman, 2014). People who are self-compassionate can protect themselves from negative self-talk, thereby reducing or preventing mental health issues such as anxiety (worrying about what hasn't happened yet) and depression (worrying about what has happened) (Bluth, et al., 2016). Neff and McGehee's (2010) research found that self-compassion in adolescents aged 14-17 had a negative correlation with depression and anxiety. Exploring self-compassion to mitigate performance-based academic stress is a goal of my research. Luo et al., (2019), while not investigating the possible mitigating effects of self-compassion, did find support for such in their research with nursing students. They found that self-compassion had a negative correlation with anxiety and depression ($r = -.44$, $p < .001$), perceived stress was positively associated with the same

factors ($r = .64$, $p < 0.001$), and perceived stress and self-compassion had a negative association ($r = -.65$, $p < 0.001$). Other research has found a negative correlation between self-compassion and stressors and concluded that self-compassionate people may perceive less stress, thereby lowering their cortisol reactivity (Breines et al., 2014). My study aimed to extend laboratory-based self-compassion findings in an academic setting.

Cortisol as a Stress Measure

Cortisol is a compound discovered by a group of Mayo Clinic researchers. The effort was spearheaded by chemist Dr. Edward C. Kendall in his research on the adrenal gland, which began in the early 1930's (Simoni et al., 2002). As a result of his discovery of cortisol, a synthetic version called cortisone was synthesized in 1948 by Kendall and his collaborators; for this work, they were awarded the Nobel Prize in 1950 (Simoni et al., 2002). Derived from beef adrenal glands, cortisone's initial primary use focused on increasing muscular strength as well as treatment for inflammatory diseases such as rheumatoid arthritis and Addison's disease; it was coined one of the 20th century's wonder drugs (Hiller, 2007). Advances in cortisol research have revealed that when present in the bloodstream it can help to manage blood pressure and increase the body's metabolism of glucose. In the context of this research, cortisol was investigated in relation to danger, stress, or any type of perceived threat.

The concept of the stress response was originally named "the non-specific neuroendocrine response of the body" by famous researcher Hans Hugo Bruno Selye; he was referred to as the founder of stress theory (Szabo et al., 2012). The foundational work of the father of stress research contributed to over 1,600 research publications and the

establishment of the International Institute of Stress (Tan & Yip, 2018). Selye's contributions to research in cortisol and stress response act as a validating source for this research and helped to establish cortisol as a reliable and effective way to measure physiological stress levels. When exploring a non-intrusive approach to cortisol measurement, saliva collection is an ideal choice. This collection approach allows researchers to collect samples without inducing significant additional stress to minimize risks associated with increasing cortisol levels as compared to other collection procedures such as urine collection or blood collection (Steptoe & Ussher, 2006). Salivary cortisol collection also generally does not require a medical professional to be present. I measured cortisol for use as a reliable, non-invasive, and efficient assessment of stress for use in my research.

Saliva samples can be collected by either an absorbent material or passive drool collection. Shirtcliff et al., (2001) found that the passive drool technique is effective in ensuring that saliva stimulants, such as cotton absorbent material (utilized in the absorbent method) do not present biased cortisol measurements. Moreover, enough saliva can typically be collected within 1- 2 minutes utilizing the passive drool method. Salivary cortisol analysis then occurs through biochemical assays, as a standard measurement technique that is easy to use and produces an analysis that has reliability (Kirschbaum & Hellhammer, 1989). However, this technique requires the following conditions for validity (a) food consumption, (b) alcohol/nicotine consumption, and (c) contraceptive use are established to maintain the integrity of the cortisol assessment measures (Steptoe & Ussher, 2006).

Factors That Affect Cortisol Levels. Variations in cortisol levels and individuals are affected differently by stress. Research suggests that there are some confounding conditions that automatically increase cortisol levels. I will briefly discuss the factors that were taken into consideration in this study.

Contraceptives. Sex steroids such as such as birth control (oral contraceptives) and estrogen levels will cause higher cortisol levels (Hellhammer et al., 2009). A pre-screening survey was used to inform researchers whether participants were pregnant or taking any oral contraceptives. Pregnant individuals were not invited to join the study and notations were made when individuals indicated their use of contraceptives to maintain the validity of salivary measures and data analysis.

Exercise. When individuals engage in moderate to intense (exhaustive) exercise it is found that they have a rise in cortisol for a duration of approximately 15 minutes after the physical activity (O'Connor & Corrigan, 1987). Thus, I surveyed participants prior to saliva collections to ensure that they had not participated in intense physical activity within 2 hours of their collection times.

Nicotine. Smokers and those who consume tobacco products display elevated salivary cortisol levels compared to non-smokers. Habitual smokers average approximately 15 cigarettes daily; the chronic consumption of nicotine products has a direct effect on the function and operation of the HPA axis, where cortisol is regulated and released (Rohleder & Kirschbaum, 2006). Individuals who indicated habitual tobacco use were not invited to join the study and notations were made when individuals

indicated low or moderate use to maintain the validity of salivary measures and data analysis.

Wake Time. Wake time and time of collection are critical factors that influence the normal cortisol cycle (Adam & Kumari, 2009). Daily cortisol levels are typically elevated during the waking hours and progressively decrease throughout the day. According to research conducted by Kirschbaum and Hellhammer (1989), on average, 15 distinct cortisol pulses are evident in the body each 24-hour cycle. Wake time and sampling times were documented during both salivary collections.

Health and Medical Conditions. Pre-existing mental, physical, and emotional health issues are important factors in the make-up of ones' cortisol levels. In a study comparing individuals between the ages of 16-25 researchers found that within the previous three months, those with a variety of mental health conditions and disorders (i.e., depression, suicide ideation, bipolar disorder, self-harmed, anxiety, eating disorders, and obsessive-compulsive disorder) had significantly increased cortisol levels in comparison to individuals who were in a healthy control group (Heinze et al., 2016). In an analysis of covariance from a longitudinal study by Walker et al. (2013), clinically high-risk individuals who met the criterion for psychosis had evidence of higher levels of cortisol at baseline when with a group of healthy individuals. Thus, those having pre-

existing health conditions were identified during the pre-screening process and were not invited to join the study.

Self-Reported Stress

The goal of my study was to specifically focus on the acute stress produced during a college student's final examination period. I was also mindful that there may also be external forces causing episodic or chronic stress during finals. Excessive and chronically stressful conditions can have a very different effect on a person when compared to acute stress. According to Miller et al., (1994) there are three types of stress, (a) acute stress, the most common type of stress which happens soon after a traumatic event; (b) episodic acute stress, which is repeated acute stress and extended over-arousal; and (c) chronic stress, physical and/or psychological long-term continuous stress with no relief in the foreseeable future. Humans can generally recover from short-term (acute) stress, but chronic stress can spiral out of control and cause additional mental, physical and health challenges. When individuals have uncontrollable setbacks (under conditions that are not perceived as stressful), they can sufficiently persist; but when compounded with prior stressors, persistence is thwarted. Thus, existing external stress can alter one's emotional response to issues that are beyond their control (Bhanji et al., 2016). Marković et al. (2011) reported that the same stressor at different time point could induce different and sometime opposite changes in stress measures in the same individual. They also suggest that subtle (acute) increases in stress can act as a protective or tolerance and that acute stress induces different effects depending on when an individual is confronted with the stressor. Therefore, I also assessed chronic stress in my research.

Elevated cortisol is frequently detected even prior to the actual stressful situation targeted in research. In general, perceived stress will moderately increase cortisol levels (Hellhammer et al., 2009). Thus, collecting self-reported acute stress levels from participants during the salivary collections aided me in further validating stress levels, even before the students entered their physics examination. Atkinson and Waddell (1997) demonstrated that cortisol can peak prior to the event, which validates this study's ability to collect salivary samples before students take their physics exam. For example, prior to a written or oral examination cortisol levels were found to increase (Ng et al., 2003). Researchers in Singapore studying undergraduate dental students found that the mean salivary cortisol levels were significantly higher before their written exam (6.32nmol/l) versus after the exam (5.16 nmol/l, $p=0.015$; Ng et al., 2003). This preemptive release of stress hormones allows the body to keep the person safe and signals to the individual whether they should engage in fight or flight (Satterwhite, 2016). Stress in moderation is not harmful; it can energize and potentially result in favorable performance outcomes (Kottler & Chen, 2011). Timing of the anticipated stressor is vitally important. According to Shannon et al., (1963), collecting a salivary sample and documenting self-reported stress levels within 1-hour of the stressful experience is the ideal protocol. However, it is important to note that increases in cortisol can start much sooner than the anticipated event, and therefore may have longer durations due to anticipatory stress. This is especially true for individuals who lack effective coping mechanisms (Smyth et al., 1998). For example, perceived stress, especially during "situational" or an acute stressor, was associated with elevated cortisol in individuals with a below average ability to cope

(Sladek et al., 2016). Talib and Zia-ur-Rehman (2012) found that perceived anticipatory stress in university students had a significant negative correlation with academic performance. Stress management is an important factor that colleges and universities should consider as it relates to student achievement. How students "cope" with stress matters, therefore I also assessed coping styles in this research to aid in the interpretation of findings and future recommendations.

Literature Review Summary

Given the findings regarding cortisol, self-reported stress, academic performance, and varying cognitive variables, the purpose of my study was to further understand the impacts of cognitive constructs on two cortisol measurements (baseline and day-of Physics I exam), self-reported baseline and acute stress levels, and actual academic performance. With improved academic performance as the goal of this research, I sought to identify various cognitive constructs (i.e., cognitive tools) that could potentially be manipulated or leveraged to improve academic performance. For example, given Satterwhite's (2016) finding that a sense of internal control was associated with lower stress levels, one possible future developmental program for students could focus on teaching skills to increase their sense of control and combat stress.

Thus, I aimed to identify potential factors that may act to inhibit or mitigate poor performance and/or college success. Specifically, I examined factors such as mental toughness, stress appraisal, self-compassion, coping skills, and grit to determine if they may predispose students for success when they are subjected to competitive or stressful academic situations, such as career fairs, examinations, major presentations, etc. I hope

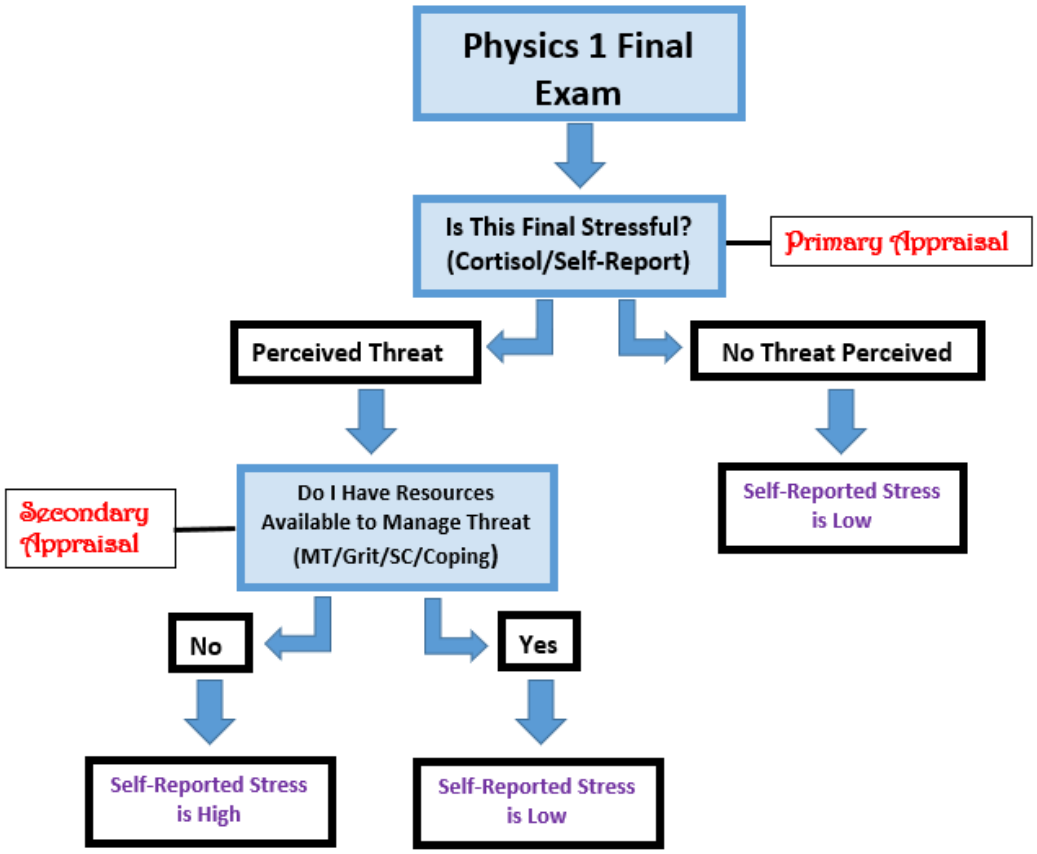
that the findings from this research can inform higher education institutions of the relative importance of psychological constructs in future admissions processes, as well as the need for interventions in student success programs and the overall well-being needs of students.

Theoretical Framework

A frequently referenced and leading cognitive-behavioral theory of stress and coping was conceptualized by Lazarus and Folkman (1984). The *Cognitive Appraisal Theory* (CAT) defines psychological stressors as taxing and/or difficult when the intersection between perceived external/internal demand and the perceived external/internal resources to confront and potentially mitigate stress are misaligned (Lazarus & Folkman, 1984). According to CAT, a two-tiered cognitive appraisal process happens during a stressful, threatening, or challenging event. First, a primary appraisal determines how significant (stressfulness) and threatening the event is, and corresponding negative emotions such as sadness or anger are displayed. During the secondary appraisal an individual will evaluate their situational coping efforts during a stressful encounter (Lazarus, 1991). At this secondary stage the individual will explore potential options and perceived effectiveness in managing the threat (stress). Lazarus (1984) clarified that these appraisals could be a conscious pursuit or could be activated without the individual's awareness. Also, the underlying conceptual processing can be unconsciously in operation. It is the combination of these 2 tiers of appraisal that indicate how one responds. In the current study I utilized this theoretical framework to identify a reasonable explanation of how individuals appraise, behave and cope during a Physics I final exam. A detailed model applying the CAT to this situation is outlined in Figure 1.

Figure 1

Cognitive Appraisal Theory: Exploration of Physics I Students' Cognitive Process



Note. Adapted Model of Lazarus' (1984) *Cognitive Appraisal Theory*

Research Questions and Hypotheses

Research questions and corresponding hypotheses for this study were as follows:

1. Are increased cortisol levels correlated with self-reported stress levels in performance-based academic situations?
    - I hypothesized that a positive correlation would exist between cortisol levels and self-reported stress as recorded on both baseline and day-of collections.
2. Does a stressful performance-based academic event increase cortisol levels and/or self-reported acute stress?
    - Based upon the literature review, I hypothesize that cortisol levels and self-reported acute stress will be elevated prior to the Physics I final exam compared to levels during baseline measurements.
3. How does chronic stress impact or correlate with self-reported stress and/or cortisol levels during a performance-based stressful academic event?
    - I hypothesized that chronic stress levels would not correlate with self-reported acute stress or cortisol levels on the day of the Physics I exam, but would positively correlate with these measures during the baseline collection.

4. What role does self-compassion play in the self-reported stress scores, cortisol levels and/or academic performance during a stressful academic setting?
    - I hypothesized that self-compassion would negatively correlate with self-reported stress and cortisol levels on the day of the Physics I exam and positively correlate with final exam score.
5. What role does grit and mental toughness play in self-reported stress scores, cortisol levels and/or academic performance within a stressful academic setting? Additionally, is there evidence that mental toughness and grit are separate constructs
    - I hypothesized a low or non-significant correlation between mental toughness and grit, suggesting that they are unique constructs.
    - I will conduct multiple regressions using only grit and mental toughness as the independent variables with stress and academic performance as dependent variables. The results will inform conclusions regarding redundancy or uniqueness between the 2 factors, in addition to understanding their role in predicting academic performance and/or stress.
6. What role does coping strategies, as assessed by the SCOPE instrument, play in self-reported stress scores, cortisol levels and/or academic performance within a stressful academic setting?

- I hypothesized that problem-focused coping would correlate positively with exam score and negatively with self-reported stress and cortisol levels on the day of the Physics I exam. Also, I hypothesized that emotion-focused coping would correlate negatively with exam score and positively with self-reported stress and cortisol levels on the day of the Physics I exam.

7. What information does a multiple regression provide in terms of understanding how specific psychological constructs are related to one another and to exam performance?
    - The regression model is exploratory, and I do not have specific hypotheses.

Methods

This research conducted a comparative measure of stress using baseline cortisol levels and cortisol levels during a perceived stressful time for students (a Physics I final exam). Utilizing the passive drool method, cortisol levels were analyzed to measure stress. In addition to two saliva collections for each participant, I collected self-reported stress levels and utilized the following instruments to collect assessments of stress (a) stress appraisal measure (SAM); and (b) stress coping survey (SCOPE) and (c) college chronic life stress (CCLSS). Additional cognitive constructs measured included (a) mental toughness (MTQ); (b) self-compassion (SCS); and (c) grit; The study was approved and compliant with IRB (Institutional Review Board) ethical standards.

Participants

Forty-one undergraduate college students enrolled in a Physics I course at Michigan Technological University partially or fully participated in the study, with 35 completing the full study (49% (n = 17) were male and 51% (n = 18) were female). Participants had a mean age of 19.14 (*SD* = 1.19). Most (83%) of the participants were non-Hispanic White Americans (*n* = 29), and participants had a mean overall grade point of 3.17/4.0. (*SD* = .42). The majority (77%) of the participants were first-year students (*n* = 27), seven were second-year students (20%), and one was a third-year student (3%). Six (17%) students were retaking the Physics I course during the semester of this study (four due to a previous failing grade and two due to a previous withdrawal from the course), while the remaining participants were enrolled for the first time. Participants were recruited utilizing a scripted call for participants and was distributed via (a) emails

from the registrar's office to students enrolled in the Physics I course, (b) instructors who volunteered to distribute the call via email to students enrolled in their Physics I courses, and (c) I attended Physics I classrooms to invite students to participate in the study. All interested participants received a link via email for an online pre-screening survey.

During the pre-screening survey potential participants were asked:

- Do you have any known pre-existing medical/health issues, if so, please describe?
- Are you currently taking any medication, if so, please describe?
- Do you use any tobacco or cigarette products, if so, please describe product type and frequency?
- Are you currently pregnant or taking any form of contraceptive?
- Are you willing to provide researchers with two saliva samples?

Pregnant females, individuals who were diagnosed with psychiatric disorders, and individuals who reported taking medication for psychiatric disorders were excluded from this study based on their responses on the pre-screening survey. Exclusion was necessary and consistent with previous research indicating that these individuals have markedly higher cortisol levels, thereby affecting the validity of the cortisol measurements (Vining et al., 1983). Contraceptive users (n = 5) and those who were cigarette or tobacco users (n = 4) were noted, but not removed from the study. Researchers were aware that these participants could potentially have higher cortisol levels and considered skewness when analyzing results.

Materials

Measuring Stress.

Cortisol Assay Kits. All saliva samples were collected and safely stored and refrigerated in an on-campus research lab. They were analyzed utilizing a cortisol Competitive ELISA (enzyme-linked immunosorbent assay) kit and followed instructions for a uniform sample (adapted from Salimetrics, LLC, Saliva Collection and Handling Advice, 2009, www.salimetrics.com). According to protocol, all samples were frozen and stored at -20°C or below until ready to perform assay, this is based on the recommended storage level from Salimetrics The baseline cortisol was intended to offer a measure of normal levels of cortisol during a typical routine day for a student. Both the baseline and day-of samples were collected during a similar time of day for all participants, between the hours of 11 a.m. – 1 p.m. I followed ThermoFisher Scientific's procedural guidelines, including using a passive droll collection process, sample preparation, and dilution instructions outlined by the manufacturer using the Cortisol Competitive ELISA kit (Life Technologies Corporation, Carlsbad, CA).

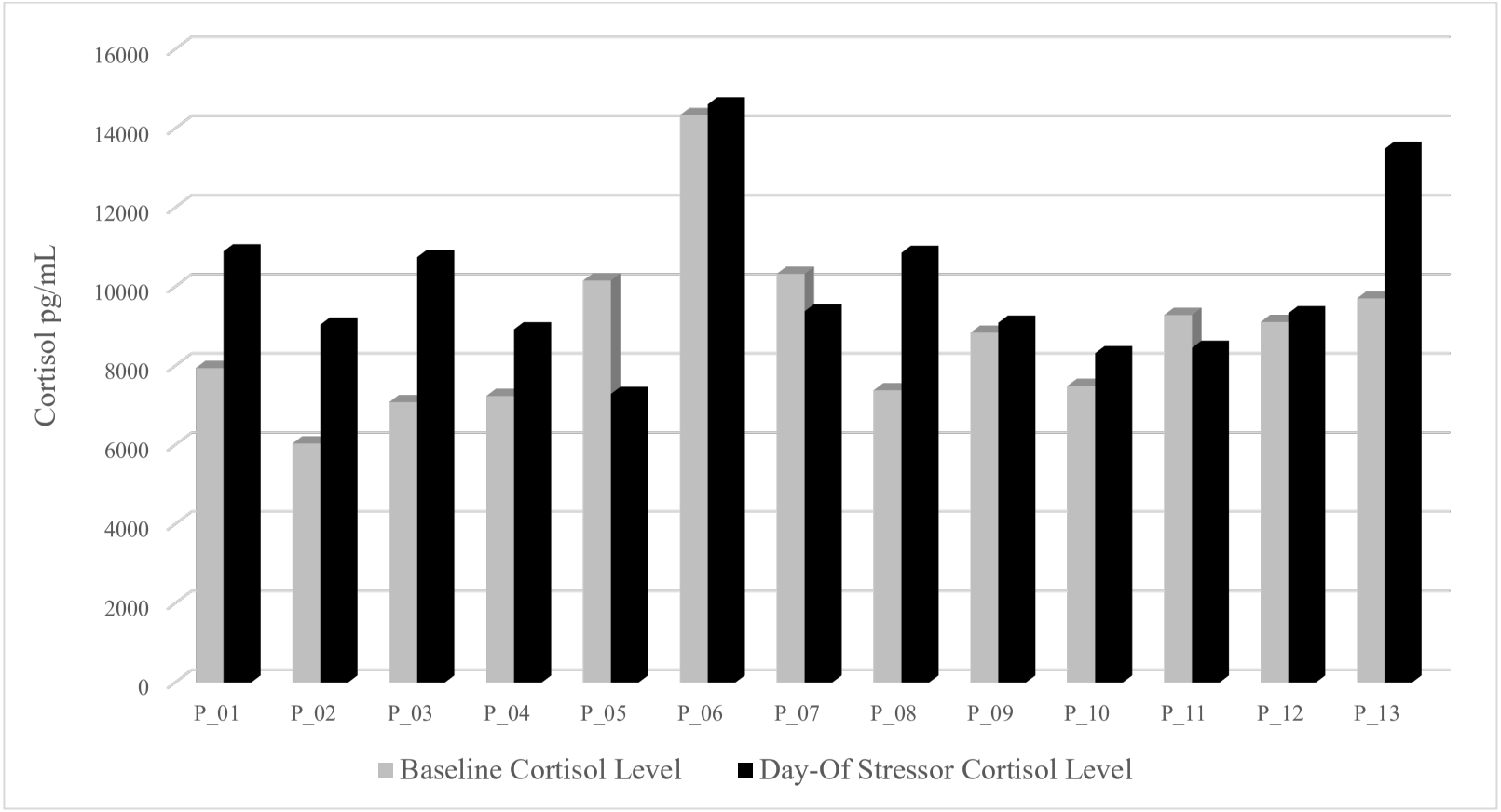
Pilot Study. I conducted a feasibility pilot study to ensure that an effective salivary collection method and quantification of cortisol was in-place. Utilizing 13 participants, salivary cortisol measurements were collected during a baseline period and again prior to an academic stressor. The results showed that the samples were adequate for testing, and the dilutions performed on the samples were in the appropriate range on the standard curve (no excessive errors observed) as outlined in Figure 2. Cortisol ranged

from a low of approximately 6000pg/mL to a high of approximately 14000 pg/mL, with the standard deviations of approximately 2100 pg/mL.

A paired sample t-test was used to analyze differences between the baseline cortisol levels and cortisol levels from the day of the academic stressor (final presentations for senior design projects for final exams). With the small sample size, no detectable differences were achieved, although they trended in that direction with baseline cortisol levels lower *(M* = 8841.815 pg/mL, *SD* = 2109.65) than day-of stressor cortisol levels (*M* = 10032.69 pg/mL, *SD* = 2076.61), $t(12) = -2.053$, $p = .063$. A medium effect size (Cohen, 1988) was noted, $d = 0.57$. As I would predict, 11 of the 13 participants showed increased day-of cortisol levels.

Figure 2

Pilot Study Baseline and Day-Of Salivary Sample Results (By Participant)



Note. N = 13.

Self-Reported Stress Level. During this study I documented participants' self-assessments of their stress levels during both the baseline and day-of collections. The goal was to have a latent variable of stress to examine participant's perceptions, and to examine correlations between self-reported stress and the direct measure of salivary cortisol. Participants were asked to rate their current level of stress on a scale of 1-100 (1=*little to no stress* and 100=*extremely high stress*).

College Chronic Life Stress Survey (CCLSS-54). The 54-item CCLSS identifies items which cause individuals to feel stressed, upset, or worried on a regular basis (Lynn & Cohen, 1996). The instrument specifically measures chronic or persistent stress levels and does not consist of any subscales. Participants were asked to mark all the listed items that caused them to be stressed, upset, or worried regularly i.e., at least two to three times per week within the last 30 days. The sum of all the stressors that participants indicated were used to determine their level of chronic stress. An average college student has a mean of 17 of these stresses in their life. The range and interpretations, as per Lynn and Cohen (1996) are (a) 0-10 items=*low chronic stress*, (b) 11-24 items=average chronic stress, (c) 25-32 items=high chronic stress, and (d) 33-54 items=*extreme chronic stress*. Example items included issues such as relationships, family issues, financial challenges, job performance, and academic performance. The CCLSS is reportedly reliable (test-retest), confirming the utility of the CCLSS instrument. This instrument was completed by students during the baseline salivary collection (Lynn & Cohen, 1996).

Mental Toughness Questionnaire (MTQ-18). The Mental Toughness Questionnaire (MTQ18; Clough et al., 2002) is reported to be a valid and reliable

instrument, having high correlations with the longer MTQ-48 instrument, offering a robust measure of overall toughness (no subscales). Mental toughness determines one's ability to cope during stressful or challenging situations regardless of the circumstances. Answers on the MTQ-18 are given on a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Responses across items are summed, with higher scores reflecting greater MT (Cronbach's alpha = 0.92; Clough et al., 2002). The abbreviated MTQ-18 produces a global unidimensional score; it doesn't measure any subscales. Participants were instructed to think about how they are in general, and they were encouraged to not spend too much time on any one item. Sample questions include *even when under considerable pressure I usually remain calm* and *when I make mistakes I usually let it worry me for days after.* The instrument was issued to the students via an online survey link that was forwarded to them after their baseline salivary collection.

Grit (Grit-12). Grit, the ability to persevere and remain focused on long-term goals (Duckworth et al., 2007) was assessed. The 12-item grit scale consists of two subscales *Perseverance of Effort* (PE) and *Consistency of Interest* (CI) (Duckworth et al., 2007). PE reflects a person's tendency to continue pursuit of long-term goals even when they are faced with challenges or setbacks. CI reflects a person's tendency to remain goal-oriented and focused over prolonged periods of time (Duckworth & Gross, 2014). Answers on the grit scale are given on a five-point Likert-type scale ranging from 1 (*not like me at all*) to 5 (*very much like me*). Responses across items are summed then divided by 12 with 1=*not at all gritty* to 5=*extremely gritty*. The subscales consist of two independent 6-item dimensions, a total of 6 items are reverse scored prior to computing

the subscales, which are summed then divided by 6. Internal consistency estimates (Cronbach's alpha) for the grit scale were 0.85 (Duckworth et al., 2007). Sample questions include *setbacks don't discourage me* (PE) and *my interests change from year to year* (CI). The instrument was issued to the students via an online survey link that was forwarded to them after their baseline salivary collection.

Self-Compassion Scale (SCS-26). The Self-Compassion Scale (SCS) reflects how an individual treats themselves in the face of difficulties or challenges (Neff, 2003). This instrument consisted of 6 subscale factors; (1) self-kindness vs (2) self-judgement (extending kindness and understanding to oneself vs. harsh self-criticism and judgement); (3) common humanity vs. (4) isolation (seeing one's experiences as part of the larger human experience vs. seeing one's experiences as separating and isolating); and (5) mindfulness vs. (6) over-identification (holding one's painful thoughts and feelings in balanced awareness vs. over-identifying with one's painful thoughts and feelings). The SCS-26 is psychometrically valid and theoretically coherent (Neff, 2003). Sample questions include *I can be a bit cold-hearted towards myself when I'm experiencing suffering* and *When I feel inadequate in some way, I try to remind myself that feelings of inadequacy are shared by most people.* Items are rated on a 5-point Likert scale ranging from 1 (*almost never*) to 5 (*almost always*). Subscale scores are computed by calculating the mean of subscale item responses. As instructed by Neff (2003), a total self-compassion score is computed by reverse scoring the self-judgment. isolation, and over-identification subscales, then computing a grand mean of all six subscale means. A high overall SCS score means that individuals are more likely to be kinder to themselves, even

when faced with adversity and failure. This instrument was issued to participants via an online survey link that was forwarded to them after their baseline salivary collection.

Stress Appraisal Measure (SAM-28). The Stress Appraisal Measure (Peacock & Wong, 1990) is a self-report instrument composed of 28-items. Each item is rated on a 5-point Likert scale regarding how the individual feels about a specific stressful situation (In this case a Physics I exam). Sample questions include, *does this situation tax or exceed my coping resources* and *to what extent am I excited thinking about the outcome of this situation.* The scales' anchors ranged from (1) *not at all* to (5) *extremely*. The SAM has seven subscales (made of 4 items each) intended to measure an individual's appraisal of future events. The three primary subscales are (1) threat - the potential for harm/loss; (2) challenge - the anticipation of growth gained from the experience; and (3) centrality - the perceived significance of the event on personal well-being. The secondary subscales measure one's appraisal of their coping resources and include (4) controllable-by-self; (5) controllable-by-others; and (6) uncontrollable-by-anyone. Finally, the SAM includes a general perception of one's stress subscale (7) stressfulness. To score the subscales I summed the respective sub-items and divided its total by 4. According to the original authors (Peacock & Wong, 1990), the scales are internally consistent with concurrent and discriminant validity. The SAM is designed to measure one's appraisal of anticipatory stress, making it a viable instrument for this study. This instrument was issued to the students on the day of their final physics exam.

Coping (SCOPE-30). The Student Coping Scale (SCOPE-30; Struthers et al., 2000), assesses students' thoughts, behaviors, and action strategies (i.e., coping styles)

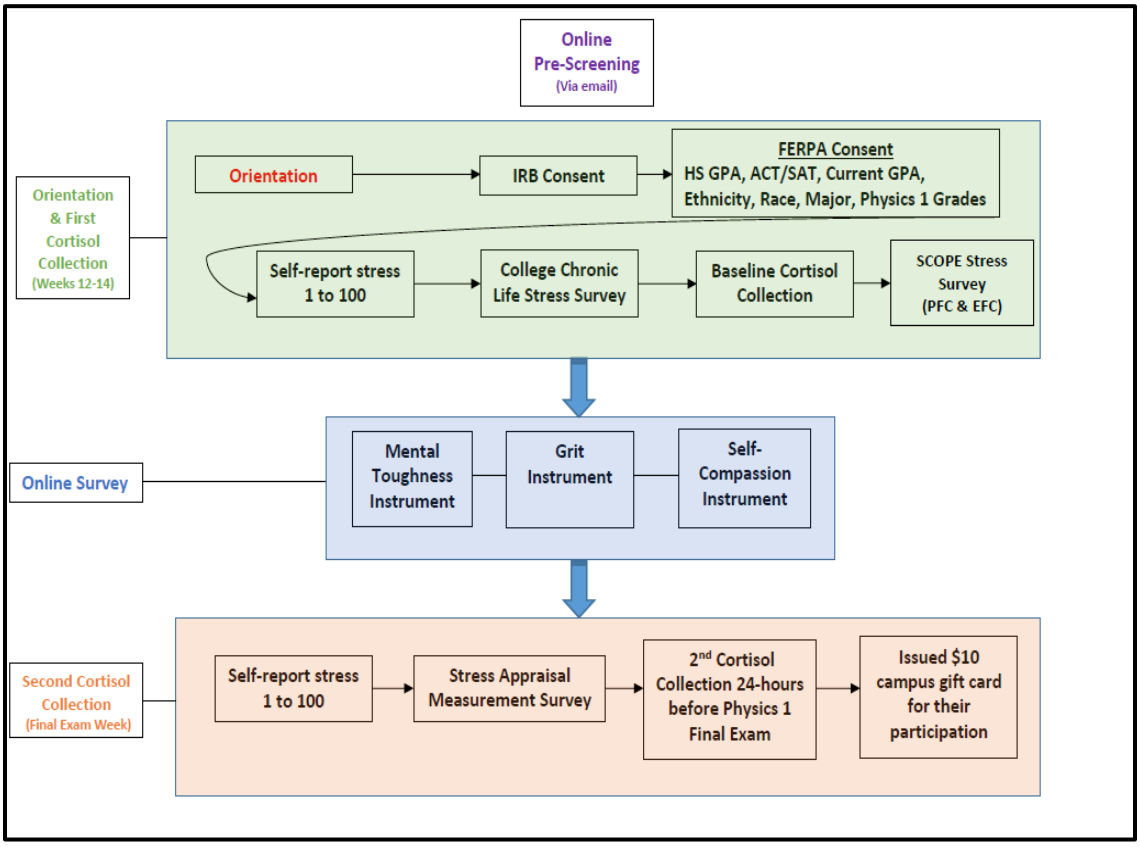
that are associated with poor academic achievements. Students were specifically asked to address how they would react if they performed poorly on their upcoming exam. Answers on the SCOPE-30 are on a 10-point Likert-type scale, it is scored by taking a simple sum of the 30 items. The subscales consist of two independent 15-item dimensions, scores are a simple sum of each subscale, demonstrating adequate reliability (Cronbach's alpha of .70 to .80) and good validity. The subscales (a) problem-focused coping (PFC) and (b) emotion-focused coping (EFC) are not absolute dichotomies; they measure two ends of a continuum. An overall coping scale in Individuals obtain subscale scores on both PFC and EFC; those with larger PFC scores are considered more problem focused. PFC is a stress management strategy aimed at removing or diminishing a stressful event and/or its impact, an example question is *I make a plan of action*. Problem-focused individuals believe that there are solutions available to them to alter their situation. EFC consists of strategies aimed at managing and reducing the distressing emotions associated with a threatening situation, an example question is *I let my feelings out.* Emotion-focused individuals perceive those stressors must be endured. The scales' anchors ranged from (1) *extremely uncharacteristic of me* to (10) *extremely characteristic of me*. This instrument was issued to the participants on the day of their final physics exam.

Procedure

Figure 3 below outlines the protocol utilized for this study.

Figure 3

Visual Plan for Study



During their orientation, students signed a FERPA *Consent-to-Release* form, per the student's consent, this form allowed researchers the ability to access the students' ACT/SAT score, high school GPA, current and final grades in individual courses during the semester, Michigan Tech transcript grades, overall GPA, ethnicity, race and major. These forms were submitted to the registrar's office and the requested information was provided to the researcher. To protect the identity of participants, during each saliva collection participants were issued randomized numbers without any identifying information. Thus, those in the lab analyzing the cortisol levels did not have a way of knowing any of the participant's personal nor identifying information. Additionally,

during cortisol collections no other medical information nor DNA testing was determined, only cortisol levels. All data was treated with strict confidentiality and only approved experimental researchers had access. After the pre-screening process, and based on their responses, selected participants were invited to an orientation meeting regarding the study. Researchers emailed participants to schedule an orientation appointment and participants were notified that the following instructions must be carefully followed on the day of their appointment: Prior to sample collection and in compliance with laboratory instructions, participants were instructed to:

- Avoid alcohol for 12 hours before sample collection
- Do not brush, floss teeth, or have dental work done 30 minutes prior to collecting saliva. Slight bleeding from these may alter test results.
- Do not eat a major meal within 60 minutes of sample collection
- Avoid dairy products for 20 minutes before sample collection
- Avoid foods with high sugar or acidity and high caffeine content immediately before sample collection as it may lower saliva pH and increase bacterial growth.

These instructions were also sent to participants via email the day prior to their orientation appointment.

Orientation. Participants were invited to an orientation meeting to outline the study approach and expectations. Researchers clarified the strict confidentiality policy and addressed any questions or concerns; everyone was notified that they could withdraw from the study at any time without consequences of any kind. Upon completion of orientation, researchers confirmed that the participant would like to be a part of the study

and participants completed and signed an approved IRB consent. Orientation took participants no longer than 15 minutes. After the orientation, participants were invited to immediately begin the study if they were still interested in proceeding. After completing the IRB consent form, participants were asked to confirm that they complied with collection guidelines. Next, participants were asked to rate their current level of stress on a scale of 1-100 (1=*little to no stress* and 100=*extremely high stress*). Researchers collected their baseline cortisol levels via a saliva sample.

Saliva Collection.

Baseline Cortisol Sample Collection Protocol. Participants were given an 8 oz. bottle of water, a 1.0mL cryogenic vial, a randomly generated number label, a segment of a straw, collection instructions, a Ziploc bag, and napkins. With the support of research assistants, they were instructed as follows:

- Rinse mouth with water to remove food residue and swallow to increase hydration
- Wait at least 10 minutes before collecting saliva
- While you are waiting, write the date, time, and the number on the label on the provided Ziploc bag
- Place one end of the straw provided in your mouth and the other end in the provided open vial
- Allow saliva to pool in the mouth. Thinking of your favorite food or looking at some yummy food photos may help

- Utilizing a passive drool method, tilt your head forward and allow the drool to go down the straw into the vial. Continue until ~1 mL has been collected, not counting any foam that has formed
- Close the cap of the vial
- Place the number label on the vial
- Place the vial in the Ziploc bag and carefully seal
- Dispose of the straw and immediately return the Ziploc bag to the researcher present.

Researchers temporarily stored the individual samples (maximum 24 hours) in a refrigerator until all samples were collected that day. Upon collection of daily samples, they were placed in an insulated freezer bag and immediately transported to the research lab for storage. To conclude the meeting each participant completed a final self-reported stress survey, the CCLSS and submitted the form to the researcher prior to their departure.

Within 10 hours of the orientation and baseline collection participants were emailed surveys facilitated via a Survey Monkey link. An outline of the online surveys conducted were as follows:

1. A brief survey regarding biographical background
2. MTQ-18 (18 items)
3. Grit Scale (12-items)
4. Self-Compassion Scale (SCS; 26-item)

All the surveys were combined into one on-line survey. This survey took participants no longer than 20 minutes and they were required to complete the survey prior to the day-of salivary collection.

Day-of Cortisol Sample Collection. All participants who provided their baseline cortisol and completed their online survey were notified via phone or email and scheduled for a second collection time. Participants were reminded of the salivary collection guidelines (passive drool method) as well as sent an email reminder the day before the scheduled collection. Upon arrival, participants repeated the same collection protocol outlined in the baseline sample collection. As in the baseline collection, participants were asked to rate their current level of stress and then submitted their saliva sample using the passive drool method. To conclude the meeting each participant completed two final self-reported stress surveys (a) SAM and (b) SCOPE. Upon completion, the researcher issued each participant a $10 gift card and thanked them for their time prior to their departure.

Results

An overview of all the key variables is presented in Table 1. In addition to central tendency and variability values, the possible range of scores on each instrument is provided. Table 2 provides correlations of all the key variables.

Table 1

Descriptive Statistics of Key Variables

Measures	*M*	*SD*	Min	Max	Range
Age (years)	19.14	1.19	18.00	24.00	
High School GPA	3.80	.29	3.13	4.32	
Overall College GPA	3.17	.49	1.98	3.97	
Final Exam Grade (Percentage)	76.76	14.76	38.00	95.00	0 - 100
Self-Compassion	3.18	.64	2.32	4.76	1 - 5
Self-Kindness	3.10	.80	1.80	4.60	1 - 5
Self-Judgement	3.11	.79	1.20	4.40	1 - 5
Common Humanity	3.44	.87	2.00	5.00	1 - 5
Isolation	2.91	.91	1.00	4.75	1 - 5
Mindfulness	3.50	.78	2.25	5.00	1 - 5
Over-Identification	2.90	.86	1.25	4.00	1 - 5
Mental Toughness	3.25	.48	2.33	4.33	1 - 5
Grit	3.20	.39	2.42	4.08	1 - 5
Perseverance of Effort	3.68	.47	2.50	4.50	1 - 5
Consistency of Interest	2.70	.58	1.67	3.83	1 - 5
SCOPE	146.51	23.68	104.00	198.00	1 - 300
Problem-Focused Coping	81.71	16.97	50.00	120.00	1 - 150
Emotion-Focused Coping	64.80	16.35	35.00	97.00	1 - 150
Stress Appraisal Measure	3.54	.42	2.46	4.71	1 - 5
Threat	2.48	.81	1.00	4.25	1 - 5
Challenge	2.84	.79	1.50	4.50	1 - 5
Centrality	3.47	1.01	1.50	5.00	1 - 5
Controllable-By-Self	3.91	.86	1.75	5.00	1 - 5
Controllable-By-Others	3.82	1.01	2.00	5.00	1 - 5
Uncontrollable-By-Anyone	1.65	.74	1.00	3.50	1 - 5
Overall Perceived Stressfulness	3.04	1.07	1.00	5.00	1 - 5
CCLSS (Chronic Stress)	11.00	5.28	2.00	21.00	0 - 54
Self-Reported Acute Stress (Baseline)	48.66	24.30	4.00	95.00	1 - 100
Self-Reported Acute Stress (Day of Exam)	60.23	24.47	5.00	90.00	1 - 100

Note. N = 35

Table 2

Correlations of Key Variables

Key Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1 High School GPA	1	.550**	0.219	0.176	-0.043	-0.198	-0.001	-0.276	0.042	-0.320	0.293	-0.100	0.172	-0.273	-0.094	-0.009	-0.127	-.350*	0.066	-.391*	-0.171	-0.138	-0.095	0.020	-0.251	-0.239	-0.210	-0.153
2 Overall College GPA	.550**	1	.668**	.497**	0.223	-.397*	0.257	-.578**	.337*	-.488**	.477**	-0.018	0.275	-0.249	0.044	0.274	-0.221	-.408*	-.384*	0.022	-0.323	0.079	0.161	-0.015	-.598**	-.441**	-0.276	-.444**
3 Final Exam Grade (%)	0.219	.668**	1	.352*	0.174	-0.183	0.279	-.439**	0.216	-0.310	.475**	0.093	0.321	-0.143	-0.071	0.279	-.377*	-0.332	-.499**	0.286	-0.232	0.293	0.149	-0.269	-.582**	-.517**	-0.177	-0.275
4 Self-Compassion	0.176	.497**	.352*	1	.795**	-.846**	.797**	-.654**	.839**	-.728**	.828**	0.043	0.295	-0.182	0.114	.408*	-0.258	-0.318	-.515**	0.161	-.485**	0.288	0.314	0.001	-.557**	-.411*	-0.145	-.473**
5 Self-Kindness	-0.043	0.223	0.174	.795**	1	-.671**	.729**	-.352*	.664**	-0.320	.586**	-0.075	0.225	-0.281	0.274	.344*	0.041	-0.028	-.342*	0.178	-0.149	0.242	0.270	-0.001	-0.245	-0.155	0.200	-0.037
6 Self-Judgement	-0.198	-.397*	-0.183	-.846**	-.671**	1	-.547**	.471**	-.691**	.591**	-.654**	-0.113	-0.223	0.031	-0.331	-.391*	-0.074	0.196	0.273	0.015	.368*	-0.151	-0.292	-0.138	.394*	.341*	0.123	.370*
7 Common Humanity	-0.001	0.257	0.279	.797**	.729**	-.547**	1	-.389*	.575**	-.463**	.644**	0.020	0.229	-0.158	-0.012	0.325	-.356*	-0.311	-.522**	0.184	-.396*	0.323	0.201	-0.143	-.455**	-0.244	0.029	-0.227
8 Isolation	-0.276	-.578**	-.439**	-.654**	-.352*	.471**	-.389*	1	-.387*	.381*	-.645**	-0.154	-.384*	0.104	-0.103	-0.322	0.185	0.318	.384*	-0.036	.381*	-0.120	-0.217	-0.028	.453**	.338*	0.159	.334*
9 Mindfulness	0.042	.337*	0.216	.839**	.664**	-.691**	.575**	-.387*	1	-.627**	.621**	-0.092	0.118	-0.218	0.043	0.323	-0.273	-0.217	-.466**	0.245	-.439**	0.290	0.292	0.018	-.449**	-.339*	-0.149	-.517**
10 Over-Identification	-0.320	-.488**	-0.310	-.728**	-0.320	.591**	-.463**	.381*	-.627**	1	-.686**	-0.058	-0.167	0.060	0.181	-0.196	.466**	.379*	.390*	-0.129	.508**	-0.218	-0.199	0.023	.570**	.480**	.454**	.706**
11 Mental Toughness	0.293	.477**	.475**	.828**	.586**	-.654**	.644**	-.645**	.621**	-.686**	1	0.225	.443**	-0.059	0.071	.441**	-.356*	-.359*	-.512**	0.097	-.516**	0.314	.341*	-0.080	-.569**	-.412*	-0.111	-.372*
12 Grit	-0.100	-0.018	0.093	0.043	-0.075	-0.113	0.020	-0.154	-0.092	-0.058	0.225	1	.662**	.797**	.442**	0.333	0.295	0.084	-0.026	0.147	-0.119	-0.028	0.205	-0.009	0.058	-0.136	0.100	0.044
13 Perserverance of Effort	0.172	0.275	0.321	0.295	0.225	-0.223	0.229	-.384*	0.118	-0.167	.443**	.662**	1	0.075	.445**	.496**	0.130	0.112	-0.239	0.307	-0.232	0.259	.360*	-0.070	-0.057	-0.132	0.024	-0.015
14 Consistency of Interest	-0.273	-0.249	-0.143	-0.182	-0.281	0.031	-0.158	0.104	-0.218	0.060	-0.059	.797**	0.075	1	0.229	0.043	0.287	0.022	0.159	-0.051	0.029	-0.247	-0.018	0.044	0.126	-0.073	0.115	0.072
15 SCOPE	-0.094	0.044	-0.071	0.114	0.274	-0.331	-0.012	-0.103	0.043	0.181	0.071	.442**	.445**	0.229	1	.723**	.697**	.514**	0.121	0.239	0.214	0.061	.483**	0.029	0.231	0.176	0.205	0.252
16 Problem-Focused Coping	-0.009	0.274	0.279	.408*	.344*	-.391*	0.325	-0.322	0.323	-0.196	.441**	0.333	.496**	0.043	.723**	1	0.010	0.285	-.358*	.541**	-0.106	.450**	.731**	-0.329	-0.170	-0.097	0.061	-0.086
17 Emotion-Focused Coping	-0.127	-0.221	-.377*	-0.258	0.041	-0.074	-.356*	0.185	-0.273	.466**	-.356*	0.295	0.130	0.287	.697**	0.010	1	.449**	.547**	-0.215	.420*	-.378*	-0.058	.383*	.510**	.356*	0.233	.453**
18 Stress Appraisal Measure	-.350*	-.408*	-0.332	-0.318	-0.028	0.196	-0.311	0.318	-0.217	.379*	-.359*	0.084	0.112	0.022	.514**	0.285	.449**	1	.453**	.487**	.609**	0.156	0.215	0.095	.714**	.427*	0.134	.524**
19 Threat	0.066	-.384*	-.499**	-.515**	-.342*	0.273	-.522**	.384*	-.466**	.390*	-.512**	-0.026	-0.239	0.159	0.121	-.358*	.547**	.453**	1	-.398*	.565**	-.631**	-.513**	.424*	.774**	.366*	0.093	.519**
20 Challenge	-.391*	0.022	0.286	0.161	0.178	0.015	0.184	-0.036	0.245	-0.129	0.097	0.147	0.307	-0.051	0.239	.541**	-0.215	.487**	-.398*	1	0.038	.689**	.546**	-.423*	-0.083	0.021	-0.074	-0.109
21 Centrality	-0.171	-0.323	-0.232	-.485**	-0.149	.368*	-.396*	.381*	-.439**	.508**	-.516**	-0.119	-0.232	0.029	0.214	-0.106	.420*	.609**	.565**	0.038	1	-0.249	-.381*	0.058	.569**	.413*	.358*	.577**
22 Controllable-By-Self	-0.138	0.079	0.293	0.288	0.242	-0.151	0.323	-0.120	0.290	-0.218	0.314	-0.028	0.259	-0.247	0.061	.450**	-.378*	0.156	-.631**	.689**	-0.249	1	.651**	-.626**	-.402*	-0.002	-0.150	-0.170
23 Controllable-By-Others	-0.095	0.161	0.149	0.314	0.270	-0.292	0.201	-0.217	0.292	-0.199	.341*	0.205	.360*	-0.018	.483**	.731**	-0.058	0.215	-.513**	.546**	-.381*	.651**	1	-.422*	-0.314	-0.127	-0.183	-0.173
24 Uncontrollable-By-Anyone	0.020	-0.015	-0.269	0.001	-0.001	-0.138	-0.143	-0.028	0.018	0.023	-0.080	-0.009	-0.070	0.044	0.029	-0.329	.383*	0.095	.424*	-.423*	0.058	-.626**	-.422*	1	.368*	-0.062	-0.043	0.055
25 Overall Perceived	-0.251	-.598**	-.582**	-.557**	-0.245	.394*	-.455**	.453**	-.449**	.570**	-.569**	0.058	-0.057	0.126	0.231	-0.170	.510**	.714**	.774**	-0.083	.569**	-.402*	-0.314	.368*	1	.499**	0.290	.653**
26 CCLSS (Chronic Stress)	-0.239	-.441**	-.517**	-.411*	-0.155	.341*	-0.244	.338*	-.339*	.480**	-.412*	-0.136	-0.132	-0.073	0.176	-0.097	.356*	.427*	.366*	0.021	.413*	-0.002	-0.127	-0.062	.499**	1	.461**	.592**
27 Self-Reported Acute Stress	-0.210	-0.276	-0.177	-0.145	0.200	0.123	0.029	0.159	-0.149	.454**	-0.111	0.100	0.024	0.115	0.205	0.061	0.233	0.134	0.093	-0.074	.358*	-0.150	-0.183	-0.043	0.290	.461**	1	.695**
28 Self-Reported Acute Stress	-0.153	-.444**	-0.275	-.473**	-0.037	.370*	-0.227	.334*	-.517**	.706**	-.372*	0.044	-0.015	0.072	0.252	-0.086	.453**	.524**	.519**	-0.109	.577**	-0.170	-0.173	0.055	.653**	.592**	.695**	1

Note. N = 35. Negative Correlations Positive Coorelations

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Relationship Between Stress Measurements

I hypothesized that a positive correlation would exist between cortisol levels and self-reported stress as recorded on both baseline and day-of collections. However, cortisol levels as returned from the lab were hugely variable – outside of normal level measurements. The assay results from my salivary samples resulted in a range of cortisol levels from 0 pg/mL to 10815 pg/mL with a standard deviation of approximately 3500 pg/mL (see Figure 4), whereas baseline cortisol ranged from a low of approximately 6000pg/mL to a high of approximately 14000 pg/mL, with the standard deviations of approximately 2100 pg/mL. In fact, 54 of the 70 cortisol samples (26 participants) fell below 6000 pg/mL (which was the lowest cortisol level in the baseline data collection). In addition, 4 samples returned a value of 0 pg/mL. After consultation with the laboratory that processed the saliva kits, it was determined that my results were not valid. Specifically, the last 25 participants as shown in Figure 4 on the right side of the horizontal axis cortisol data are out of normal range. Therefore, I was unable to reliably analyze the cortisol data and test any hypotheses related to the cortisol results. I was not able to specifically determine the root-cause, but suspect that one or all the factors below were impacts:

- Discrepancies in the cortisol assays obtained from the manufacturer
- The assay kits were from different lots.
- Improper collection or storage of the samples.
- Unexplained variability in a significant proportion of the salivary samples.

- Potential food, blood or other sputum contaminated some of the samples causing interference with the molecular tests (American Society of Microbiology, 2020).

These were not issues detected when I conducted the confirmatory pilot study. I did consider multiple alternatives to try to correct these discrepancies, but my research was halted because of the COVID-19 pandemic limitations in the lab and at the university, preventing me from constructing an alternative and safe collection process. Therefore, none of the cortisol hypotheses were pursued in this study.

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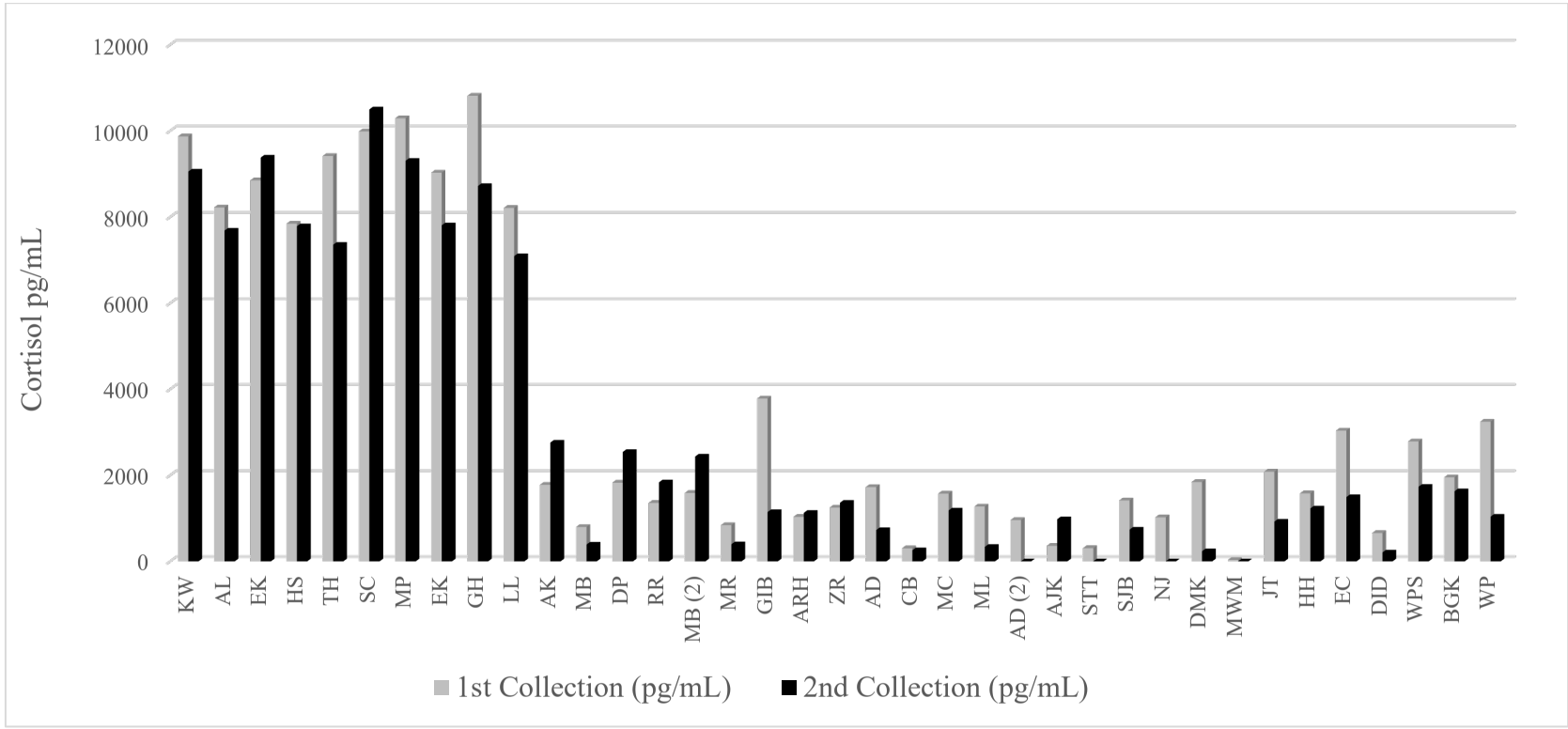
Figure 4

Physics I Students' Baseline and Day-Of Salivary Sample Results (By Participant)



Note. N = 35.

I hypothesized that cortisol levels and self-reported acute stress would be elevated prior to the Physics I final exam as compared to cortisol levels during baseline measurements. Although unable to test cortisol levels, a paired-sample t-test revealed significant differences in self-reported stress levels between baseline and final exam measurements. Day of exam self-reported stress (M = 60.23, SD = 24.47) was significantly higher than baseline self-reported stress (M = 48.66, SD = 24.30), $t(34) = -3.592$, p =.001. A medium effect size (Cohen, 1988) was noted, d = 0.47, indicative of a medium degree of impact of the final exam on self-reported stress levels. In addition, there was a significant positive correlation between baseline and day-of stress reports (r = .695, p< .000).

I also hypothesized that chronic stress (CCLSS) levels would not correlate with self-reported acute stress or cortisol levels on the day of the Physics I exam but would positively correlate with these measures during the baseline collection. This hypothesis was tested using Pearson r correlation coefficients. Inconsistent with my hypothesis that chronic stress would not correlate with the acute stress on exam day, there was a significant positive correlation (r = .592, p < .000). Consistent with the second hypothesis, baseline self-reported stress and chronic stress were also significantly positively correlated (r = .461, p = .005). The scatter plot for CCLSS and baseline self-reported stress are shown in Figure 5, while Figure 6 contains the scatter plot for CCLSS and day of acute academic stress, providing a visual representation of the results.

Figure 5

CCLSS and Baseline Self-Reported Stress Scatterplot

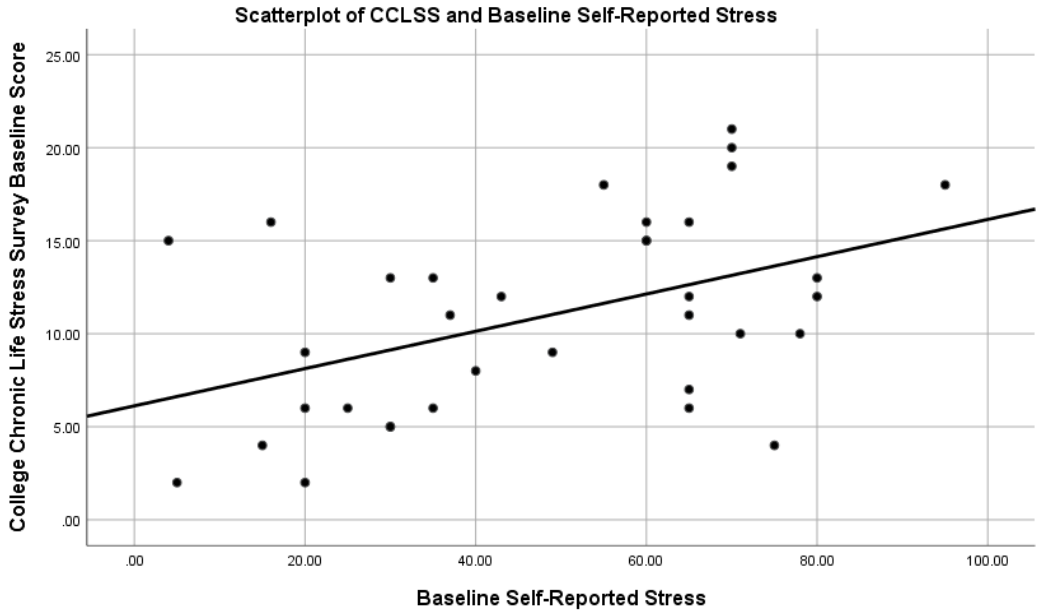
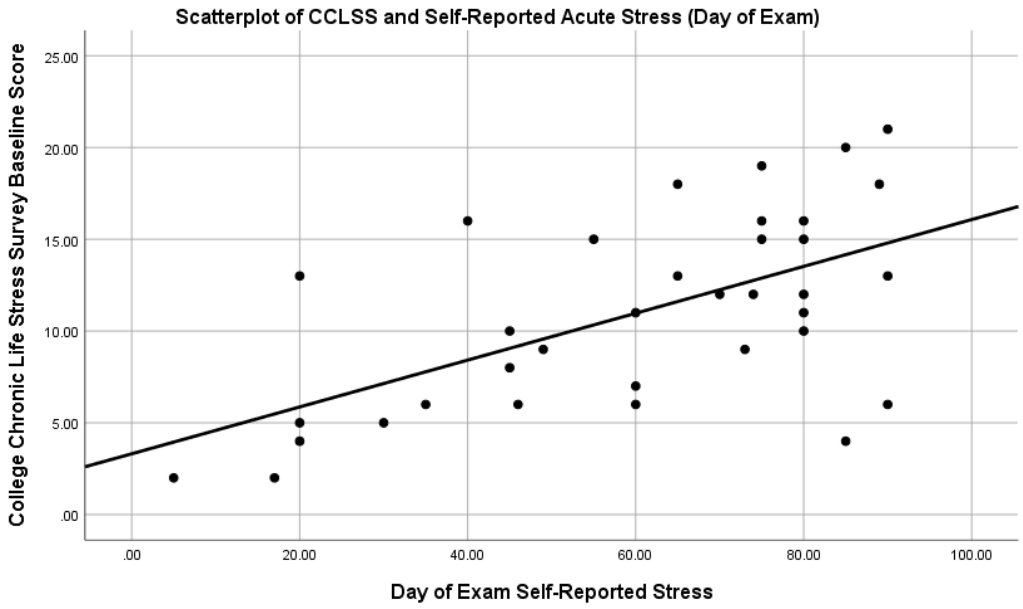


Figure 6

CCLSS and Day-Of Acute Academic Stress



Role of Self-Compassion

I hypothesized that self-compassion would negatively correlate with self-reported stress and cortisol levels on the day of the Physics I exam and positively correlate with final exam scores. These hypotheses were tested using Pearson r correlation coefficients. Consistent with my first hypothesis, self-compassion negatively correlated with self-reported stress on the day of the physics exam (r = -.473, p = .004). Consistent with my second hypothesis, self-compassion positively correlated with final exam scores (r = .352, p =.041). Significant correlations between self-compassion subscales, self-reported day-of acute stress and final exam scores are presented in Table 3.

Table 3

Descriptive Statistics and Correlations for Self-Compassion Subscales

Variable	*n*	*M*	*SD*	1	2
1. Self-Kindness	35	3.09	0.80	—	—
2. Self-Judgement	35	3.11	0.79	.37*	—
3. Common Humanity	35	3.44	0.87	—	—
4. Isolation	35	2.91	0.91	.33*	−.44**
5. Mindfulness	35	3.49	0.78	−.52**	—
6. Over-Identification	35	2.91	0.86	.71**	—

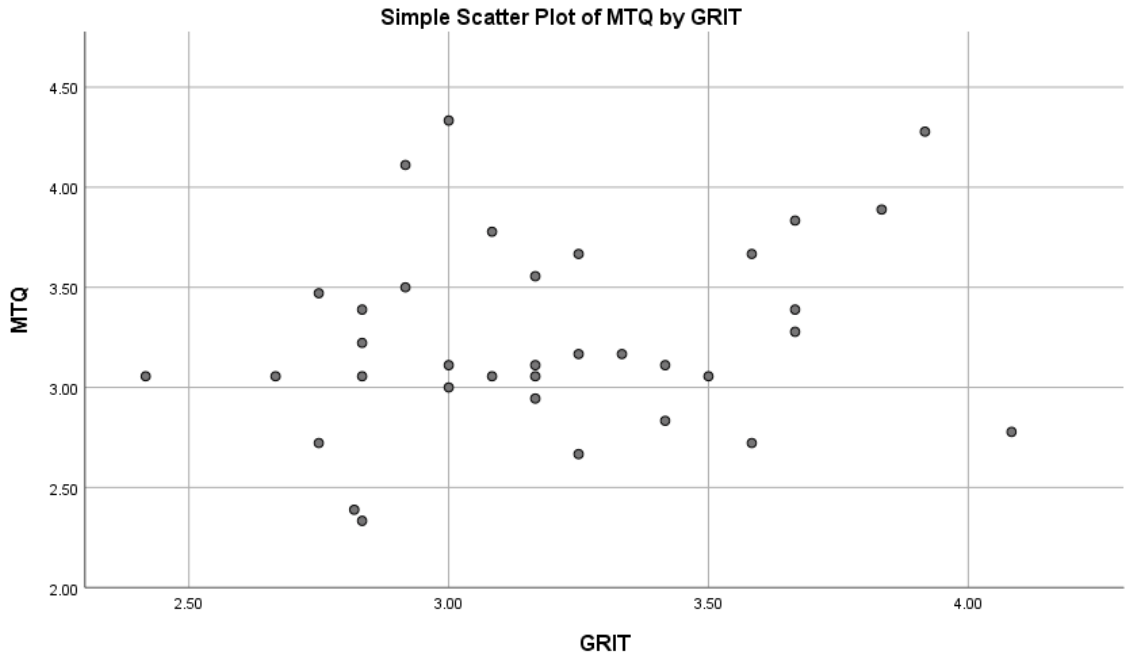
Note. 1 = Self-Reported Acute Stress on Day of Exam and 2 = Final Exam Score

*p < .05. **p < .01.

Role of Grit and Mental ToughnessI hypothesized there would be a low or non-significant correlation between mental toughness and grit. Consistent with my hypothesis, the relationship was weak in strength and not statistically significant. (r = .225, p = .194). Figure 7 offers a simple scatter plot as a visual representation of the results.

Figure 7

Simple Scatter Plot of Mental Toughness by Grit



Note. N = 13

I also performed multiple regressions with MT and grit as independent variables (stress and academic performance as dependent variables) to aid in the question of whether there is redundancy or uniqueness between MT and grit as suggested by January (2016), Scharneck, (2017), and Price (2019). Results show a model trending toward significance, $F(2, 32) = 2.954$, $p = .067$, in which 15.6% of the variance in self-reported stress can be accounted for by the regression equation ($R^2 = .156$). Mental Toughness was a significant negative predictor of stress ($B = -20.416$, $p = .022$, but grit was not ($B = 8.493$, $p = .424$). Furthermore, a significant regression equation, $F(2, 31) = 4.509$, $p = .019$, shows that 22.5% of the variance in final exam score can be accounted for by the regression equation ($R^2 = .225$). Consistent with the previous model, mental toughness was a significant positive predictor of final exam scores ($B = 15.121$, $p = .006$) and grit was not a significant predictor ($B = .231$, $p = .970$). To test the notion that grit is directed toward more long-term goals, regression equations predicting both high school and college GPAs resulted in no statistically significant models. In sum, findings suggest that grit does not provide any predictive power (or does not provide unique predictive power) for self-reported stress and exam scores.

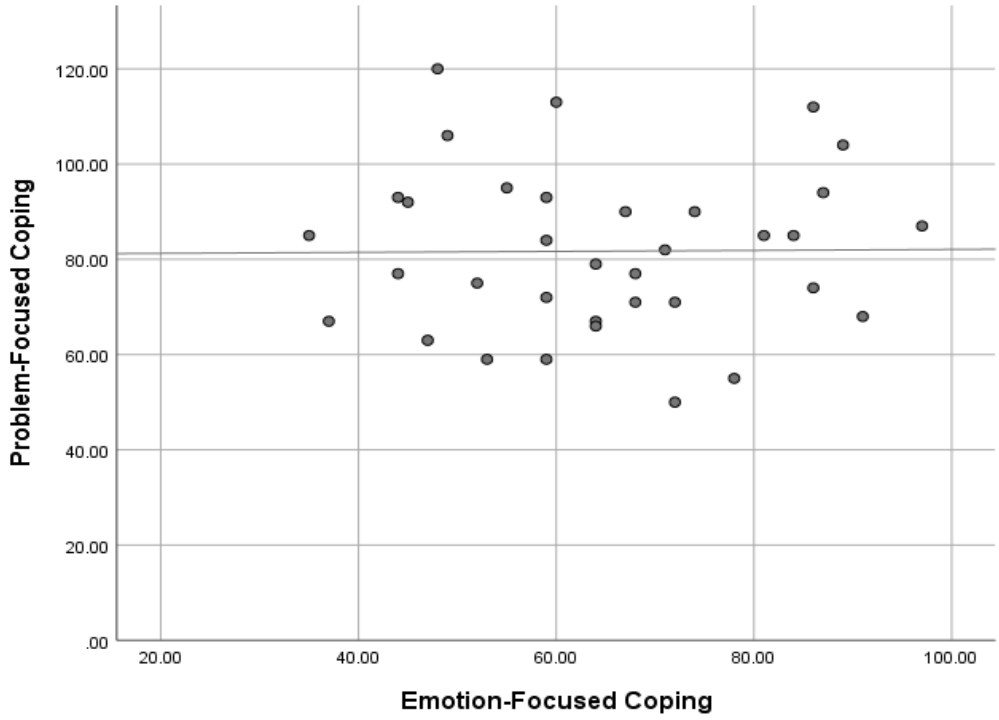
To further understand the value of grit, if any, in educational endeavors, I conducted two multiple regressions using grit and MT as independent variables, with emotion-focused coping and problem focused coping as the dependent variables. I hypothesized that grit would positively predict emotion-focused coping (one feels they can't solve the immediate problem, they revert to their longer-term goals and would try to mediate their emotional reaction to the more immediate/uncontrollable problem), while

MT would positively predict problem-focused coping (one's focus is on the immediate stressor). A significant model ($F(2,32) = 6.058$, $p = .006$) resulted in which grit was a positive predictor ($p = .016$, $B = 16.591$) and mental toughness was a negative predictor ($p = .007$, $B = -15.056$) of emotion-focused coping. A significant model ($F(2,32) = 5.397$, $p = .010$) resulted in which only mental toughness was a positive predictor ($p = .020$, $B = 13.560$) of problem-focused coping.

Role of Coping StrategiesMost participants (82.4%) had higher PFC scores as compared to those who had higher EFC scores (17.6%; see Figure 8). Pearson r correlation coefficients were used to test the hypotheses regarding problem-focused and emotion-focused coping. I did not find support for my hypotheses that PFC ($r = .279$, $p = .110$) would correlate positively with exam score and negatively with self-reported stress ($r = -.275$, $p = .116$); no significant correlations existed with final exam score or day-of self-reported acute stress. I did, however, find support for my hypotheses that EFC would correlate negatively with exam scores and positively with self-reported acute stress on the day-of the Physics I exam. EFC was significantly negatively correlated with final exam scores ($r = -.377$, $p = .028$) and significantly positively correlated with day-of acute reported stress levels ($r = .453$, $p = .006$).

Figure 8

Physics I Students Coping Strategies



Predicting Exam PerformanceA multiple regression was calculated to predict final exam percent score based on all the descriptive statistical variables. A significant overall regression equation was found $F(5, 28) = 12.110$, $p < .000$, with an R^2 of .684. See Table 4 for significant predictors of final exam percent score.

Table 4

Summary of Multiple Regression Analysis for Variables Predicting Final Exam Performance

Variable	*B*	*SE B*	β	*t*	*p*
Self-Reported Acute Stress (Day of Exam)	.248	.092	.411	2.689	.012
CCLSS (Chronic Stress)	-1.090	.399	-.378	-2.733	.011
Stress Appraisal Measure (Challenge Subscale)	5.767	2.034	.307	2.836	.008
Stress Appraisal Measure (Overall Perceived Stressfulness Subscale)	-4.839	2.182	-.357	-2.218	.035
Overall College GPA	13.532	4.017	.458	3.369	.002

Note. $N = 35$.

Discussion

The intention of this study was to analyze performance measures of Physics I students during their final exam to obtain a deeper understanding of how students persist during academically stressful times by utilizing psychological constructs. The *Cognitive Appraisal Theory* provided a theoretical framework to understanding the conscious or unconscious cognitive steps a student can take when confronted by emotions associated with the challenge or difficulty.

First, I wanted to confirm that stress was detectable through cortisol and would significantly correlate with self-reported stress measures. Cortisol results for 25 out of 25 participants in this study were not usable due to discrepancies in the assay process. However, looking at the 10 cortisol results that appeared to be valid, the effects of the final exam appear to be negligible on the final exam. Although I couldn't utilize cortisol to confirm stress hormones, I was able to conclude that there were significant differences between baseline and day-of stress utilizing a self-reported acute stress measure. Also, the SAM subscale of stressfulness further confirmed a correlation with stress levels on the day of the exam ($r = .653$, $p < .000$). Consistent with my literature review, self-reported stress is a reliable measure of stress.

I was also able to gain a better understanding of the distinctions between chronic and acute stressors, and how they help or hinder a student's ability to persist and perform during exams, and throughout their college experience. Based on literature from the Marković et al. (2011) study, I hypothesized that chronic stress would not correlate with self-reported acute stress on exam day, however a significant positive correlation was

found. One explanation is that I didn't consider that multiple acute stressors were happening during finals week. In other words, the Physics I exam was not the only short-term stressor as students were completing other exams, final projects, job searching, and making summer plans. Therefore, multiple acute stressors happening simultaneously may have a stronger correlation with chronic stress. Another possible explanation of the positive correlation is that chronic and acute stress are cumulative, such that those with more chronic stress will also tend to report higher exam day stress because their "baseline" comparison level is already high. This notion of stress accumulating is also supported by the regression analysis, with self-reported stress, chronic stress, and the overall perceived stress as measured by SAM all contributing significantly to the prediction of final exam scores. To ensure that multicollinearity was not artificially inflating my findings, both the Variance Inflation Factor (VIF) and Tolerance statistics were examined. VIFs were all substantially lower than 10, and Tolerance statistics were within acceptable ranges (not substantially greater than 1). Alternatively, the correlations between variables were moderate, which suggests that multicollinearity may be present. An inspection of eigenvalues also revealed no multicollinearity problems.

An alarming aspect of this interpretation is the danger of students remaining in a cyclical state of chronic stress which could lead to underlying health conditions such as high blood pressure and mental health challenges. Therefore, it is important to acknowledge the impact of chronic and multiple acute stressors that our students experience. Based on the CCLSS scale, students in this study reported an average level (11 stressors) of chronic stressors in the weeks leading-up to final exams (during the

baseline collection period; weeks 12-14 of the 15-week semester). Incorporating de-stressing activities, especially leading up to final exams and final presentations is recommended. For example, instructors could offer extra credit for students who attend mindfulness, physical activities, and other stress relievers throughout the semester. Another recommendation is to require students to report-out stress mitigating strategies that they leveraged leading up to presentations such as senior design, oral defense, etc. These recommendations can incentivize students while institutionalizing a culture of utilizing stress management techniques. Another potential solution for stress management could lie within the self-compassion arena, which is discussed next.

Self-compassion (SC) was positively correlated with final exam scores and negatively correlated with self-reported stress on the day of the final exam. This finding is consistent with the notion that SC can mitigate stress, thereby enhancing performance. While SC did not contribute to the regression model, it may be that its variance was accounted for by one of the significant predictors. Given the relative ease of teaching SC skills, it may provide an alternative route through which to arm students against the impacts of stress. The self-compassion subscales provided me with a better understanding of the adverse and mitigating factors of stress and final exam performance. The moderately positive and statistically significant relationship between self-judgement and isolation with exam day stress shows that students with increased levels of reported stress were less gentle with themselves and experienced feelings of isolation. Additionally, the strong negative and statistically significant relationship between isolation and final exam score shows that feelings of isolation are predominate among those that perform poorly

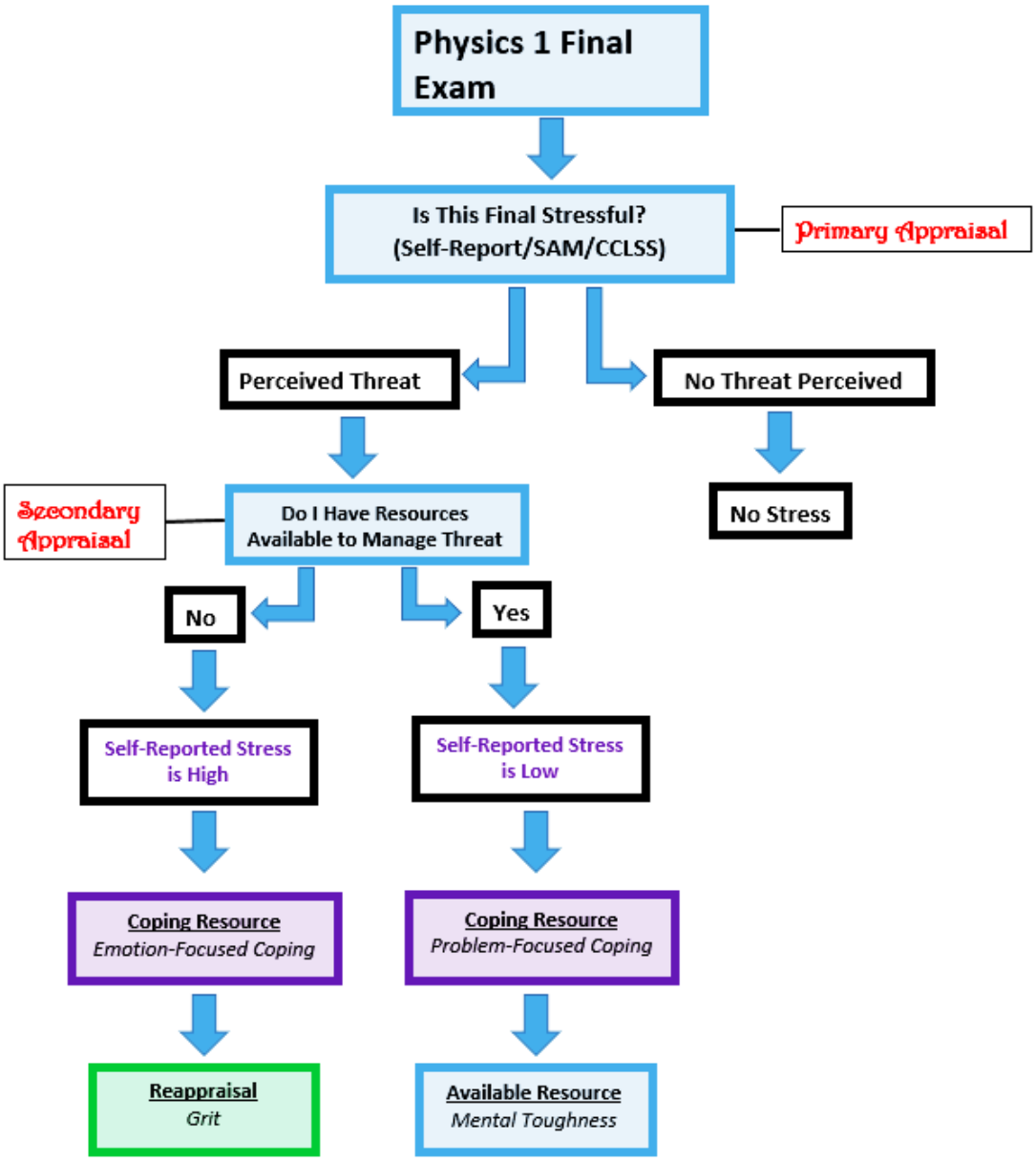
on the exam. Students who suppressed or exaggerated (over-identification) their negative emotions had a strong positive and statistically significant tendency to report increased stress levels. Finally, in confirmation with previous literature, mindfulness techniques, found to be negatively related to stress, likely offer a mitigating effect on stress, thereby resulting in higher performance levels. In sum, individuals who can (a) seek support (academic and personal), (b) build community, (c) understand that imperfections and failures are inevitable, and (d) remain in the present moment while being accepting of what they are experiencing may, in fact, have more favorable stress and performance outcomes.

The analysis of grit and mental toughness was performed to gain further understanding of the potential redundancy between the two measures, as well as to understand their unique contributions to exam performance and relationships with other variables of interest. Regarding the potential redundancy between grit and mental toughness, the current study found no evidence of such a relationship. A small, non-significant correlation existed between grit and MT (r = .225). Additionally, regression analysis utilizing grit and MT as independent variables, and exam score as the dependent variable, resulted in a model in which only MT was a significant predictor or exam performance. While at face value this could be cause to question variable redundancy (i.e., they both predict the same variance in exam score, or no unique variance is predicted with grit), an examination of collinearity statistics such as LIV (1.035), tolerance statistics (0.966), and eigenvalue table analysis suggests that collinearity is likely not an issue, and that grit appeared to overlap most with the regression equation

constant (suggesting it just doesn't offer much, if anything, in the way of predicting exam performance). It is possible that no detectable differences were found because grit is more appropriately measurable when analyzing an individual's long-term goals such as career and family/life goals. Evidence from my regression models predicting EFC and PFC provide support for this notion of grit being more important for long-term goals, grit positively predicted EFC while MT negatively predicted EFC. This finding aligns well with the *Cognitive Appraisal Theory* (CAT), such that during secondary appraisal students responded with emotion-focused coping when they determined that they didn't have the resources to solve the immediate (acute) threat (Physics I Exam). They therefore leveraged positive reappraisal of the present threat utilizing grit and focused on their long-term goals. Alternatively, those who deemed that they had the necessary resources during the secondary appraisal, responded with problem-focused coping and cognitively leveraged mental toughness to manage stress and exam performance. Figure 9 contains a proposed model of CAT, applying this new understanding of how grit, MT, and coping styles were utilized by Physics I students to cognitively manage their final exam. This model is a generalization that largely supported my findings and are ecologically valid. To further confirm the cognitive process of Physics I students, a larger sample size would provide more power and combat uncertainty.

Figure 9

Proposed Cognitive Process of Physics I Students



Note. Adapted Model of Lazarus' (1984) *Cognitive Appraisal Theory*

With these points in mind as well as conclusions based on my results which found that there was not a significant correlation between mental toughness and grit leads me to conclude that they are two distinct constructs. I am cautious in making this conclusion as I understand that a non-significant contributor to regression could simply indicate that the variable does not provide any unique knowledge above and beyond what mental toughness is providing. I am mindful of the ongoing debate between grit and mental toughness that I addressed in the literature review, especially the results reported by Price (2019) regarding a deeper understanding of MT and grit subscales. However, during the literature review I discussed Satterwhite's (2016) results that MT could potentially alter one's perception of stress and result in an adaptive use of their high cortisol levels. My results found that MT was significantly negatively correlated the stress and significantly positively correlated with final exam scores. Confirming Satterwhite's (2016) results of the adaptive utilization of mental toughness during an acute difficulty.

The SCOPE instrument aided in understanding characteristics of my institution's students. Leveraging their secondary appraisal techniques may influence the effectiveness of coping styles during stressful situations and buffer stress and academic performance. Institutionalizing training (i.e., a first-year success program) to develop and/or strengthen PFC and EFC can be especially beneficial for students who are facing new and/or challenging academic experiences. Most of the participants in this study were problem-focused copers, this is important to understand as it provided insight to their secondary appraisal approach when stressed. Knowing this in advance, can aid faculty and support services professional to reinforce students' innate coping tendencies. In other words,

offering students with a PFC tendency emotional support may not be the most effective way to aid them in navigating through a challenging time. They may prefer solutions to their problems instead. Additionally, those who most identify as PFC have characteristics of pre-emptive strategies of academic success such as active coping, academic planning, and efficacy. One additional point of clarity, although EFC was significantly positively correlated with day of exam stress and negatively correlated with final exam scores it is still considered an effective secondary appraisal coping approach according to Struthers et al. (2000). I simply did not find it to be so in the context of this study.

Finally, I conducted an exploratory analysis to determine specific psychological constructs that could predict Physics I final exam grade. In terms of the overall model, I am aware that other variables may be predictive of academic achievement, and simply does not add any new predictability to the model. My exploratory model showed that 62.7.3% of the variance in final grade score can be accounted for by five predictors. Current GPA being the only historically utilized predictor by universities was a significant positively correlated predictor. However, I am excited to see that other psychological constructs can be explored in the future. The models reiterated the critical need to support students in managing their stress levels as self-reported stress, SAM overall stressfulness and chronic stress were contributing predictors of the model. The SAM challenge subscale provides an interesting insight to explore in the future. It is considered a primary appraisal measurement which aids individuals in reframing a stressful or difficult situation as an opportunity to grow from the experience. It was a significant positively correlated predictor with final exam score. This subscale lends itself

to Dweck's (1975) growth mindset and the student's confident belief in their ability. Moreover, as mentioned in the literature review, Wing and Lee's (2017) research confirmed the importance of a student's perception of a challenge as a valuable predictor or success. In other words, strategies such as mindfulness and re-framing problems are effective approaches for students to develop and apply throughout their college career.

Limitations

Limitations of this study include my inability to reliably analyze the cortisol results. Although I saw a trend in 10 of the assay results, it was not in the direction expected. One justifiable explanation could be the timing of the baseline salivary collected. It is possible that the students were already experiencing anticipatory stress in weeks 12-14. For future studies I recommend multiple salivary and self-reported collections throughout the semester (starting in week 1) to have a more accurate understanding of physiological stress and stress appraisal trends. Despite the absence of cortisol in this study, several studies confirm that self-reported perceived stress correlates with cortisol levels (Pruessner et al., 1999; Walvekar et al., 2015; West et al., 2004), therefore I anticipate seeing similar results in corresponding cortisol data. I encourage colleagues who are interested in the impact of stress in an academic setting to explore cortisol collections as a confirmatory measure. Also, statistical power was a limitation of this study. Having a small sample size hindered my capabilities for extensive data analysis.

Recommendations

Future directions include having a broader range of participants from a wider variety of majors, educational institutions, ethnicities, and cultural backgrounds. Also, I was surprised that problem-focused coping did not correlate with stress or exam scores. I suspect that individuals who are problem-focused have efficient strategies to perform academically and/or when faced with difficult situations. This aspect of the study needs more exploration. Additionally, I recommend conducting a baseline and day-of assessment of grit to further explore this construct. It could provide more clarification of its uniqueness and whether it can be utilized during acutely stressful situations. Finally, I recommend utilizing an alternative mental toughness instrument in the future. The MTQ-48 or MTQ-74 instruments will provide subscale scoring as that would aid researchers in a deeper understanding of subscale which are predictors of academic performance. These strategies will help universities have more accuracy in developing and training students in customized psychological constructs. Nonetheless, my research provided a reasonable explanation of the differences between the mental toughness and grit constructs. Students with the tendency to problem-focused cope effectively leveraged mental toughness as an available resource when they perceived the exam as a threat. Alternatively, students with the tendency to emotion-focused cope did not have the immediate resource to mitigate exam stress shifted to their long-term goals and leveraged grit to cognitively manage elevated stress levels. These results might stimulate new insights into the interplay between mental toughness, grit, and stress in academia.

While my study provided several contributions to previous research related to a contextual understanding of physiological stress responses in academic environments, I encourage further collaboration between researchers to elucidate links between stress, coping style, perceived control, grit, and MT in academic performance settings as these findings can potentially aid in the way we approach college admissions and retention efforts. Additionally, an examination of institutional environmental factors and support systems are worth exploring in an effort to retain college students during stressful times throughout their matriculation. The Physics I *Cognitive Appraisal Theory* model worked very well in understanding a student's cognitive approach during an academic stressor. Specifically, Figure 9 provides a visual representation of how my variables of interest fit into the theory and could be helpful in a more holistic understanding of the many factors (outside of ACT/SAT exam and GPA) involved in academic success.

The passion behind this research is to bring awareness to the imminent change in make-up of the U.S. demographics in the coming decades. These changes require shifts in how we recruit, retain, and support students in their academic success, especially at historically PWI's (Predominantly White Institutions). Attention to psychological constructs and ability to succeed academically should be a consideration in the admissions process. By understanding one's mental toughness, the way they cope, their perceptions of stressful situations, grit, and self-compassion we can arm educators with necessary information in the development and ultimate success of students.

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