UC SANTA BARBARA
Undergraduate Research
& Creative Activities

“Effects of Stress on Cognition and Performance (ESCAPE)”

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Abstract

The purpose of this study is to gauge the effects of perceived general stress levels and acute stress on working-memory-based cognitive performance. Cortisol is the long-term stress hormone of the body, and is vital to enacting a quick and efficient stress response. However, when chronically present at higher-than-normal levels—as often can be the case with long-term perceived stress—cortisol has been known to negatively affect many bodily systems, including reproductive, immune, and cognitive function. Our study seeks to explore the effect that higher-than-average perceived general stress levels have on female students' performance on two cognitive tasks: a math exam with gradually increasing difficulty, and a complicated traceable maze that participants must solve after being shown the answer key for a few seconds beforehand. This study will utilize a basic health questionnaire, a general stress questionnaire, a mental math exam that gradually increases in difficulty and has a time limit (thus creating increased stress with urgency to complete), and a traceable maze test that is intended to test working memory. This study has far-reaching implications in understanding the relationship between ambient stress, general stress and cognitive performance, and could pave the way for improvements in mental health resources, accessibility to these mental health resources in higher education, and women's health in general.

Introduction

The stress response is one of the most valuable mechanisms human beings have. Finely tuned to any possible threat, it is incredibly sensitive and has both short-term and long-term functions. In the short term, the stress response is governed by the hormones norepinephrine and epinephrine, which dilate peripheral blood vessels, inhibit digestive function, and increase heart rate. They serve to "turn off" any functions that are not necessary for escaping the danger at hand. During more long-term stress, the steroid hormone cortisol is released to activate glucose release and turn off even more energy-wasting bodily functions. It is important to note that these stress responses evolved to combat evolutionary stressors, such as escaping a predator or seeking out food.

In today's industrial world, fast-paced, high-stress work and school environments have become synonymous with success and modernity. Unfortunately, our stress responses are not evolved to handle such long-term, chronically stressful situations, and chronic stress is doing far more harm than good. High levels of cortisol for long periods of time can completely impede some of the body's most important functions, and this can result in serious issues like anxiety, depression, memory and concentration problems, infertility, and gastritis. Specifically, in college students, high perceived stress levels have been observed, usually occurring during stereotypically stressful times such as midterms and finals (Lee & Jang, 2015). Additionally, further studies have shown that long-term high perceived stress levels are directly related to "high cortisol levels, which have been documented to have a negative effect on neurocognitive functioning and general mental wellness" (Suor et al., 2015).

Higher education is notoriously expensive, and financial constraints can be a huge source of stress for undergraduates. Additionally, stress associated with leaving home and making the necessary adjustments to excel within the rigorous demands of university can also take a huge toll on students. These aforementioned sources of chronic stress are a large part of the reason that American college students consistently report a much higher level of stress than students from most other countries (Misra & Castillo, 2004).

Unfortunately, there is not much data on the effects of general stressors on the academic prowess of college students, as most research focuses on the effects of intense academic demand on college performance. Although cortisol has been linked to decreased memory and cognitive function, few connections have been drawn regarding the effects of chronic perceived stress on

academic performance. For our study, we felt that approaching the issue with a broader perspective would be more useful: do higher *perceived* stress levels negatively affect higher cognitive function? We felt that this was a useful approach because a marked flaw in many of these studies was that they measured perceived stress only before and after a exam, which failed to take into account other types of stressors, or the fact that some students' sources of stress might have chiefly been their preparation for the exam. Preparation for the exam introduced a confounding variable, and thus it is difficult to pinpoint if the stress is what caused the students to score poorly, or if the stress was simply a result of the students knowing they were going to score poorly. Our study hoped to eliminate this variable by having students take a general stress questionnaire that gauges interpersonal, academic, financial, and health-related stress. We also chose to focus on a primarily female population, as ambient stressors have been shown to affect women very differently, and women often face a variety of specific stressors related to interpersonal relationships and violence (*Gender and Stress,* 2018; Joo, Durband, & Grabble, 2018).

Additionally, we had participants take a timed, 32-question multiplication test, as well as a working-memory maze test, which eliminated the "preparation" aspect. We also introduced a potential reward of 12 dollars as a stressor, in which students could lose money from this reward based on their accuracy and speed. We predicted that we would observe a positive correlation between the total amount of stress participants reported and the amount of time they took to complete the tasks, the amount of money they lost, and the number of questions they answered incorrectly.

Methods

We chose a participant population of 30 female undergraduates from the University of California, Santa Barbara (30 female, ages 18-24, M=19.41, SD=1.01). Participants completed a pre-test stress questionnaire, created by the researchers (see *Figure 1*), where they were asked to rate their General (overall stress), Interpersonal (roommates, intimate partners, friendships, classmates, professors), Financial (student loans, rent, food insecurity, school expenses), Academic (grades, degree choice, degree progress, schoolwork, falling behind), Familial (family issues, siblings, extended family, foster care), and Personal (mental health, body image, adjusting to college, fulfillment) stress levels on a Likert scale ranging from 1 ("Not Stressed") to 5 ("Extremely Stressed"). Participants were instructed that "Extremely Stressed" meant that they

spent time on a daily basis worrying about this stressor, and that it affected their day-to-day functionality. They were also instructed that "Not Stressed" meant that they never thought about the given stressor. They were then asked to complete a 32-item math test (see *Figure 2*), which tested single-digit and double-digit multiplication. Participants were instructed to attempt to finish in 2 minutes, but that that the task would cut off at 3 minutes (180 seconds). The following consequences were outlined to the participant:

- For every incorrect question, subjects were told they would lose 1 dollar from a starting point of 12 dollars.
- For every 10 seconds over 2 minutes subjects took to complete the task, the would lose 75 cents.

Next, subjects were asked to complete a maze intended to test working memory (see *Figure 3*). Researchers showed participants the answer key to a medium-difficulty maze for 5 seconds. The participants were then asked to reproduce the answer on an unsolved maze. Subjects were told that they should attempt to finish in 1 minute, but that the task would cut off at 2 minutes. The following consequence was outlined to the participant:

- For every 10 seconds subjects took to complete the task over the allotted 1 minute, they would lose 50 cents off the amount they had left over from the math test.

When processing data, the total amount of stress was added up via three categories: General, Financial, Academic, and Interpersonal (included familial, interpersonal, and personal). For data coding purposes, "Extremely Stressed" was given a 5, "Not Stressed" was given a 1, and so on. This was summed, and participants were given 4 scores.

Results

To examine the association between types of stressors and executive functioning, we conducted a bivariate linear regression analysis predicting the number of math mistakes and time to complete the task from different stressors. Results revealed a significant association between financial stress and the number of math mistakes ($t(30) = 4.28$, $p < 0.001$, one-tailed). All other stressors were not significantly related to math mistakes (see *Table 2*), nor were any stressors significantly related to performance on the working memory task (see *Table 3*). In addition, results revealed a significant association between financial stress and the amount of time taken to complete the cognitive task ($t(30) = 0.31$, $p = .042$, one-tailed).

Participants with higher levels of financial stress tended to make more math mistakes and take longer to complete the task (b = 7.99, B = 2.41; b = 173.78, B = 1.52) (see *Table 1 & Figure 4)*. Although this association was significant, the magnitude of the effect was moderate; financial stress explained approximately 38% of the variance in math mistake scores ($r2 = .379$). In addition, as indicated by the unstandardized slope, for each increase of one point on Likert scales measuring financial stress, math mistake scores increased by 2.41 points on average.

Discussion

Overall, while the association between total stress and task performance was not significant, there was a strong positive correlation between financial stress and general performance on the math task, meaning those who scored high in financial stress tended to make more math mistakes, to take more time to complete the math task, and, therefore, to lose more money during the task. This was a somewhat surprising finding, as we had earlier predicted that a high level of total perceived stress would be correlated with lower performance on the cognitive tasks. Importantly, the fact that financial stress was the only significant mediator for poorer scores points to a few salient implications.

In the past, research has found financial stress to be a contributing factor to academic struggle and dropout rates (Joo et al., 2008). Additionally, financial stress is known to be a "root cause" stressor for a number of other stressors, such that those who report higher financial stress also report more "interpersonal stressors, greater psychological distress, and lower levels of psychological well-being" (Sturgeon et al., 2017). In the modern context, financial crises have had massive impacts on the physical and mental health of those affected; for example, studies have shown that the rise in unemployment, financial stress, increased work hours, and food insecurity during the 2008 Great Recession predicted a rise in cardiovascular disease, dysthymia, and suicide in the general working population (Mucci et al., 2016). In our case, it is also likely that the financial stressor in the experimental conditions itself—the potential loss of money based on performance—had a greater effect on those who were already reporting high levels of financial stress. In fact, it is possible that the prospect of losing more money acted as an acute stressor in the moment, and may have played a role in performance on the math exam. Because financial stress has been known to have such a potent effect, on a number of health-related variables, it follows logically that it might also play a role in cognitive performance, especially in a high-stress environment like a university.

In terms of limitations, our study focused on a relatively small population. While we chose to observe a small population for accessibility and compensation purposes, future studies might benefit from a larger population of female college students. That being said, age also presents another limitation to the study; it might be beneficial for future studies to further explore the effect of financial stress on cognitive performance within a diverse range of age groups. Additionally, it would be interesting to observe the role that socioeconomic status plays in cognitive performance, particularly in the context of math exams. A first-generation college student could be dealing with immediate financial stressors, as well as socio-cultural expectations of providing for a family and community, which could have a large impact on their general stress levels and cognitive performance.

Conclusion

Stress is a ubiquitous part of the college experience, academic or otherwise. However, although this stress has become the norm in our culture, it is useful and important to explore the effects of stressors on our cognitive performance, as there are both optimal and detrimental levels of stress. Regarding financial stress, research on its relationship with academic performance and general well-being could lead to more informed policies surrounding financial aid, student mental health resources, and public policy.

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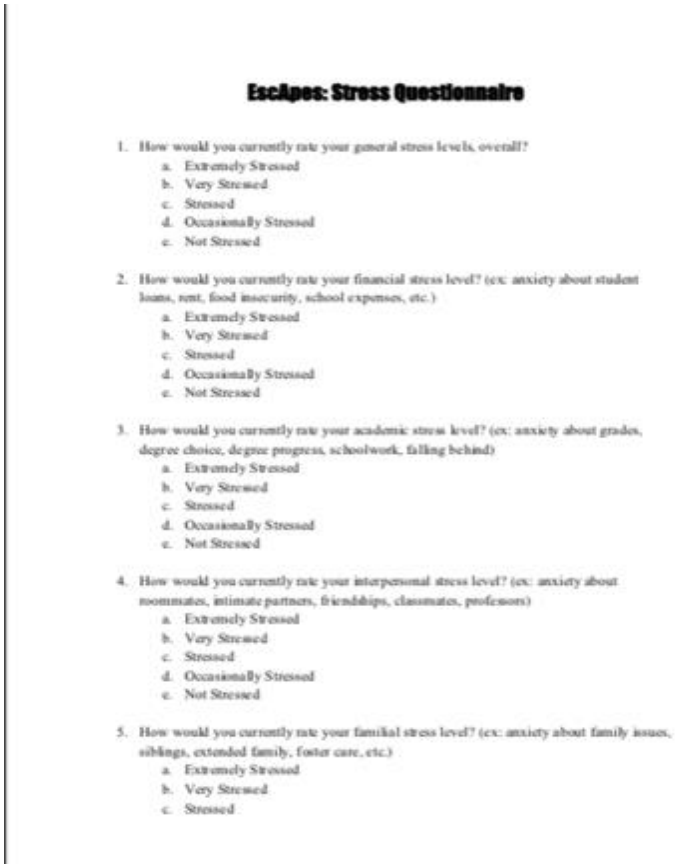
Appendix



EscApes: Stress Questionnaire

1. How would you currently rate your general stress levels, overall?
   a. Extremely Stressed
   b. Very Stressed
   c. Stressed
   d. Occasionally Stressed
   e. Not Stressed

2. How would you currently rate your financial stress level? (ex: anxiety about student loans, rent, food insecurity, school expenses, etc.)
   a. Extremely Stressed
   b. Very Stressed
   c. Stressed
   d. Occasionally Stressed
   e. Not Stressed

3. How would you currently rate your academic stress level? (ex: anxiety about grades, degree choice, degree progress, schoolwork, falling behind)
   a. Extremely Stressed
   b. Very Stressed
   c. Stressed
   d. Occasionally Stressed
   e. Not Stressed

4. How would you currently rate your interpersonal stress level? (ex: anxiety about roommates, intimate partners, friendships, classmates, professors)
   a. Extremely Stressed
   b. Very Stressed
   c. Stressed
   d. Occasionally Stressed
   e. Not Stressed

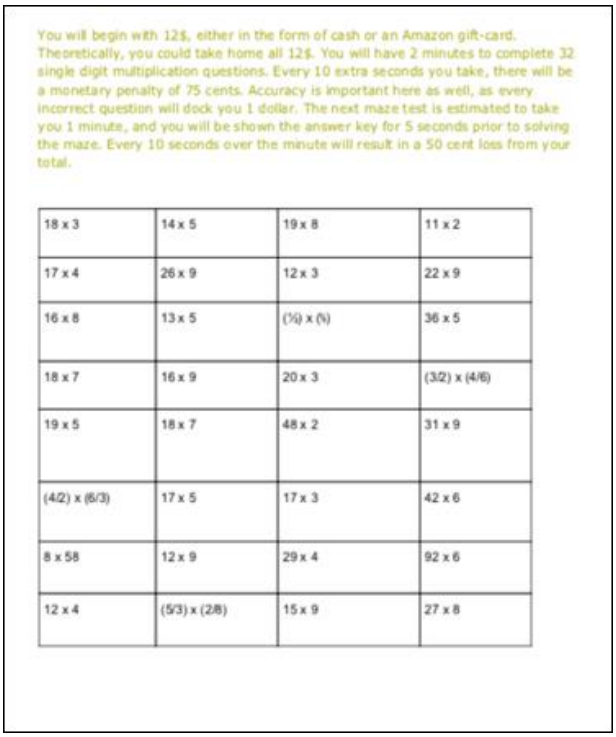
5. How would you currently rate your familial stress level? (ex: anxiety about family issues, siblings, extended family, foster care, etc.)
   a. Extremely Stressed
   b. Very Stressed
   c. Stressed

Figure 1. Stressor Questionnaire

d. Occasionally Stressed
e. Not Stressed

6. How would you currently rate your personal stress level? (ex: anxiety about personal mental health, body image, adjusting to college, fulfillment, etc.)
   a. Extremely Stressed
   b. Very Stressed
   c. Stressed
   d. Occasionally Stressed
   e. Not Stressed

Figure 1. (cont.)



You will begin with 12$, either in the form of cash or an Amazon gift-card. Theoretically, you could take home all 12$. You will have 2 minutes to complete 32 single digit multiplication questions. Every 10 extra seconds you take, there will be a monetary penalty of 75 cents. Accuracy is important here as well, as every incorrect question will dock you 1 dollar. The next maze test is estimated to take you 1 minute, and you will be shown the answer key for 5 seconds prior to solving the maze. Every 10 seconds over the minute will result in a 50 cent loss from your total.

18 x 3	14 x 5	19 x 8	11 x 2
17 x 4	26 x 9	12 x 3	22 x 9
16 x 8	13 x 5	(½) x (⅝)	36 x 5
18 x 7	16 x 9	20 x 3	(3/2) x (4/6)
19 x 5	18 x 7	48 x 2	31 x 9
(4/2) x (6/3)	17 x 5	17 x 3	42 x 6
8 x 58	12 x 9	29 x 4	92 x 6
12 x 4	(5/3) x (2/8)	15 x 9	27 x 8

Figure 2. Math Task

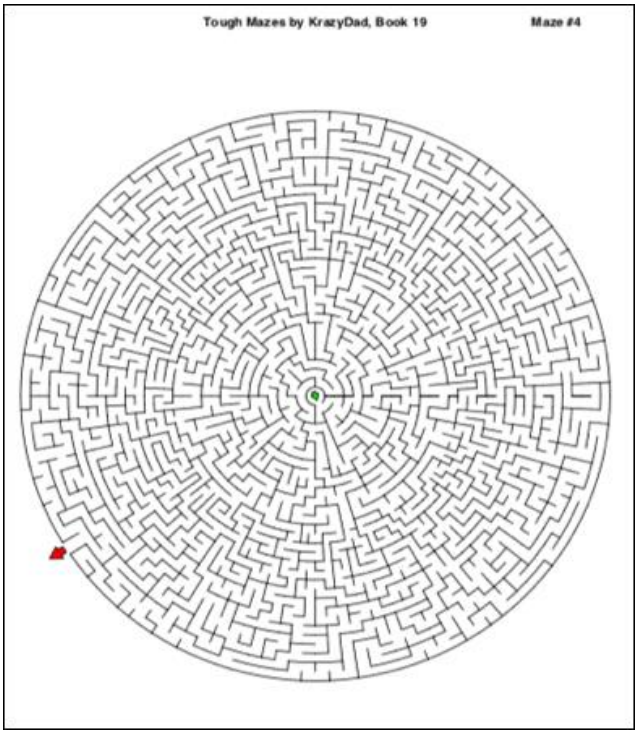


Figure 3. Maze Task

Math outcome vs Financial stress	Correlations (r)	Significance (p)
Math time vs Financial stress	0.310	p=0.042
Math mistakes vs Financial stress	0.612	p<0.001
Math amount lost vs Financial stress	0.616	p<0.001
Math total earned vs Financial Stress	-0.617	p<0.001
Total earned vs Financial Stress	-0.638	p<0.001

Table 1.

Math Outcomes vs Stressors	Correlations (r)	Significance (p)
Math Mistakes vs. General Stress	0.081	p=.331
Math Mistakes vs. Interpersonal Stress	0.136	p=.229
Math Mistakes vs. Financial Stress	0.612	p<0.05
Math Mistakes vs. Academic Stress	-0.200	p=.136
Math Mistakes vs. Total Stress	0.280	p=0.060

Table 2.

Maze Amount Lost vs. Stressors	Correlations (r)	Significance (p)
Maze Amount Lost vs. General Stress	-0.014	p=0.470
Maze Amount Lost vs. Interpersonal Stress	-0.071	p=0.349
Maze Amount Lost vs. Financial Stress	0.092	p=0.309
Maze Amount Lost vs. Academic Stress	0.106	p=0.282
Maze Amount Lost vs. Total Stress	0.007	p=0.485

Table 3..

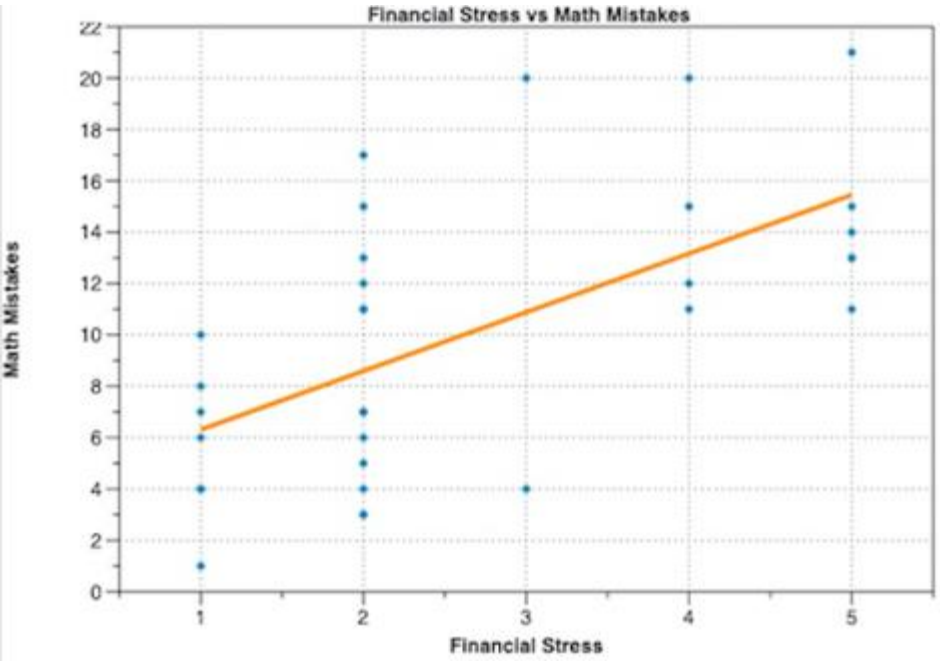


Figure 4. Positive Correlation between Financial Stress and Math Mistakes