Stress Response Associated with Finishing a Test Slower than One's Peers

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Abstract

Numerous non-academic variables, such as negative emotions, confidence, and cognitive appraisal, influence one's success on a test. Such indirect time pressures applied to test-taking situations may influence one's cognitive self-assessments, and consequently, one's confidence during a test. Collectively, these variables may affect one's performance on a test. In this study, the participant was falsely told he or she was taking part in a study involving how sleep affects test performance. Two confederates took the test with the participant, and were signaled to finish before the participant was done with the test. Subjects' heart rates, blood pressures, and skin conductances were measured throughout the test, and averages were compared at three intervals: before the first confederate left, between the departures of the two confederates, and after the second confederate left. This research focused on how finishing slower than one's peers may affect stress levels while taking a test. It was hypothesized that a slight increase in blood pressure and skin conductance and a larger increase in heart rate would be observed upon realizing one was completing the test slower. While each variable measured increased slightly on average, these increases were not statistically significant. These findings reveal that spending more time taking a test than one's peers does not necessarily cause physiological changes in heart rate, skin conductance, and blood pressure.

Introduction

Administering exams to test a student's knowledge and skills in a particular subject is widely utilized and accepted in the United States (Soderman, 2001). There are, however, numerous variables that have been shown to have an impact on student performance that have no relation to the knowledge and skills being tested (Gardner, 2001, Soderman, 2001).

Cognitive appraisal, one's personal interpretation of a situation, has been shown to influence student performance on exams, and thus it is important that test administrators control for variables which influence a student's cognitive appraisal (Zalewski, 2011) (Lengua, 2002). Negative emotions may prime negative appraisals before, during, or after completing a test, which may restrict cognitive ability and thus test performance (Lengua, 2002). Emotional self-regulation is the main mechanism by which one appraises cognitive function during exams. Poor emotional self-regulation may explain adverse cognitive appraisals in test-taking situations (Bazinet, 2011). Self-regulation is an active practice that involves controlling, monitoring, evaluating, modifying, and directing emotions toward a goal (Schunk, D.H. & Zimmerman, B.J., 1998). This idea was first introduced by Zimmerman and Schunk (1989), whose research suggested that self-regulation involves a network of processes, actively applying skills, and practicing strategies. These variables imply that self-regulation can be indicative of one's confidence about a test. Little confidence in test-taking performance or in the ability to control the result of the test induces regulation failure and test anxiety (Smith, 1991; Smith & Ellsworth, 1987). Positive emotions and higher confidence have been positively correlated with higher cognitive aptitude. The contrary was also observed: lower confidence has been correlated with lower cognitive aptitude (Ackerman & Heggestad, 1997, Bandura, 1986, Roznowski et al., 2000 and Zeidner and Matthews, 2000). In addition, focus contributes to actively self-regulating emotions while being tested. Thus, focusing on emotions may shift one's focus from the test to thoughts about his or her test performance and the causes of that performance; these emotions can either be positive or negative (Schutz and Davis, 2000). Knowledge of how preparing for a test can affect one's overall confidence with the tested material is extremely applicable to the hypothesis of this paper. This is because it demonstrates that the act of self-regulation appeals to and contributes to the emotions that one feels before, after, and during testing, which affects one's confidence in his or her performance on the test (Lengua, 2002).

Time pressure is a variable that has been empirically shown to impair emotional regulation and influence cognitive appraisal (Landy, 1993, Dunlosky, 1994). Timed tests induce a direct stress on test-takers because they are aware of being limited in some respect. It has been found that knowledge of time constraints while taking a test may cause test-takers to disengage from the test (Dunlosky and Thiede, 2004 and Kellogg et al., 1999). This can evoke negative impact on a student's cognitive appraisal, which may reflect his or her test performance. Additional research paralleled these findings; knowledge of a less pressing time constraint motivated students to further apply their knowledge and remain focused on the test (Henderson, Gollwitzer, & Oettingen, 2007). In fact, less intense time constraints were found to potentially improve memory and reading comprehension skills (Walczyk, Kelly, Meche, & Braud, 1999). Ackerman and Goldsmith (2011) proposed an alternate idea regarding testing under time pressure; they found that time constraints gave students less creative cognitive freedom, but motivated them to engage in the challenge of working under time constraints. This idea may allude to the fact that mastering a time-controlled task is rewarding, and thus causes one to self-regulate positive and confident emotions.

While much research has been done to show the effects that direct time pressure has on student cognitive appraisal, little has been done to test how indirect time pressure may influence appraisal, which may be indicative of test failure or success. In this study, the test-takers were unaware that time was of concern. Because the test was not timed, students completing the test sooner than others indirectly imposed a time pressure on the slower test takers. This idea prompts the question: If direct time pressures when taking tests negatively influences emotion and confidence, will an *indirect* time pressure sourced from faster test takers yield a similar response? It is a relevant question in academia how different, non-academic factors, such as how long a student takes to complete a test relative to his or her peers, may influence that student's confidence. For example, if being one of the last to finish an exam has a negative impact on a student's cognitive appraisal, then that student may perform worse, regardless of how well he or she knows the course material.

The following research specifically focuses on understanding emotional variables as they relate to time while taking a test to better improve national test administration. The purpose of this study was to determine the degree to which taking longer to finish an exam influences cognitive appraisals, as this may influence student test performance. One problem that arises when designing an experiment to explore such an issue is that cognitive appraisal and emotional self-regulation cannot be measured directly. To resolve this issue, physiological changes associated with stress were assumed to be indicative of decreased emotional regulation and negative cognitive appraisal (Ackerman & Heggestad, 1997, Bandura, 1986, Roznowski et al., 2000 and Zeidner and Matthews, 2000). Specifically, blood pressure, heart rate, and skin conductivity were measured throughout an exam, with specific attention given to the change in these variables. The changes in the variables were measured with three intervals (Figure 2). The first interval correlated to the time from the beginning of data recording to the first confederate finishing. The second interval correlated to the time between the first confederate finishing and the second confederate finishing. Lastly, the third interval correlated to the time after the second confederate finished to the time the subject finished. Given what is known about the effects of negative appraisal and time awareness on performance, it was hypothesized that blood pressure and skin conductance would increase slightly and heart rate would increase greatly following the student's realization that he or she was the completing the test slower than his or her peers.

Materials and Methods

Materials

The following materials were used in this experiment:

- Nonin Pulse Oximeter and Carbon Dioxide Detector (Model 9843, SN# 118102926, Plymouth, Minnesota)
- Reusable electrodermal activity amp (EDA) Setup: EDA Transducer (SS3LA/L), Electrode Gel (GEL101)
- Omron Healthcare Inc. Automatic Blood Pressure monitor (Model BP791IT, SN# 20141004280LG, Lake Forest, IL)
- BIOPAC Student Laboratory System (BSL 4.0 software, MP36 hardware, BIOPAC Systems, Inc., Goleta, CA)
- Windows 7 PC
- R (Statistical Software)
- Test Taking Materials (word searches and pencils)

Participants

Twenty Physiology 435 students from UW-Madison individually participated in this study on a voluntary basis. Prior to participating, students signed a consent form from the University of Wisconsin-Madison Department of Physiology. In order to keep participants blind to the true nature of the study, participants were told that the purpose of the study was to test the effect that sleep has on test performance. This was done to provide participants with intrinsic motivation to complete the test as fast as possible. Following the test, participants were told the true purpose of the study. Anyone aware of the true nature of the study was excluded from participation. The participants were not compensated for their involvement in the study.

Procedure

Tests were administered in groups of three at separate times, with two of the three test-takers being confederates, and the third being the true participant. Testing occurred with two confederates in order to control when the first and second person finished their word searches. Only the participant, not the confederates, was given a sleep survey in which they answered questions regarding the length and quality of their sleep and how well rested they were at the time of participation. Participants, being from the same class as the group administering the study, were told that the confederates were to act as controls whose sleep schedule and quality were known. All three of the students were then given identical word searches that contained 15 words. Participants were spread out around the table so they would not be able to see each other's word searches. Students tested in this research did not prepare or study for the test that was administered.

After the participant filled out the sleep survey and signed the consent form they were hooked up to the equipment. The participant's skin conductance was recorded when the test began and blood pressure and heart rate were recorded 30 seconds after the test began. Heart rate was measured in beats per minute (BPM) using a Nonin Pulse Oximeter and Carbon Dioxide Detector and blood pressure was measured in mmHg using an Omron Healthcare Inc. Automatic Blood Pressure monitor. Skin conductance was measured in microSiemens using a reusable EDA and BIOPAC BSL 4.0 software, and averages from before and after the subjects' peers finishing were obtained using the same software. Blood pressure was measured every 60 seconds while taking the test, heart rate was measured every 30 seconds while taking the test, and skin conductance was measured continuously. When the true participant found nine words the first confederate was signaled by the researcher observing the participant to stop and say, "I am done," out loud. Thirty seconds later the second confederate stopped and said, "I am done," out loud. The time it took the first and second confederate to finish was recorded. The participant's heart rate, skin conductance, and blood pressure were measured for two more minutes following the last confederate finishing or until they found all 15 words. The participant was then instructed to stop whether or not he or she was done with the word search. This procedure was repeated with 20 different participants and the same word searches were used for each participant.

However, participants were told that different word searches were used every time so that they could not attribute finishing last to extra practice the confederates may have had from administering the test multiple times.

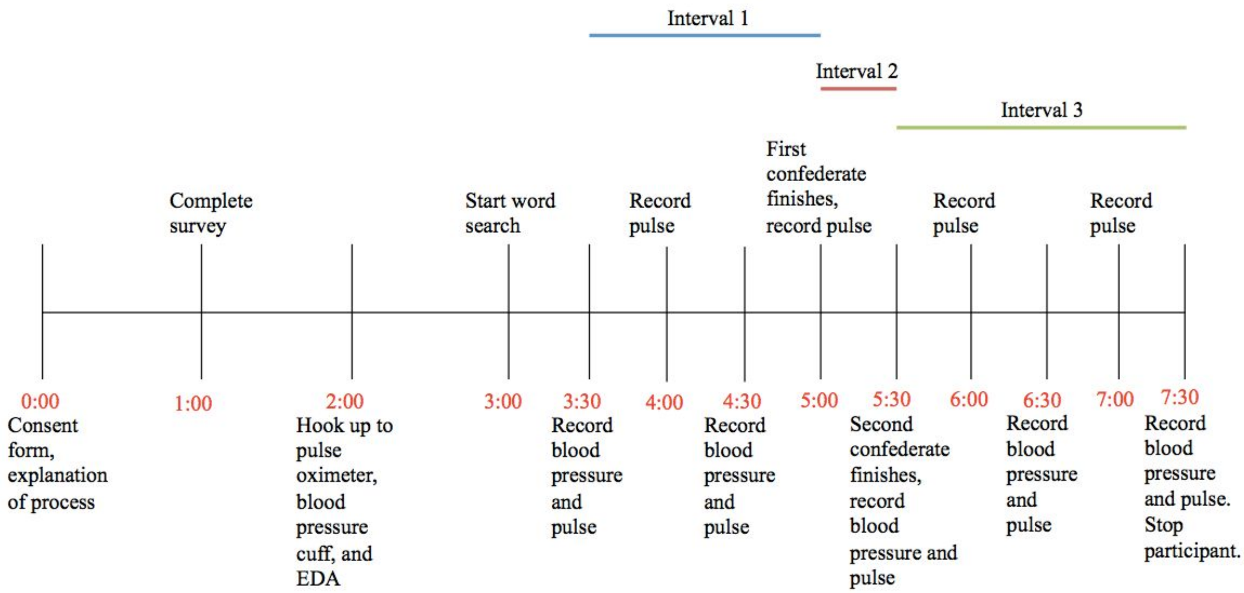


Figure 1. Timeline of Events. Note that times of confederates finishing are approximate, and differ depending on how quickly the subject moved through his or her word search.

Positive controls for blood pressure and heart rate were obtained by measuring each of these variables before and after physical exercise (Table 1). Physical exercise acts as a positive control for stress because stress, like exercise, is associated with increased blood pressure and heart rate (Schneiderman, Ironson, Siegal, 2005). A positive control for skin conductance was obtained by measuring a baseline reading, having a subject rub her hands together quickly (while keeping the EDA connected), and then observing the change in skin conductivity (see Figure 1). Skin conductivity increased by 4.8 mS.

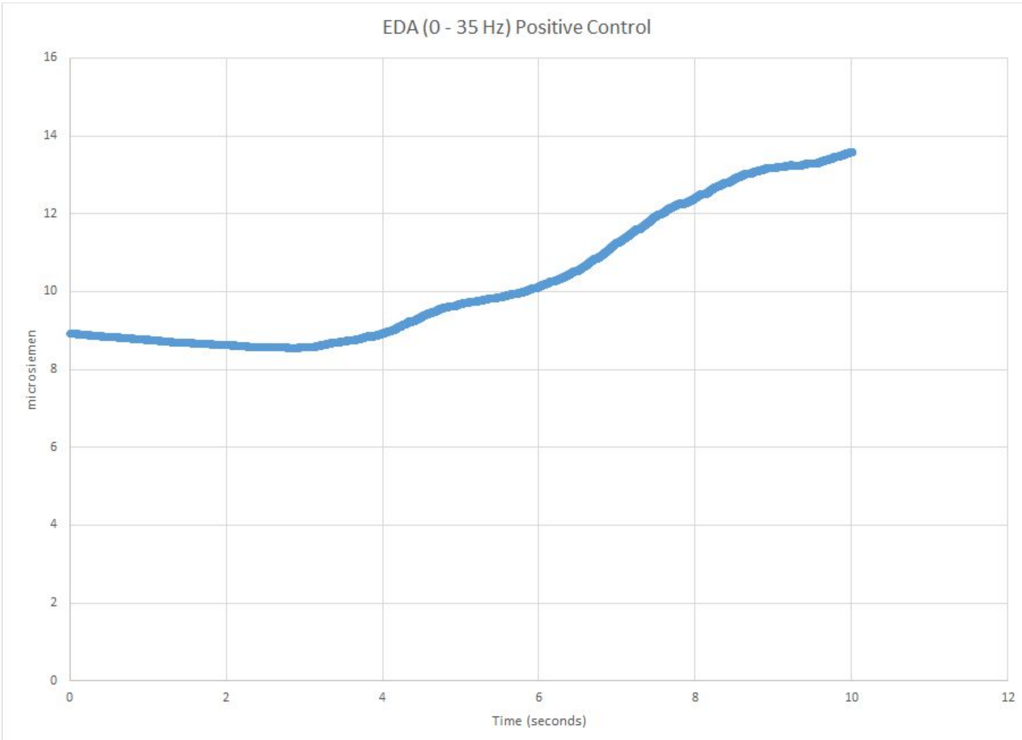


Figure 2. The change in skin conductance as the subject rubbed her hands together quickly with the EDA connected.

	Blood Pressure (mmHg)	Heart Rate (BPM)
Before exercise	106/70	80
After exercise	127/77	122
Change	21/7	42

Table 1. Blood pressure and heart rate before and after exercise.

Statistical Analysis

The positive control data was used to demonstrate competency with the materials and to preview the types of measurements used in the experiment. After completing the measurements, the average heart rate, blood pressure, and skin conductance of each participant was calculated for intervals one, two, and three. Next, two comparisons in heart rate, skin conductance, and blood pressure were made in this experiment: using a one-tailed, paired t-test, the heart rate, skin conductance, and blood pressure of the participant were compared between interval one and interval three. Secondly, also using a one-tailed, paired t-test, the heart rate, skin conductance, and blood pressure of the participant were compared between interval one and interval two. P-values were calculated, and the null hypothesis was accepted or rejected. All statistic calculations were performed in R.

Results

Heart Rate

The total average heart rate difference between interval one and interval three was .619 BPM, with standard error of +/- 1.4 (n=19). Figure 3 shows the increasing average heart rate of subject 6, which was not representative of the other subjects. Figure 4 shows how the average heart rate at the intervals varies from subject to subject. There was no statistically significant relationship between the average heart rate difference of interval one and interval three and the experimental conditions (p=.3275). Similarly, the total average heart rate difference between interval one and interval two was .461 BPM +/- 1.45 (n=20). There was no statistically significant relationship between the experimental conditions and the average heart rate difference between interval one and interval two (p=.3745).

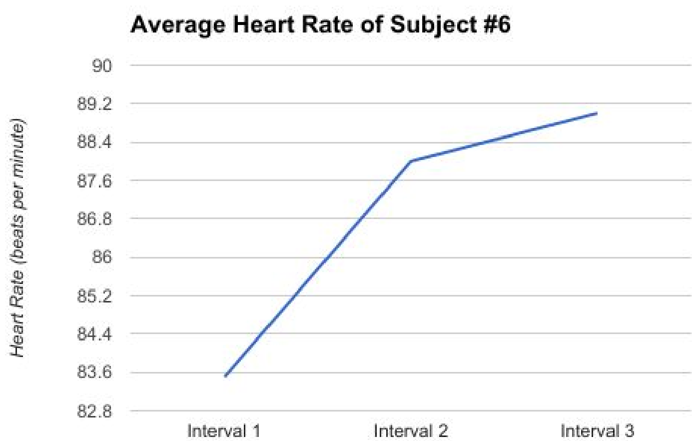
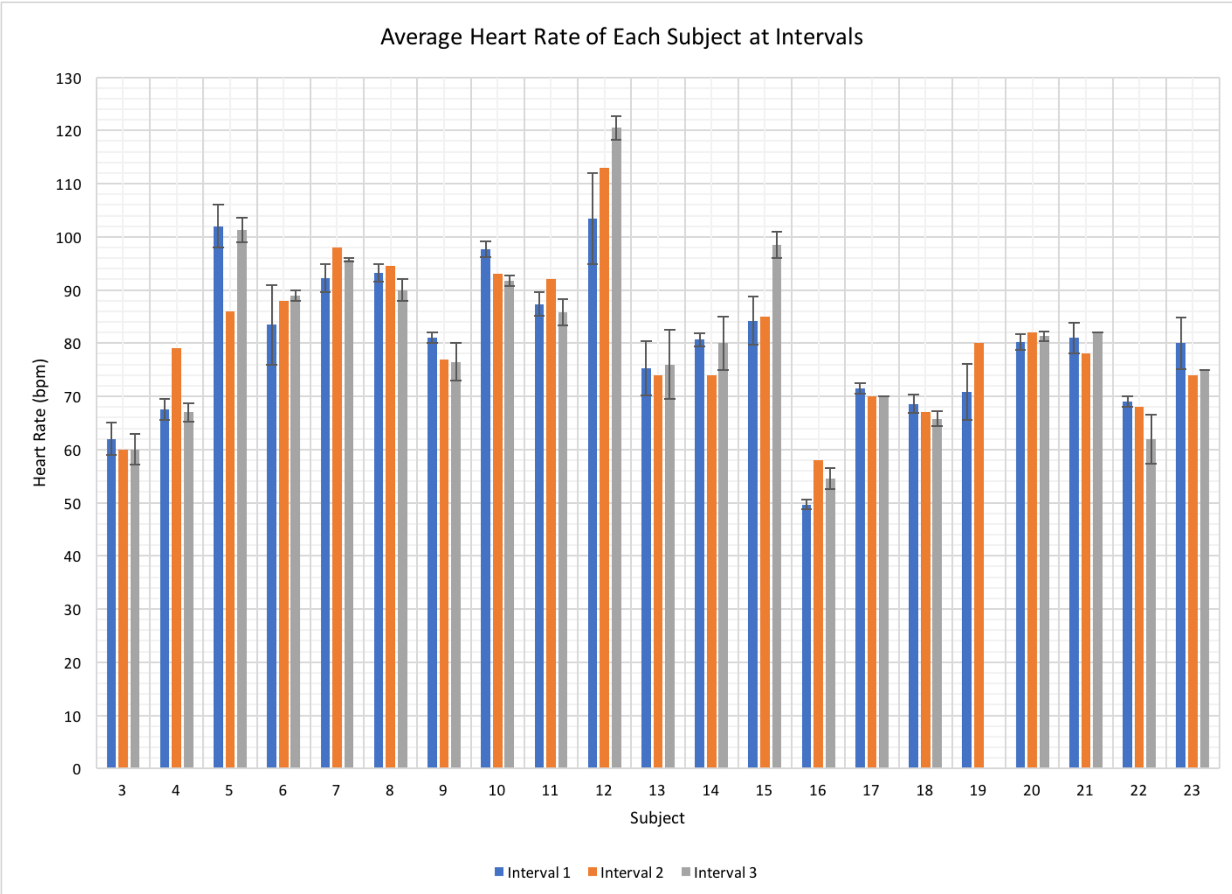


Figure 3. The average heart rate of subject 6 at time interval one (30s to time of first confederate finishing), time interval two (time between after confederate 1 finishes to confederate 2 finishing), and time interval three (time after confederate 2 finishes to end).



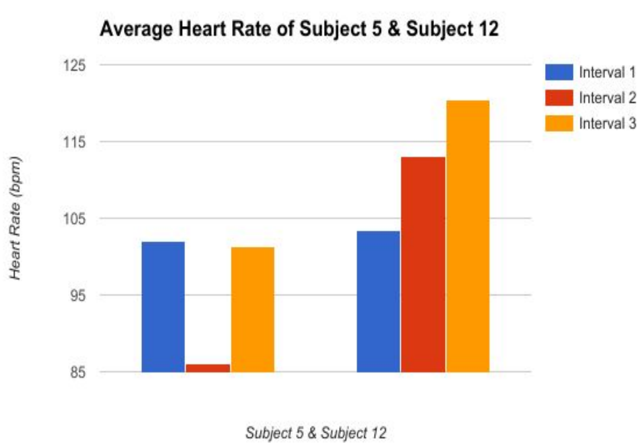


Figure 4. The average heart rate of each subject at intervals one, two, and three with standard error. Note, lack of standard error at interval two due to only one blood pressure measurement taken at that time. The variance in average heart rates between subjects is highlighted in subjects 5 & 12.

Blood Pressure

The total average systolic blood pressure difference between interval one and interval three was 2.11 mmHg, with standard error of +/- 4.20 (n=14) as shown in Figure 5. The total average diastolic blood pressure difference under the same conditions was 3.07 mmHg +/- 4.07. Figure 6 shows the increasing blood pressure of subject 3, which was not seen in all subjects. Neither of these changes were considered to be statistically significant, yielding p-values of .298 and .244, respectively. Additionally, the total average diastolic blood pressure difference between interval one and interval two was 3.88 mmHg, with standard error of +/- 5.21 and the systolic was 1.10 mmHg +/- 4.1 (n=8) as shown in Figure 5 as well. Again, neither of these increases were shown to be statistically significant, with p-values of .464 and .430, respectively.

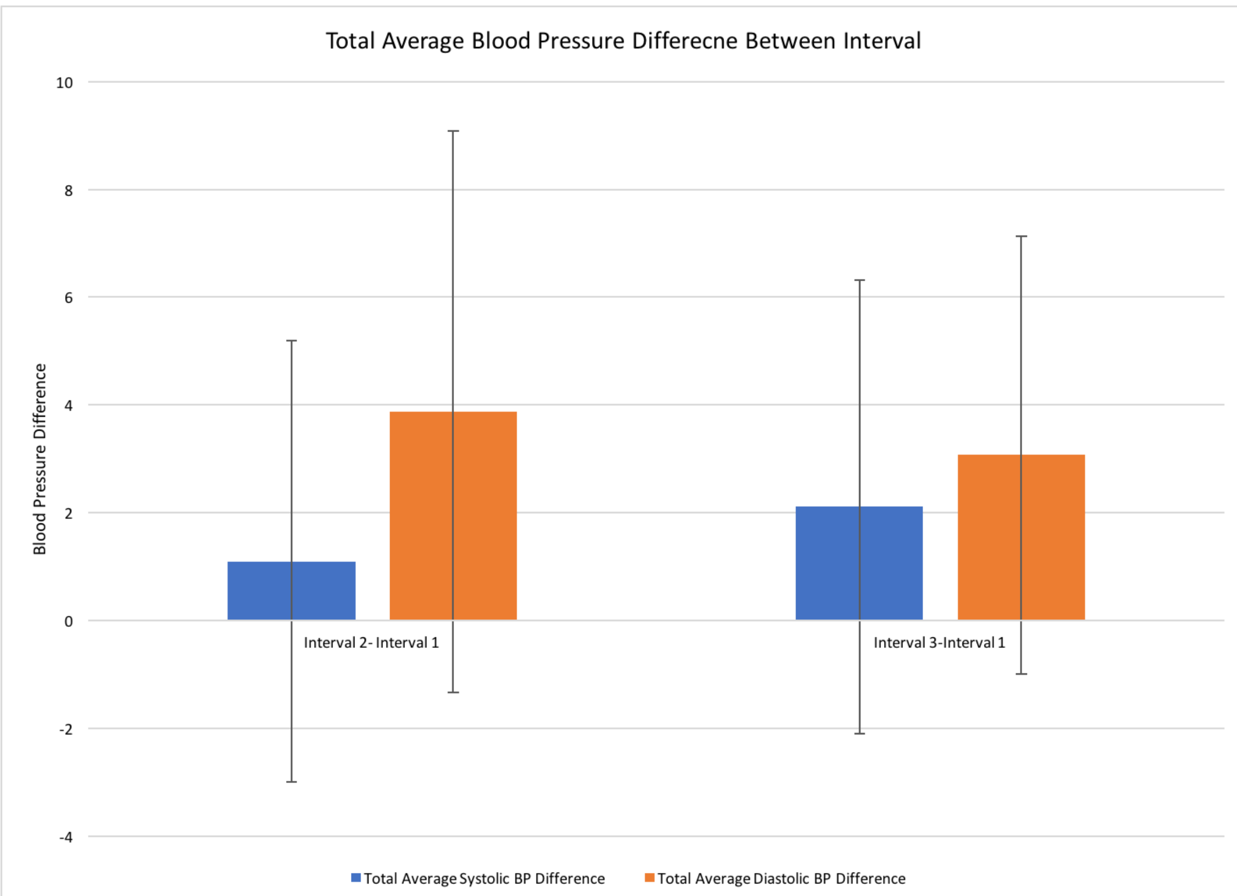


Figure 5. The total average blood pressure difference between intervals two and one, and between intervals three and one with standard error.

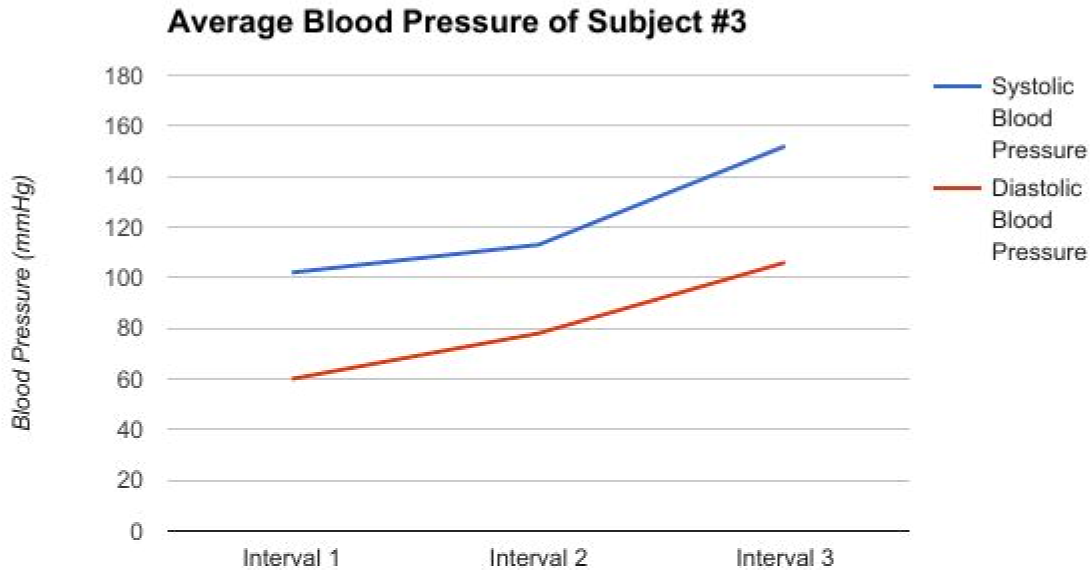


Figure 6. The average blood pressure of subject 3 at time interval one, time interval two, and time interval three.

Skin Conductance

Lastly, the total average skin conductance between interval one and interval three was -0.003 mS, with standard error of +/- 0.16 (n=20) as shown in Figure 7. Figure 8 shows the increasing GSR response of subject 3, which was not seen in all subjects. There was no statistically significant relationship between the total average skin conductance between interval one and interval three and the experimental conditions ($p=.494$). The total average skin conductance between interval one and interval two was -0.063 mS +/- 0.09 (n=20) as shown in Figure 7. There was also no statistically significant relationship between the total average skin conductance between interval one and interval two ($p= .229$).

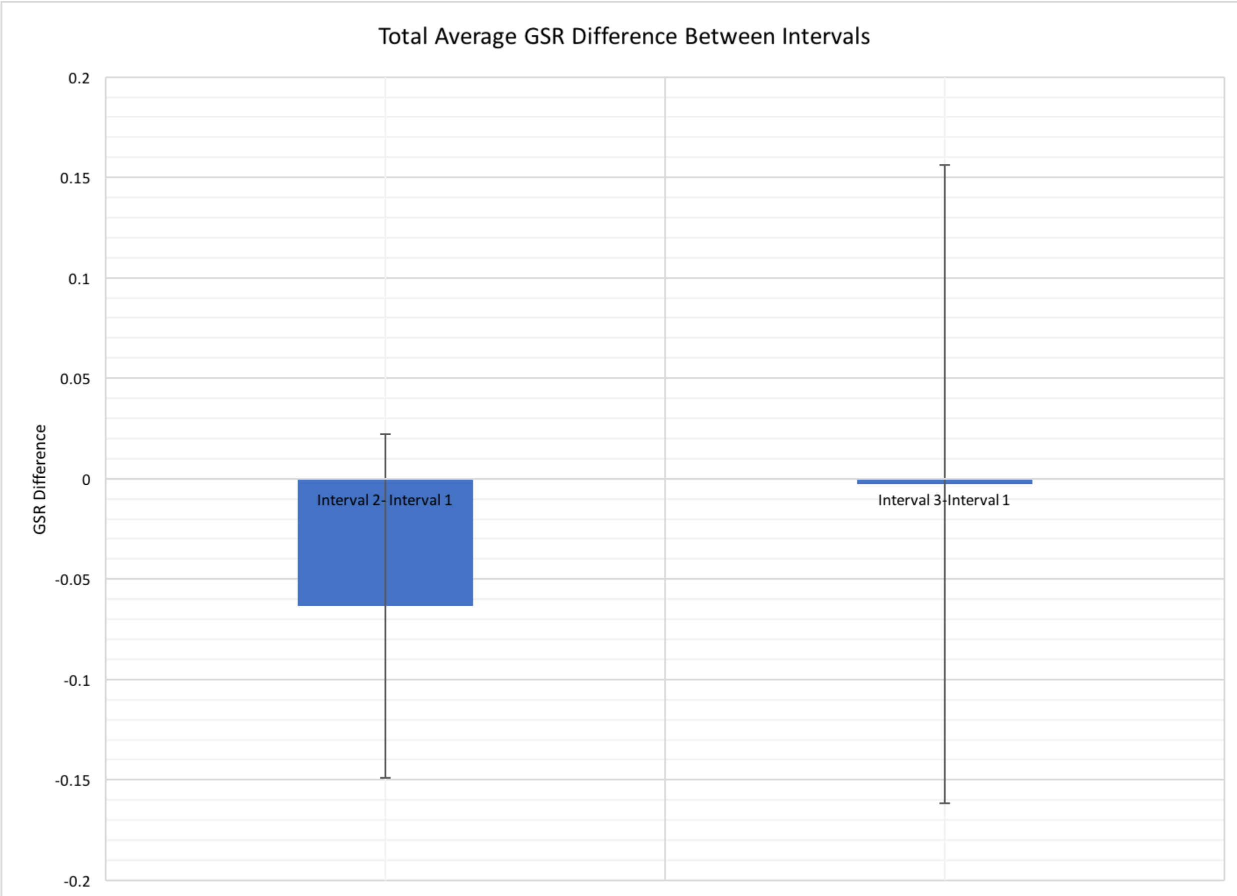


Figure 7. Total average galvanic skin response difference between intervals two and one, and between intervals three and one.

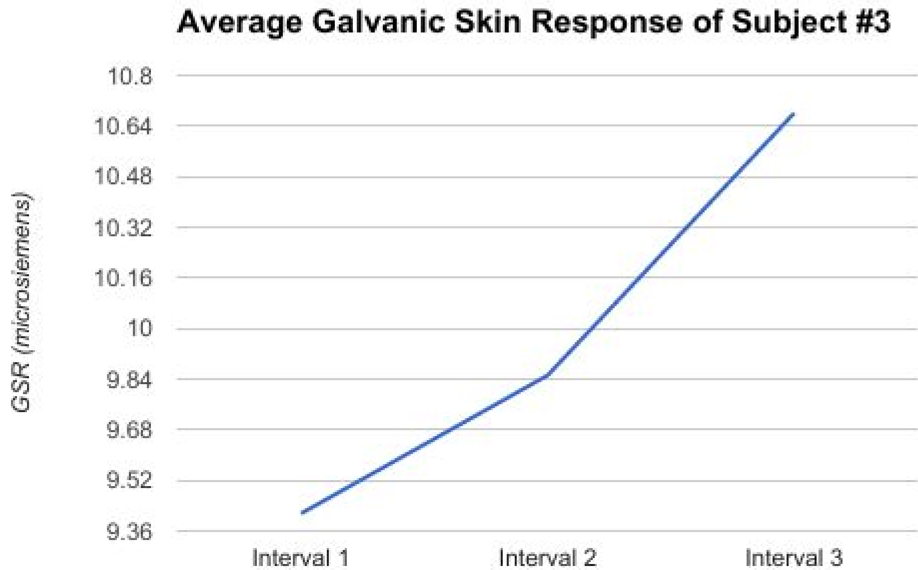


Figure 8. The average galvanic skin response of subject 3 at time interval one, time interval two, and time interval three.

Discussion

The purpose of this experiment was to examine if the extraneous variable of test-taking speed may induce a stress response in students. The potential for such a phenomenon is important because emotional control and self-appraisal have been shown to influence test performance (Lengua, 2002). The initial hypothesis stated that physiological changes associated with stress would be observed upon realizing one is completing a test slower than other students. Positive changes in blood pressure and heart rate were observed. However, paired t-tests revealed that these positive changes were not statistically significant, and thus this experiment failed to reject the null hypothesis that finishing slower than one's peers has no influence on heart rate, blood pressure, and skin conductance. Since these physiological factors were assumed to be associative of stress in subjects (Ackerman & Heggestad, 1997, Bandura, 1986, Roznowski et al., 2000 and Zeidner and Matthews, 2000), the experiment also failed to reject the notion that finishing slower than one's peers is a potential stressor.

Despite being statistically insignificant, trends within the data were observed. The majority of participants experienced an increase in blood pressure. The magnitude of this increase was extremely variable between individuals. The average heart rate also increased by an insignificant amount on average, again with large variance between subjects. These trends indicate that time constraints while taking a test may trigger increases in blood pressure in some individuals, but future studies are needed to prove this correlation.

Multiple sources of error could account for a lack of statistical significance in the data. Although using a paired t-test adequately controlled for variation among individuals by comparing only the differences in physiological measurements between intervals, and not the absolute measurements themselves, the study could not control for the possibility that these variables may not increase at the same rate for individuals with different lifestyles. For example, positive health and self esteem have been found in individuals with higher parasympathetic activity (McEwen, 2007). The higher proportion of parasympathetic stimulus indicated a state of cardiac health associated with lower cortisol production, lower resting heart rate, and lower blood pressure. Opposite conclusions were found for negative health, and the panel of negatively-associated physiological consequences that it yields. Therefore, those with positive health could have more positive appraisals and self-esteem, which may allow these individuals to cope with stress more easily leading to smaller changes in heart rate, lower blood pressure, and lower skin conductance. Conversely, individuals with more negative appraisals and lower confidence may have displayed more exaggerated physiological changes upon realization of stress during the test.

Another source of error may be credited to the equipment used to measure blood pressure. In a few trials, there was variability in the blood pressure machine, disrupting a uniform mechanism of data collection. Additionally, in a few subjects, stress changes were observed near the beginning of the test (potentially the consequence of giving students a test in a new environment). These high readings may have skewed the initial averages upward, resulting in smaller differences when comparing them to end stress physiological indicators.

Errors concerning the pool of participants and the environment that they took the test in may have caused the lack of substantial changes in physiological stress responses as well. First, the participants in this study were all higher-education students who take difficult tests frequently. The students' increased exposure to intense tests may have resulted in a sample that was not representative of the population as a whole because frequent exposure to intense test taking may have diluted the intensity of the testing environment, yielding less exaggerated physiological responses. Second, it is possible that the study failed to replicate a testing environment necessary to induce stress in slow test takers, which again would have decreased the overall stress response. Additionally, the relatively small sample size may not have been large enough to assume normality via the central limit theorem, rendering the statistical tests used invalid. Finally, while it was assumed that the subjects in this experiment would not reveal the true purpose of the study after participating, participants may have discussed the study with their peers. Thus, new participants may not have been blind to the nature of the study.

Future studies would benefit from adding a negative control group. In the context of this experiment, it was not possible for negative controls to further validate the results found. This is due to the learning effect; running a negative control on a subject who has undergone the experiment would not work because he or she would be aware of the true purpose of the study. A naive subject would be most appropriate to run a negative control on, however that was not possible in this experiment due to time constraints. Thus, a future group looking to improve upon the methodology of this study might consider testing the same subject twice (the first test being a negative control in which no confederate finishes before the subject, and the second test mirroring what was done in this experiment).

Comparing the results gathered to the positive control in this study did not reveal any additional information within the context of this experiment. Future experiments may wish to improve positive control measurements to ensure that the variables being measured accurately indicated stress in subjects. This suggestion was prompted by the qualitative observation that many subjects responded to the stress of finishing slower in ways that are inconsistent with the assumptions of this study. A subject experiencing increases in one stress variable should not experience a decrease in another stress variable if both variables are indicative of stress, yet this seemed to be the case with many subjects. This phenomenon could theoretically negate otherwise significant data. An improvement in this study may, for example, tailor positive control measurements for each subject by mentally stressing the subject in an unrelated fashion prior to administering the test to determine how that subject's physiology changes in response to stress. These changes could then be compared to the changes induced by slower test taking.

Given the results from this experiment, it is suggested that additional studies explore the physiological changes that peers in a test taking room induce on each other. This may be in the form of testing subjects in smaller groups versus larger groups and comparing their physiological states. This concern may also be applied to an individual's mental health, in which studies compare physiological states of individuals with strong emotional health and subjects with a history of mental health problems. Lastly and most importantly, the relationship between stress and test taking must be clearly defined in a physiological sense. Various extraneous factors contribute to stress. Thus, it is crucial to define and specify the factors that induce physiological stress responses directly versus indirectly, and structure further research from there.

While this study does not suggest any need to change test administration policies at this time, it is important to continue exploration further in order to improve test-taking strategies and test administration. There are not many published studies focusing on both indirectly applied time constraints during a test and the cognitive effects that the time pressure provides. In applying the results of this study to its purpose, it can be advised that further research is needed to prove a relationship between test-taking speed and stress. The results from these future studies will be crucial to prove a relationship between test-taking speed and stress. Both test-takers and test administrators should benefit from the results of these future studies because they will yield information about areas of test administration that may induce negative appraisals for test-takers.

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