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# Physiological Effects of Varying Waiting Periods and Perceived Arrival Times on the Performance of a Timed Quiz

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**Abstract**

Tests and quizzes are often used by schools and workplaces to judge performance and knowledge of the participants who take them. Although the aim of these evaluations is to test cognitive function, there are many underlying factors that may influence performance. Test anticipation and test anxiety are only some of the factors that may influence performance. This study aims to investigate the physiological changes, specifically for blood pressure, heart rate, and respiratory rate, that may occur when a student has varying amounts of time to anticipate a quiz. Participants performed a 7 question math quiz in 5 minutes. It was predicted that when students are given less perceived time to take the quiz and perceive themselves as having a later arrival time, they will experience an increase in blood pressure, respiratory rate, and heart rate, which will ultimately impact quiz performance. Our results yielded that students who were given less perceived time had no significant increase in heart rate, respiration rate or blood pressure, both systolic and diastolic, as compared to the groups that were given longer waiting periods and perceived themselves to have more time to complete the quiz.

**Introduction**

Physiological stress is commonly defined as anything that has an effect on homeostatic conditions and its influences on an individual's physical and mental health (Schneiderman *et. al*., 2005). Cortisol is one steroid hormone that is released into the bloodstream during acutely stressful situations in order to support sympathetic nervous system stress responses such as pupil dilation, increased heart rate, and increased blood pressure. However, elevated levels of this hormone over a long period of time can cause chronic stress and lead to hypertension (Aronson, 2009). In addition to causing hypertension, chronic levels of cortisol have also been linked to depression and other cognitive impairments, for example, increased levels of cortisol have been shown to negatively impact simple and complex memory (Kirschbaum *et. al*., 1996). Due to the long-term effects of chronic cortisol levels established in various studies, we began to question what the effects of acute stress and cortisol levels would do to individual during the administration of a quiz .

The body has multiple responses to stress-eliciting events. One response pathway is through the adrenal gland. The adrenal gland is responsible for the secretion of epinephrine, norepinephrine, and cortisol. These hormones combined act on many physiological functions causing a shift in homeostasis, producing an increase in blood pressure, respiratory rate, and heart rate (Krajnak *et. al*., 2014). For college students in particular, taking quizzes can be a very stressful experience. Because increased cortisol has shown to have a negative effect on various cognitive functions, it is imperative to discover the impacts of a physiologically and psychologically stressful testing environment. This knowledge could then potentially be applied to learn how to maximize a student's testing ability through altering their environment.

Test taking and the period before a quiz have been associated with physiological changes in students of all ages, including blood pressure and heart rate. Previous studies have investigated the effects of increased heart rate and blood pressure, in particular, in college students before and during a exam and found both variables increased both before and during the exam (Zhang *et. al.,* 2010). They were able to conclude that diastolic blood pressure (DBP), systolic blood pressure (SBP), and heart rate (HR) increased significantly during the exam, as compared to prior to the exam. Using questionnaires to assess anxiety levels, the study concluded that increasing anxiety levels are positively correlated with increased blood pressure and heart rate measurements during a testing situation (Zhang *et. al.,* 2010). While this study was able to conclude that for 31.25% of all students blood pressure and heart rate increased, and significantly more for students with higher anxiety, other studies have found opposing results. A study measuring blood pressure and heart rate before, during, and after a licensing exam found that only diastolic blood pressure significantly increased, but systolic blood pressure did not change while heart rate decreased during the exam (Zeller *et al*., 2004). Both studies by Zhang *et al*. (2010) and Zeller *et al*. (2004) examined the effects of testing on physiological measurements, but neither addressed the effect of the amount of time given immediately before the test on anxiety levels or the physiological measurements. If having different amounts of time immediately before the test affected anxiety levels, according to the study by Zhang *et al*. (2010), it may also have an effect on an individual's heart rate and blood pressure. For this reason, it is important to explore the impact of the amount of time given before a test on these physiological measurements that are correlated with anxiety.

In addition to anxiety levels affecting physiological measurements, time limits during exams have also previously been found to negatively affect students' performance on exams (Hill & Wigfield, 1984). A study that included students with and without anxiety disorders found that with a time limit, students with high-anxiety performed two to three times worse than the students with low-anxiety. However, when a time limit was removed no significant changes in test scores were observed between the anxious and low-anxious groups (Hill & Wigfield, 1984). Thus, including a time limit in our study to induce stress in participants would hopefully ensure a stronger physiological response. Another study exploring the relationship between anxiety and test performance looked at these variables while also taking perceived test difficulty into consideration (Hong, 1999). The study was done on undergraduate students who had rated their anxiety and how they perceived the difficulty level of the test both before and after completing the exam. The study concluded that students who perceived the test to be harder before the exam had worse performance on the test. Using the results from the questionnaires they concluded this was due to a specific aspect of test anxiety that focuses on negative expectations, self-evaluation, and preoccupation with performance and potential consequences (Hong, 1999). In a similar light, this study chose to examine the effect of the perceived amount of time available for taking the test on students' test performance and physiological response. It is possible that if the students perceive they are late to the test, and therefore perceive it will be more difficult to complete due to less time, their test performance will suffer.

Current literature shows that test-taking, and the stress it induces, does affect students physiologically and psychologically (Zhang *et. al.,* 2010; Hill *et. al*, 1984; Hong, 1999). Although these results are meaningful, there seems to be a lack of studies that focus on which aspect of the testing environment actually causes the increased physiological stress response and decreased testing ability. A study by Hill and Wigfield (1984) shows that time limits negatively impact student performance on tests; however, removing time limits on tests is not realistic due to the limitation of resources, such as classrooms, test proctors, and other necessities for college tests. According to Hong, student perception of a test impacts test performance through the initiation of anxiety, but does not examine whether there is a physiological stress response or what role a physiological response may play in determining test performance (1999). This study aimed to mimic the real-life situation of a student perceiving himself or herself to be either early, on-time, or late to an examination. After correlating these groups to test performance and physiological data, this study then hoped to determine whether a realistic solution can be found to address the role of anxiety on test performance.

Due to the fact that testing is an unavoidable aspect of student life, it is important our study mirrors common testing environments experienced by students. Students have the ability to alter their testing environment by choosing when to arrive for the test, which could include arriving early, on-time, or late. A situation that leads to increased level in stress hormones may cause a physiological response. This study proposed that blood pressure, heart rate, and respiratory rate will all increase as students wait to take an exam and will remain elevated as they take the exam when compared to baseline measurements across all experimental groups. It was hypothesized though that for those that perceive they are arriving late and have less time before the quiz will have a larger physiological response as indicated by higher blood pressure, heart rate, and respiration rate measurements, and will perform worse than other experimental groups on the quiz because of this response.

## Materials and Methods

### *Participants*

The participants of the study consisted of 24 students from the University of Wisconsin-Madison students enrolled in Physiology 435, between the ages of 18-23. All participants signed a consent form prior to participating in the study.

### *Materials*

Prior to being informed of the quiz, participants' respiration rate was measured for a duration of one minute to serve as a baseline. Respiration rate was measured using a BioPac Device (Model # MP36E1204002762; Goleta CA) with a respiratory transducer (model SS5LB; SN 13116897). An automatic blood pressure cuff (OMRON 10 series+, BP791IT, Omron Healthcare, INC. Lake Forest, IL, USA) measured participants' heart rate and systolic/diastolic blood pressure. Together, these form the basis of our physiological measurements.

The experiment also utilized previous GRE mathematical questions from Cracking the GRE 2017 Edition (The Princeton Review, Random House Publishing, 2016). Seven quiz questions were selected from geometry, algebra and the math etc. sections of the book for the quiz. In order to account for varying levels of math knowledge, the chosen questions were prerequisite knowledge for students of the Physiology 435 class. The seven questions were to be completed in a five minute time frame.

*Experimental Design/Methods*

Participants were randomly assigned to one of three research groups: an on-time group (group 1), an early group (group 2), or a late group (group 3). While all groups received an equal amount of time of five minutes to complete the quiz, group 3 was read a script to make them believe they had arrived five minutes late and therefore had only half the original amount of time to complete the quiz. Participants of group 1 were made to wait two and a half minutes before starting the quiz. Participants of group 2 were told that they must wait five minutes before starting the quiz to mimic arriving early to an exam.

As shown in Table 1, baseline data for respiration rate, blood pressure, and heart rate was taken after the participant had sat down and been connected to all of the machines. Baseline respiration rate data was taken over a one minute timespan. Then a script that aligned with the assigned experimental group was read to each participant upon being seated to inform them of their participation in the study and the provisions for the quiz. Data collection of each participant's mean respiration rate was started immediately after the script was finished until they were to begin the quiz to obtain data during the waiting period. Then respiration rate data was taken for the duration of the quiz. Heart rate and systolic and diastolic blood pressure were taken 1.5 minutes before the quiz was started and again 2.5 minutes into the quiz.

The percentage change in respiration rate, pulse, and blood pressure between the baseline and waiting period and the baseline and measurements while taking the quiz were compared. After all individuals had participated, the mean percentage difference between pre-quiz and during-quiz physiological data was calculated for each variable. An analysis of variance (ANOVA) test was conducted for comparison in categories of pulse, blood pressure, respiration rate, and test performance (a number 1 through 7). A p-value of $\leq 0.05$ was considered statistically significant.

*Controls*

In order to ensure that changes in respiratory rate and pulse rate could be accurately measured and detected during the experiment, a fellow researcher performed fifty jumping jacks while their respiratory rate, pulse, and blood pressure were monitored. The percent change for respiratory rate, pulse, and systolic and diastolic blood pressure before activity and after were 106.05%, 14.12%, 16.50%, and 7.25%, respectively. This served as the positive control for our experiment to be sure a result could be measured if it were to occur. Baseline measurements of participants pulse, blood pressure, and respiratory rate taken prior to the announcement of a quiz served as a negative control for the experiment.

| | Positive Control |
|---|---|
| Mean Change in Respiratory Rate (%) | 106.5% |
| Mean Change of Heart Rate (%) | 14.12% |
| Mean Change of Systolic Blood Pressure (%) | 16.50% |
| Mean Change of Diastolic Blood Pressure (%) | 7.25% |

**Table 1.** Positive Control Data. Subject's respiratory rate (mV), heart rate (bpm), systolic, and diastolic blood pressure (mmHg) were taken before and after 50 jumping jacks. Mean percent change was calculated by subtracting the data pre-exercise from the data after the jumping jacks, and dividing this number by the pre-exercise data for each variable.

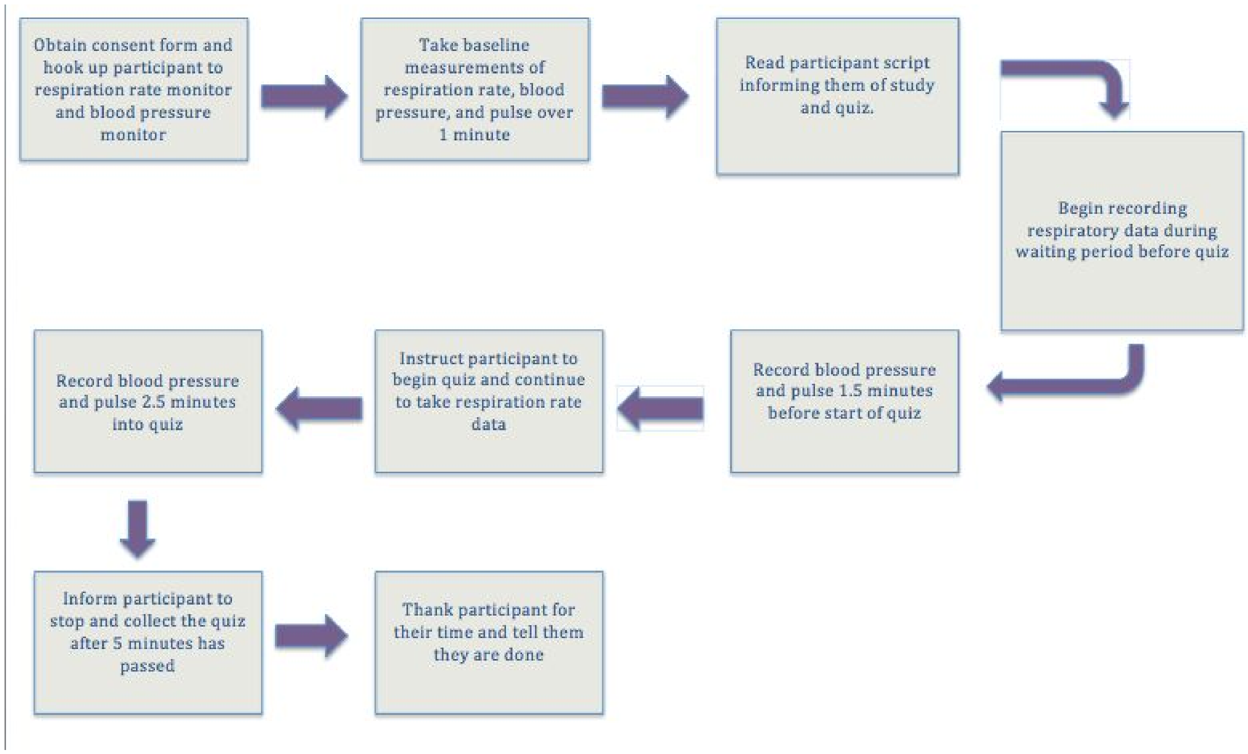


**Figure 1.** A timeline showing the sequence of events for collecting data. The figure outlines the timing of taking the participant's heart rate, blood pressure, and respiration rate throughout the experimental period.

## Results

Data for this study was analyzed using Microsoft Excel 2016 and one-way analysis of variance (ANOVA) statistical tests to compare each of the three groups (early, on-time, and late) across the categories of heart rate, respiration rate, and both systolic and diastolic blood pressure.

*Test Scores*

As seen in Table 2, the mean of the test scores obtained from each group were found to be 5.38 (SE: 0.46) for the early group, 5.38 (SE: 0.42) for the on-time group, and 5.63 (SE: 0.60) for the late group. While the late group showed a slightly higher mean quiz score when these values were compared in Figure 2, no significant difference was found with a p-value of 0.923 when subjected to an ANOVA test.

*Heart Rate*

Initial baseline values of the heart rate (in beats per minute) returned means of 78.38 (SE: 6.36), 66.38 (SE: 4.37), and 80.38 (SE: 4.55) for the early, on-time, and late groups respectively. During the waiting period for the early group, the heart rate increased to an average of 80.25 (SE: 7.11), a 2.39% total increase. The heart rate was further elevated during the quiz, where the mean was recorded as 85.25 (SE: 7.03), 8.77% higher than the baseline. The on-time group experienced a decrease in heart rate, dropping to an average of 63.38 (SE: 4.08), a decrease of 4.52%. During the quiz, the average increased to 71.00 (SE: 4.37), which was a 6.97% increase over baseline.The late group heart rate average remained consistent with a waiting period value of 80.38 (SE: 5.68) for a 0% change from the baseline. During the quiz, the heart rate average increased to 86.75 (SE: 4.35), an overall increase of 7.93%.

A comparison of the heart rate values (Table 2) indicates average percentage changes for each group that are similar, due to the overlap from the standard error. An ANOVA test performed between the three groups for both the waiting time and during quiz returned p-values of 0.078 and 0.070 respectively.

*Respiration Rate*

Baseline values for respiration rate (in breaths per minute) of participants were recorded as 20.54 (SE: 3.02) for the early group, 19.47 (SE: 3.97) for the on-time group, and 18.54 (SE: 1.02) for the late group. During the waiting period, the early group respiration rate decreased to 16.67 (SE: 1.44), the on-time group slightly increased to 19.82 (SE: 1.98), and the late group increased to 20.19 (SE: 2.72) for percent changes of -18.86%, 1.85%, and 8.87% respectively. During the quiz, the early group showed an average increase to 25.90 (SE: 4.00) breaths per minute, for a 26.10% increase compared to baseline. The on-time group increased to 22.46 (SE: 1.37), an overall 15.36% increase. The late group increased to an average of 30.00 (SE: 3.45), a 61.79% increase.

Respiration rates were compared, as seen in Table 2, and showed little difference in the averages obtained between groups. An ANOVA test confirmed this trend, yielding a p-value of 0.51 for the waiting period of the three groups. The p-value for the time during the quiz was calculated at 0.53.

*Blood Pressure (Systolic)*

The baseline values for systolic blood pressure (in mmHg) were 112.00 (SE: 2.61) for the early group, 115.13 (SE: 4.26) for the on-time group, and 120.25 (SE: 7.11) for the late group. All three groups experienced a decrease for the waiting period with the early group decreasing to 106.63 (SE: 3.58), the on-time group to 113.25 (SE: 3.19), and the late group to 108.50 (SE: 3.19). The groups showed a percent change of -4.80%, -1.63%, and -9.77% for the early, on-time, and late groups respectively. During the quiz, the early group had a mean systolic blood pressure of 113.25 (SE: 3.05), a 1.12% increase. The on-time group had a mean systolic blood pressure of 113.88 (SE: 1.99), which was a 1.09% decrease. The late group followed the trend of the on-time group with a value of 115.13 (SE: 3.28), an overall decrease of 4.26%.

The overall comparison of systolic blood pressure indicated little to no difference between the groups as seen in Table 2. An ANOVA test confirmed this with a p-value of 0.365

for the waiting period systolic blood pressures and a p-value of 0.896 for the systolic blood pressures measured during the quiz.

*Blood Pressure (Diastolic)*

Baseline diastolic blood pressures (in mmHg) were measured as 74.13 (SE: 2.39) for the early group, 78.00 (SE: 3.91) for the on-time group, and 81.88 (SE: 8.88) for the late group. The measured diastolic blood pressure during the waiting period was 72.00 (SE: 2.96) for the early group, which was an overall 2.87% decrease. The on-time group decreased to 73.25 (SE: 1.31) for an overall 6.09% reduction in diastolic blood pressure. The late group experienced an average decrease to 70.63 (SE: 4.29) for a 13.74% reduction. During the quiz, the diastolic blood pressure was measured at 76.88 (SE: 4.26), 72.75 (SE: 2.67), and 75.13 (SE: 1.94) for the early group, on-time group, and late group respectively. The overall percentage changes were 3.71% for the early group, -6.73% for the on-time group, and -8.24% for the late group.

The mean diastolic blood pressure was compared between groups in Table 2 and an ANOVA test yielded p-values of 0.837 for the waiting period and a p-value of 0.650 for the time during the quiz.

**Discussion**

*Significance of Findings*

The initial hypothesis that students would have elevated blood pressure, heart rate, and respiratory rate both waiting for the quiz and while taking the quiz prior was not supported by our data. The only data that could have supported the hypothesis that the greatest percent increases would be experienced by the late group was the increased respiration rate while taking the quiz, as shown in Table 2, and this data was found insignificant with a p-value greater than

0.05. The early group was the only group to show consistently increased percent change in systolic and diastolic blood pressure, heart rate, and respiratory rate during the quiz, despite the results showing p-values above 0.05, indicating that the differences were not significant. The late group also showed the highest mean quiz score of 5.625, contrary to our hypothesis, however, with a p-value above 0.05 the difference was also not significant. According to the data, the quiz failed to produce a physiological stress in the form of a significant percent increase in heart rate, respiration rate, and blood pressure both before and during the quiz for any of the experimental groups.

Our findings from this study could provide a couple of possible explanations for several theories. These include the idea that when students are less focused on the grade for a test or class, they are less likely to be stressed physiologically before and during the test and be able to think more clearly. If it is assumed that the participants in this study were not as stressed as they would be for normal quiz, this could help explain why even the group that was perceived to be late to the quiz did not experience the highest increase in physiological stress. Our findings and other studies testing similar variables as this study could be used to potentially support the argument for the promotion of alternative testing methods. Another explanation for why the late group did not experience as much physiological stress as hypothesized could possibly be due to the fact that participants in the late group were disproportionately strong test takers, especially in math. Therefore, although they were simulated in this study to be arriving late to a quiz, their confidence in their math ability outweighed other variables, and they were able to perform well without vast physiological changes.

Our findings indicate that students appear to handle psychological stress, such as an impending quiz, in different manners, which is shown by vastly different physiological stress responses between participants. Our findings also support the notion that physiological stress may not impact the cognitive functioning necessary for taking a quiz, a relief to students everywhere. The last significant implication from our data would be that even though physiological stress is not correlated to quiz results in this study, the psychological stress could possibly have a positive effect on quiz performance, as shown by the late group. Their respiration rate increased by 61.79%, meaning more oxygen was reaching the brain, thus affecting brain function. An increase in brain functioning could have led to better test results for the late group as seen by their mean quiz score of 5.625 as compared to the lower mean quiz score of 5.375 for the early and on-time groups. These results are of importance to students, as they may experience psychological stress before an exam as an advantage. Despite the fact that no significant difference was found between the quiz scores of each group, future studies with larger sample sizes could allow for this trend to manifest itself more apparently. We hope this study inspires further inquiry into the extraneous factors that could potentially affect the testing performance of students so as to maximize each student's potential.

*Limitations*

Although the study aimed to minimize the amount of confounding variables, there were some seemingly avoidable factors that may have impacted the results collected. These factors include the collection of more metadata, such as whether the participant had been diagnosed with anxiety, their gender, their age, etc. These variables may skew the data regardless of the conditions controlled by the researchers. Additionally, baseline measurements could have been impacted by the travel to the exam room prior to taking the study. Because baseline measurements were taken immediately following the participant walking a short distance, depending on the participant's health, it may have caused a rise in the baseline measurements. In addition, this study was limited to 24 Physiology 435 students from UW-Madison which is not a sample that is reflective of all college students. Expansion of the study to include a much larger sample size would ensure validity of the results. To combat the effects of students with different mathematical backgrounds, this study could be repeated with a quiz consisting of multiple subject areas other than mathematics to make it more fair for those who are not gifted in math. An implication for the late group in particular is that they were lead to perceive they were late, but a more effective technique would to be to create an environment in which the students were actually late, such as a distraction or barrier to beginning the quiz on-time. An example of a barrier could be a locked door that prevents entry to the quiz room, while a distraction could be talking to participants outside of the room so they enter late. Both of these scenarios cause participants to become actually late for the quiz and could induce higher levels of stress that could alter their physiological measurements more significantly. Future studies should address these factors by gathering more metadata about the participants, minimizing experimental error, more accurately mimicking test-like and late testing environments, creating a more comprehensive quiz subject-wise, and using a larger sample size.

**Conclusion**

Initially, it was hypothesized that students who are perceived to be late to the quiz will experience the highest percent increase in heart rate, blood pressure and respiration rate. This hypothesis was rejected, as no statistically significant values were obtained to show an elevated physiological stress response during the waiting period and during the quiz period for all three groups. Similarly, neither a significantly elevated physiological stress response nor lower quiz scores were observed for the late group. The hypothesis that elevated heart rate, blood pressure, and respiration rate would be experienced by all experimental groups both while waiting and taking the quiz was rejected, as there was no significant data.

Limitations of the study contained confounding variables including students with a history of anxiety disorder, travel time to the testing room affecting baseline measurements, a possibly biased quiz subject-wise, and the inability to an equivalently stressful environment such as actual testing conditions. For future studies we would suggest addressing these limitations by including a larger sample size, gathering metadata, creating a quiz with broad subject area, and creating a more accurate testing environment that would simulate the stress students experience during an actual quiz. While the data found in this study was not significant, further research is needed due to the lack of current data examining physiological correlations to test performance and its importance for students in reaching their greatest academic potential.

**References**


Aronson, D., (2009). Cortisol - Its role in stress, inflammation, and indications for diet therapy. *Today's Dietitian*, 11(11): 38. Retrieved from: http://www.todaysdietitian.com/newarchives/111609p38.shtml

Hill, K., & Wigfield, A. (1984). Test Anxiety: A Major Educational Problem and What Can Be Done about It. *The Elementary School Journal, 85*(1): 105-126. Retrieved from: http://www.jstor.org.ezproxy.library.wisc.edu/stable/1001622

Kirschbaum, C., Wolf, O.T., May, M., Wippich, W., & Hellhammer, D.H. (1996). Stress- and treatment-induced elevations of cortisol levels associated with impaired declarative memory in healthy adults. *Life Sciences*, 58(17): 1475-1483. Retrieved from: (http://www.sciencedirect.com/science/article/pii/002432059600118X)

Krajnak, K. M. (2014). Potential Contribution of Work-Related Psychosocial Stress to the Development of Cardiovascular Disease and Type II Diabetes: A Brief Review. *Environ Health Insights, 8*(Suppl 1), 41-45. doi:10.4137/EHI.S15263

Schneiderman, N., Ironson, G., & Siegel, S. (2005). Stress and health: psychological, behavioral, and biological determinants. *Annual Review of Clinical Psychology*, 1(1): 607-628. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2568977/

Zeller, A., Handschin, D., Gyr, N., Martina, B., & Battegay, E. (2004). Blood pressure and heart rate of students undergoing a medical licensing examination. *Blood Press. 12*(1): 20-4. Retrieved from: https://www.ncbi.nlm.nih.gov/pubmed/15083636

Zhang, Z. H., Su, H., Peng, Q., Yang, Q., & Cheng, X. S. (2011). Exam Anxiety Induces Significant Blood Pressure and Heart Rate Increase in College Students. *Clinical and*

*Experimental Hypertension, 33*(5): 281-286. Retrieved from: http://www.tandfonline.com/doi/abs/10.3109/10641963.2010.531850?journalCode=iceh20

Hong, E. (1999). Test Anxiety, Perceived Test Difficulty, and Test Performance: Temporal Patterns of their Effects. *Learning and Individual Differences*, 11(4): 431-447.

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## Tables

| | | EARLY | ON-TIME | LATE |
|---|---|---|---|---|
| Waiting Period | Diastolic BP (mean % change) | -2.87 (+/-2.85) | -6.09 (+/-3.24) | -13.74 (+/-7.79) |
| | Systolic BP (mean % change) | -4.80 (+/-2.61) | -1.63 (+/-1.90) | -9.77 (+/-3.77) |
| | Heart Rate (mean % change) | +2.39 (+/-4.74) | -4.52 (+/-3.39) | 0.00 (+/-5.09) |
| | Respiration Rate (mean % change) | -18.86 (+/-14.37) | +1.85 (+/-12.20) | +8.87 (+/-18.73) |
| During Quiz | Diastolic BP (mean % change) | +3.71 (+/-4.14) | -6.73 (+/-5.79) | -8.24 (+/-6.92) |
| | Systolic BP (mean % change) | +1.12 (+/-3.12) | -1.09 (+/-3.64) | -4.26 (+/-3.77) |
| | Heart Rate (mean % change) | +8.77 (+/-1.96) | +6.97 (+/-6.35) | +7.93 (+/-4.29) |
| | Respiration Rate (mean % change) | +26.10 (+/-16.76) | +15.36 (+/-19.69) | +61.79 (+/-9.39) |
| | Mean Quiz Scores | 5.375 | 5.375 | 5.625 |

**Table 2.** This table shows the mean percentage change of the variables considered as part of the physiological stress response (diastolic blood pressure, systolic blood pressure, heart rate, and respiration rate) between the either the data collected during the waiting period or the data collected during the quiz compared to the baseline data for the early, on-time, and late experimental groups. This table also shows the mean quiz score for each experimental group. The negative values are shaded in red and indicate that the measurement went down when compared to baseline data. The positive values are shaded in green and indicate the values went up compared to baseline data. Standard errors are listed under the mean percent change in parentheses.

## Figures

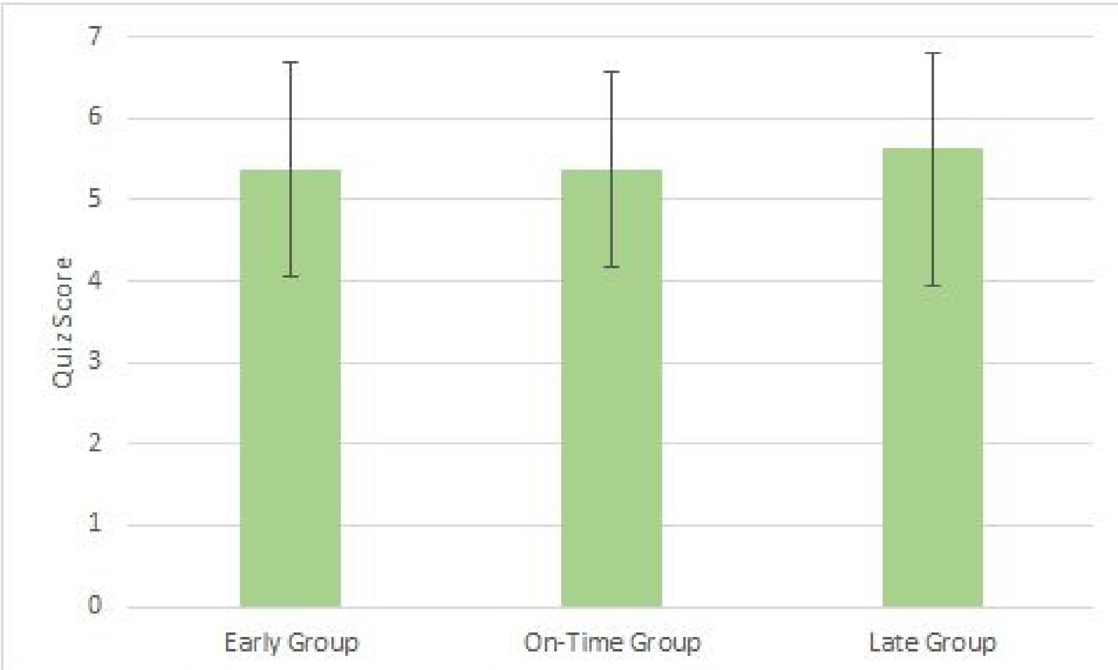



**Figure 2.** Quiz Score averages for experimental groups. This figure compares the mean quiz scores for each experimental group. The bars represent the standard deviations for each group. The early group had a mean score of 5.375 with a standard deviation of 1.30. The on-time group had a mean score of 5.375 with a standard deviation of 1.19. The late group had a mean score of 5.625 with a standard deviation of 1.19.

**Appendix A – Alternate Data Analysis**

An alternate method of data analysis considers the average change of each individual's baseline data, as opposed to the change of the mean of the data, which effectively pools the individual participant data into one number for each group. Because of the natural variation of physiological data from one person to the next, this alternate method may serve as a better indicator of the population trends.

| | | EARLY | ON-TIME | LATE |
|---|---|---|---|---|
| Waiting Period | Diastolic BP (mean % change) | -2.85 (+/-2.64) | -5.05 (+/-3.24) | -9.49 (+/-7.79) |
| | Systolic BP (mean % change) | -4.77 (+/-2.61) | -1.31 (+/-1.90) | -8.50 (+/-3.77) |
| | Heart Rate (mean % change) | +2.52 (+/-4.74) | -3.93 (+/-3.39) | 0.32 (+/-5.09) |
| | Respiration Rate (mean % change) | -7.34 (+/-14.37) | +16.04 (+/-12.20) | +13.04 (+/-18.73) |
| During Quiz | Diastolic BP (mean % change) | +3.58 (+/-4.14) | -5.18 (+/-5.79) | -3.34 (+/-6.92) |
| | Systolic BP (mean % change) | +1.41 (+/-3.12) | -0.24 (+/-3.64) | -2.95 (+/-3.77) |
| | Heart Rate (mean % change) | +8.85 (+/-1.96) | +9.37 (+/-6.35) | +8.82 (+/-4.29) |
| | Respiration Rate (mean % change) | +35.80 (+/-16.76) | +40.95 (+/-19.69) | +68.18 (+/-9.39) |
| | Mean Quiz Scores | 5.375 | 5.375 | 5.625 |

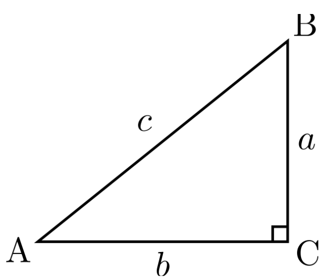
**Table S1.** This table shows the average percentage change for the individuals of each group considered as part of the physiological stress response (diastolic blood pressure, systolic blood pressure, heart rate, and respiration rate) between the either the data collected during the waiting period or the data collected during the quiz compared to the baseline data for the early, on-time, and late experimental groups. This table also shows the mean quiz score for each experimental group. The negative values are shaded in red and indicate that the measurement went down when compared to baseline data. The positive values are shaded in green and indicate the values went up compared to baseline data. Standard errors are listed under the mean percent change in parentheses.

## Appendix B - Quiz Template and Answer Key

1. Quantity A: 1/16 + 1/7 + ¼ Quantity B: ¼ + 1/16 + ⅙
- ❏ Quantity A is bigger
- ❏ Quantity B is bigger
- ❏ The two quantities are equal
- ❏ The relationship cannot be determined from the information given

2. If a is multiplied by 3 and the result is 4 less than 6 times b, what is the value of (a - 2b)?
- ❏ -12
- ❏ - 4/3
- ❏ - ¾
- ❏ 4/3
- ❏ 12

3. It takes Carla three hours to drive to her brother's house at an average speed of 50 miles per hour. If she takes the same route home, but her average speed is 60 miles per hour, what is the time, in hours, that is takes her to drive home?
- ❏ 2 hours
- ❏ 2 hours and 14 minutes
- ❏ 2 hours and 30 minutes
- ❏ 2 hours and 45 minutes
- ❏ 3 hours

4. 


In the triangle above, if the distance from point B to point C is 6 miles and the distance from point B to A is 10 miles, what is the distance from point C to point A?
(Pythagorean Theorem states: $a^2 + b^2 = c^2$)
- ❏ 4
- ❏ 5
- ❏ 6
- ❏ 7
- ❏ 8

5. Quantity A: The diameter of a circle with area 49π Quantity B: 14

(Area of a circle= $\pi r^2$ )

- ❏ Quantity A is greater
- ❏ Quantity B is greater
- ❏ The two quantities are equal
- ❏ The relationship cannot be determined from the information given

6. Joe has $200. If he buys a CD player for $150, what is the greatest number of CDs he can buy with the remaining money if CDs cost $12 each?

- ❏ 6
- ❏ 4
- ❏ 5
- ❏ 3
- ❏ 7

7.

| |
|---|
| $\frac{1}{3} + \frac{2}{5} = x$ |
| $y = 3$ |

Quantity A: y/x Quantity B: 4

- ❏ Quantity A is greater
- ❏ Quantity B is greater
- ❏ The two quantities are equal
- ❏ The relationship cannot be determined from the information given

## Answer Key:

1. B
2. B
3. C
4. E
5. C
6. B
7. A