# The Effect of Acute Psychosocial Stress on Short Term Memory

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University of Wisconsin Madison- Physiology 435
Section 602
Group 5

Key Words: Trier Social Stress Test (TSST), Short Term Memory, Stress

Word Count: 4,661

**Abstract**

Our study's focus was to demonstrate the effects of an acute psychosocial stress event on short-term memory. We hypothesized that an acute psychosocial stress event would lead to an impairment of short-term memory. To induce a psychosocial stress event a Trier Social Stress Test (TSST) was used and blood pressure, heart rate, and respiratory rate were measured before and after to determine if stress occurred. A short-term memory test was administered immediately after the TSST and consisted of a series of randomly assorted letters and numbers followed by blank slides during which the participant recalled the previously shown characters. The results were compared to a control group that did not experience a stress event. There was no statistically significant change in short-term memory scores between the control and experimental groups. There was a statistically significant change in mean arterial blood pressure (P-value = 0.037) likely indicating a stress response was induced. However, there were no statistically significant changes in heart rate or respiratory rate. The final results did not provide statistically significant evidence that the acute psychosocial stress event affected short-term memory. Further research should be done on a larger sample size and with slight variations on the methods to study the effects of stress on short-term memory.

**Introduction**

According to a study performed by the American Psychological Association in 2011, 44% of Americans surveyed replied that their stress had increased over the past five years. The term stress is defined as an event that elicits a range of behavioral and physiological responses based on the individual's perception of control over the situation (Kim & Diamond, 2002). After an individual has been exposed to a stressor, the body undergoes a coordinated neuro-hormonal response to address the event (Muraille et al., 1996). When an individual is subjected to a stressor such as psychosocial stress, the stress response can result in cognition being impaired (Joels & Baram, 2009; Wolf, 2009). One form of cognition, memory, is divided into long-term memory and short-term memory. Long-term memory is defined as information stored in the brain on the order of days, weeks, or years whereas short-term memory is information stored for a brief span of time.

Stress affects memory by causing the body to activate the hypothalamic-pituitary adrenal (HPA)-axis in response to that particular stressor (Feilhauer et al., 2013). The net result of the

HPA-axis activation is the production of stress hormones called glucocorticoids such as cortisol (Trammell & Clore, 2014). Cortisol aids in stress response by mobilizing energy into the bloodstream and delaying long-term processes in the body so that the individual can focus on dealing with the stressor (Chrousos & Harris, 1998). This response causes cardiovascular and respiratory rates to increase in order to disperse the energy throughout the body. Although cortisol is useful in dealing with stressors, there may be potential side effects to cortisol production on memory. Memories are retained by the process of neurogenesis where new connections between neurons are formed. One particular section of the brain involved in neurogenesis and affected by cortisol is the hippocampus (Erickson et al., 2010). Maximal memory performance occurs when glucocorticoid receptors in the hippocampus have low glucocorticoid occupancy (De Kloet et al., 1998).

It has repeatedly been shown that psychosocial stress affects long-term memory due to the effect of cortisol on memory creation resulting in much research examining long-term memory (Wolf, 2006; Lupien et al., 1999). Although psychosocial stress events also trigger a cortisol response in the short term, there is conflicting information on the effect of psychosocial stress on short-term memory (Elzinga & Roelofs, 2005; Kuhlmann et al., 2005). These conflicting results have resulted in less research examining short-term memory (Bentz et al., 2013). Does an acute event that causes psychosocial stress, as evidenced by an increased cardiovascular and respiratory response, result in impaired short-term memory? We hypothesize that an acute psychosocial stress-inducing event, evidenced by increased blood pressure, heart rate, and respiratory rate, leads to impaired short-term memory as measured by a memory test immediately after the stress-inducing event.

In order to test our hypothesis, we propose inducing an acute psychosocial stress-causing event followed by a short-term memory test in order to measure the effect of psychosocial stress on short-term memory. Experimental subjects will be subjected to the Trier Social Stress Test (TSST) in order to induce moderate psychosocial stress. The TSST is a standard experimental protocol for inducing stress in test subjects by recreating an interview scenario for 15 minutes (Olver et al., 2014). Measurements of heart rate, blood pressure, and respiration rate will be taken before and immediately after the TSST or control 15 minute period. These physiological tests will demonstrate the level of stress each participant experiences and will allow for a comparison between stress level and cognitive performance. To measure cognitive performance, we will use our own short-term memory test. Our test consists of a PowerPoint presentation that shows participants slides with varying length strands of numbers and letters that the participant must memorize then write down between slides. The results from the memory test will be used to evaluate short-term memory. The control group will be exposed to the same tests as the experimental group; however, the control group will sit quietly instead of undergoing the TSST before taking the memory test.

**Materials**

- Littmann Master Classic II Stethoscope (3M Health Care, Model 2139, MN)
- LabTron Sphygmomanometer (GE Health Products Inc., Model 204/204X, GA)
- Pulse Oximeter/Carbon Dioxide Detector (NONIN, Model 9843, MN)
- BSL Respiratory Effort Xdcr (BIOPAC Systems Inc., Model SS5LB, CA)
- Consent Forms and Survey (Physiology 435, WI)
- Biopac Software (BIOPAC Systems Inc., Model MANBSL4, CA)
- Memory Test (PowerPoint Presentation, Model Year 2007, WI)

## Methods

### *Participants*

All procedures included in our experiment followed the guidelines and regulations presented by the University of Wisconsin- Madison and the Journal of Advanced Student Science. Every participant was a volunteer student taking Physiology 435 and gave written consent to partake in our experiment, shown in Appendix1 .

### *Group Assignment*

There were two groups that took part in this experiment, a control group and an experimental group. The participants were assigned randomly to one of the groups immediately before the initial physiological measurements.

### *Experimental Procedure*

Participants filled out a simple survey asking for their age, gender, and any relevant health risks. Next, measurements of blood pressure, heart rate, and respiratory rate were recorded for each participant. The stethoscope and sphygmomanometer, pulse monitor, and respiratory effort were used to obtain each respective measurement.

Following measurements, participants in the experimental underwent the Trier Social Stress Test (TSST). The TSST lasted 15 minutes and consisted of scientifically supported stress-inducing exercises. Multiple proctors administered the test, each with specific roles ranging from taking vital signs to administering instructions. In the first five minutes, participants were given a note card and pencil to prepare notes for a presentation on African Rain Dancers. Before the participant presented, the note card was unexpectedly taken away. For the next five minutes the

participant was told to talk entirely about African Rain Dancers. If the participant stopped talking prior to the five-minute minimum, or talked about a different subject, the proctors strictly steered the participant back to the correct subject for the remainder of the time. Following the presentation, the participant was asked to count backwards from 1,022 in increments of 13. If the participant made a mistake at any point, they were told to start over. The counting continued for the final five minutes of the TSST or until the participant reached zero. Throughout the TSST the proctors remained emotionless. After the TSST, the participant was told another presentation was necessary due to poor performance on the first presentation. Immediately following the TSST, all of the physiological measurements were retaken. Participants that were in the control group quietly sat for fifteen minutes instead of undergoing the TSST then had their measurements retaken.

After the second sets of measurements were recorded for both groups, participants took the short-term memory test, shown in Appendix 2. The short-term memory test was composed of a series of PowerPoint slides, each consisting of varying length strands of letters and numbers. Strands increased from two characters in length to ten characters. Slides with strands were shown for five seconds. After participants viewed the slide with the letter/number strand, a blank slide was shown for ten seconds. This allowed the individual to write down as much of the strand as remembered before moving on to the next slide. Following the conclusion of the short-term memory test, participant's scores were recorded and their participation ended. Although participants in the TSST experimental group were originally told another presentation would be required, the participants were informed that the second presentation was not required and were free to leave (Figure 1). Short-term memory tests were scored by awarding one point for every correct character in the correct position within the strand with a maximum score of 80 points.

A positive control was tested by decreasing exposure time of the short-term memory slides to two seconds. This showed poor memory test performance. To show an increase in vital signs, a positive control was tested through two minutes of intense stair climbing, this is shown in Figure 2**.**

*Data Analysis*

Results obtained were used to calculate means and standard errors for all measurements. The calculated means and standard errors were also used to compare memory test scores and percent changes from baseline in heart rate, blood pressure and respiratory rate measurements using paired t-tests in order to determine if there was a difference or correlation in test scores or percent change from baseline between the control group and the TSST experimental group.

# Results

All test subjects were students from Physiology 435 at UW Madison. There were a total of 16 participants that were split into 8 control and 8 experimental tests. Of the control group, 4 were males and 4 were females. Within the experimental group, there were 3 males and 5 females.

*Respiratory Rate*

Respiratory rate was measured as breaths per minute, both before and after the TSST in the experimental group, and before and after a 15 minute break in the control group. The control group had an average respiration rate of 12.75 +/- 1.41resps/min before the 15 minute wait period and 13.25 +/- 1.29 resps/min after the 15 minute wait period. The experimental group had an average respiration rate of 15.13 +/- 1.42 resps/min before the TSST and 14.625 +/- 1.34 resps/min after the TSST (Figure 3). Average percent change in respiratory rate was an increase

of 6% ± 0.05 for the control and an increase of 6% ± 0.18 for the experimental group. A paired t-test was performed and showed that the average respiration rate change was not significantly different (P-value=0.494) between the control and experimental groups (Figure 4).

*Mean Arterial Blood Pressure (MABP)*

Systolic and diastolic blood pressures were measured before and after the TSST in the experimental group, and before and after a 15 minute break in the control group. Mean arterial blood pressure was calculated using the equation [(2*Diastolic)+Systolic]/3. The control group had an average MABP of 92.0 +/- 1.8 mm Hg before the 15 minute wait period and 90.4 +/- 2.3 mm Hg after the 15 minute wait period. The experimental group had an average MABP of 90.7 +/- 2.1 mm Hg before the TSST and 98.6 +/- 2.1 mm Hg after the TSST (Figure 5). Average percent change in MABP was a decrease of 1% ± 0.03 for the control and an increase of 9% ± 0.02 for the experimental group. A paired t-test was performed and showed that the average MABP change was significantly different (P-value=0.037) between the control and experimental groups (Figure 6).

*Heart Rate*

Heart rate was taken twice, once before and after the TSST in the experimental group, and once before and once after a 15 minute break in the control group. The control group had an average heart rate of 69.0 +/- 3.16 beats/min before the 15 minute wait period and 69.1 +/- 2.9 beats/min after the 15 minute wait period. The experimental group had an average heart rate of 77.0 +/- 2.4 beats/min before the TSST and 95.9 +/- 2.1 beats/min after the TSST (Figure 7). Average percent change in heart rate was 0% ± 0.03 for the control and an increase of 26% ±

0.13 for the experimental group. A paired t-test was performed, and revealed the average percent change in heart rate was not significant but verging on significance (P-value=0.052) (Figure 8).

*Memory Test*

A memory Power Point test was performed after all of the secondary measurements were recorded from the subjects. The memory test was out of a possible 80 points, with one point being awarded for every correct character the subject was able to recall from the letter/number strand. The scores were then converted to percent correct. The control group scored 68% $\pm$ 4% correct while the experimental group scored 65% $\pm$ 3% correct. A paired t-test was performed comparing the average control group's score to the average of the experimental groups. The t-test revealed a P-value=0.224 which is not significant (Figure 9).

# Discussion

Results did not provide evidence of a change in short-term memory due to a psychosocial stress event. This could be due to faulty execution of the experimental protocol. There were inconsistencies between the participants. Not all participants were in the same room when taking the short-term memory test or when having a fifteen-minute break in the control group. There were a different number of proctors in the room for each participant; sometimes five people were in the room and sometimes less. While these probably were not major contributors to the lack of effect of stress on short-term memory, making a better, more replicable experiment could provide clearer results.

We did not see significant increases in all three of our physiological measurements. Blood pressure did result in a significant change. This result could possibly support that some form of stress was induced since the trend was an increase in the blood pressure. However, during the TSST the participants were standing while giving their presentation on African Rain

dancers while the control group sat the entire time. The change from sitting to standing position may be a possible reason for the statistical difference in mean arterial blood pressure. Heart rate and respiratory rate did not have a significant change. In some subjects heart rate and respiratory rate increased slightly along with MABP. An alternative explanation for increased physiological measurements could have resulted from epinephrine or norepinephrine as they are immediately released during stress and have immediate effects due to being protein-like amine hormones. Additionally, cortisol does not peak until 10 minutes after stress is induced, possibly contributing to the lack of significance between control and experimental heart and respiratory rates (Kirschbaum et al. 2008). In future experiments, the short term memory test should be administered 10 minutes after the TSST to compensate for the delayed effects of cortisol. Furthermore, significant changes in physiological measurements would now be expected 10 minutes after administration of the TSST due to peak cortisol levels. A different method could be used for further testing in order to provide a larger stress response. One way this could be done is by testing men and women in separate experiments as men performed better in the counting portion whereas women performed better in the presentation portion. Finally, directly measuring the levels of stress hormones in the body would give a better idea of whether the body was responding to the psychosocial stress event with a full stress response.

Making continuous measurements of blood pressure, heart rate and respiratory rate during the TSST and the short term memory test would have provided more accurate stress measurements. This could be performed in future experiments, but would require more planning ahead of time for this experiment. For example, we would have had to use different equipment to take continuous physiological measurements during the TSST and short term memory test. ECG continuously measures heart rate, but it prevents the participant from writing. We were unable to

use the ECG because the participants were required to write for the TSST and short term memory test according to our protocol.

In the future, it would be ideal to acquire continuous measurements during the TSST to ensure the participant is stressed and to ensure that the participant is still stressed when measuring memory. In order to allow continuous measurements, future studies would need to use a different short-term memory test that can be performed without writing or much movement. The short term memory test used in this experiment was developed based on short term memory tests researched online and is considered a serial recall task. A serial recall task requires the participant to recite the sequence in the order that it is presented. There have been conflicting results on the test's effectiveness, but similar tests have been used in these types of studies (Schoofs et al. 2008). In this study, character sequences were made by randomly selecting letters and numbers, eliminating sequences that looked too similar to words. Movement and elimination of writing during the TSST should also try to be reduced if possible. The TSST is a standardized test commonly used in research experiments to induce stress and thus it may be a challenge to eliminate parts of it while maintaining legitimacy.

Another change in the method could be to find a short-term memory test that, in addition to reducing arm movement, has been scientifically proven to test for short-term memory accurately and consistently. The short-term memory test used in this experiment may have been too challenging to allow a good comparison between the control group and the experimental group. Future studies may consider using an n-back paradigm as a short-term memory test. This test consists of participants being presented with multiple sequences of stimuli that they must memorize and then being asked to identify stimuli from *n* steps earlier among non-presented stimuli. This memory test could be done without the participant writing and has been shown to

be an effective way to test short-term memory (Schoofs et al. 2008). Additionally, using more participants and selecting participants in a more random manner would also improve the quality of this study.

We saw evidence that a stress response may have occurred in participants and that there was a slight decrease in memory test performance. The results were mostly insignificant but they provide ground work for further research in how acute psychosocial stress events affect short-term memory.

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## Figures

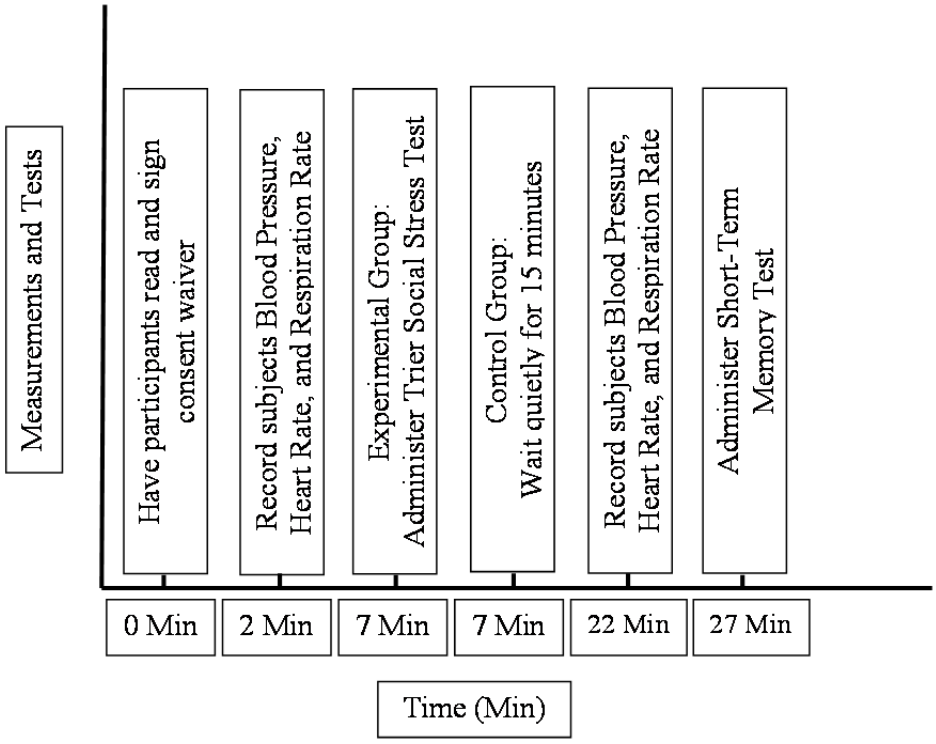


**Figure 1:** Figure shows timeline for the experimental and control procedures. After participants have read and signed the consent waiver, resting blood pressure, heart rate, and respiration rate were recorded. Experimental groups underwent the Trier Social Stress Test (TSST) following measurements while the control group waited quietly for the same amount of time (15 minutes) as the experimental group. Participants then underwent a final round of blood pressure, heart rate, and respiration rate measurements. Finally, participants took the short-term memory test and were allowed to leave after it was finished.

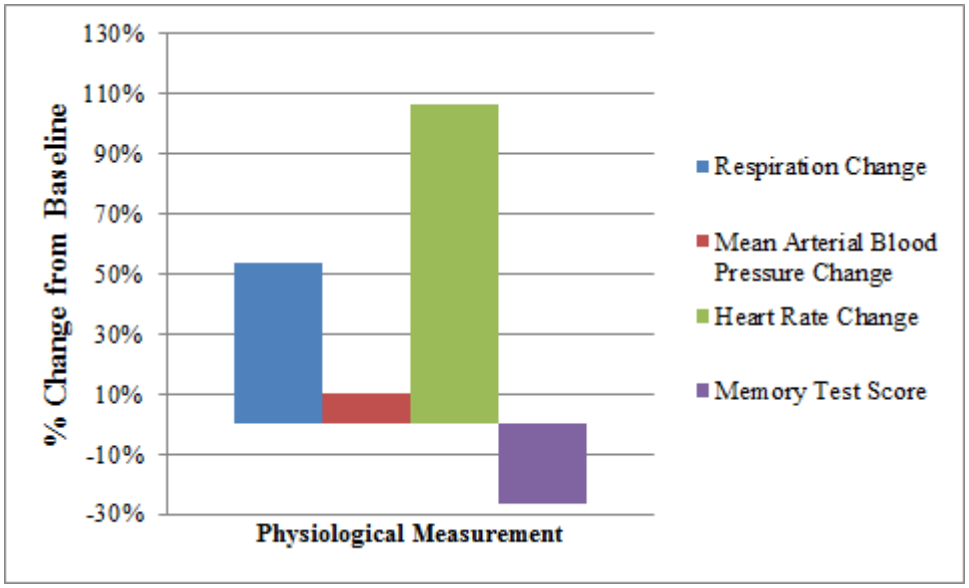


**Figure 2:** Bar graph depicting the percent changes from baseline of physiological measurements in the positive control. The subject underwent two minutes of vigorous exercise in order to increase respiration rate shown in blue (53%), mean arterial blood pressure shown in red (10%), and heart rate shown in green (106%). The subject also took a modified memory test which led to a lower score relative to the negative control shown in purple (-26%). Values were calculated from n=1.

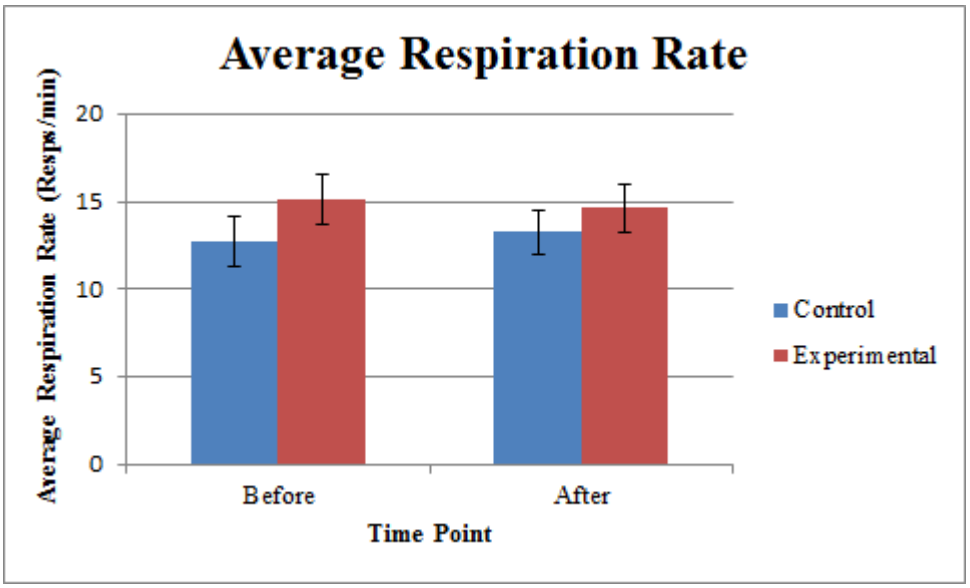


**Figure 3**: Bar graph depicting the average respiration rate of control and experimental subjects. The x-axis shows the time point of the measurement and the y-axis shows the average respiration rate in respirations/minute. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

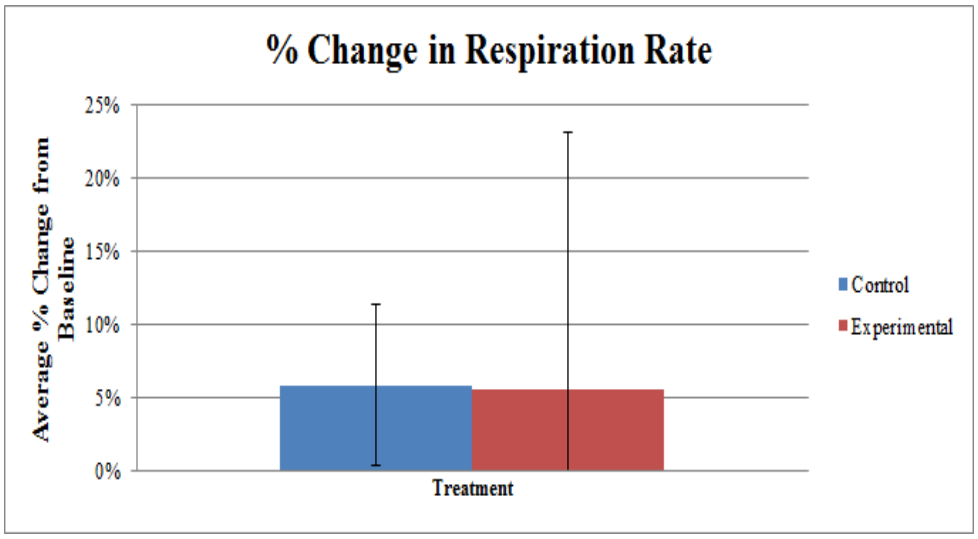


**Figure 4:** Bar graph depicting the average percent changes in respiration rate for control and experimental subjects. The x-axis shows the Treatment group and the y-axis shows the average percent change from baseline. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

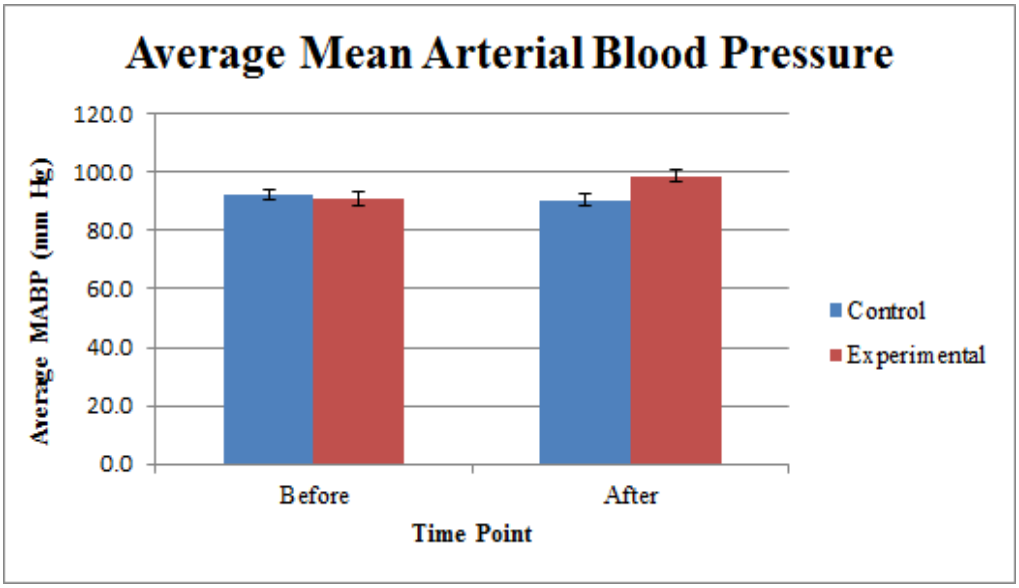


**Figure 5**: Bar graph depicting the average mean arterial blood pressure of control and experimental subjects. The x-axis shows the time point of the measurement and the y-axis shows the average MABP in mm Hg. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

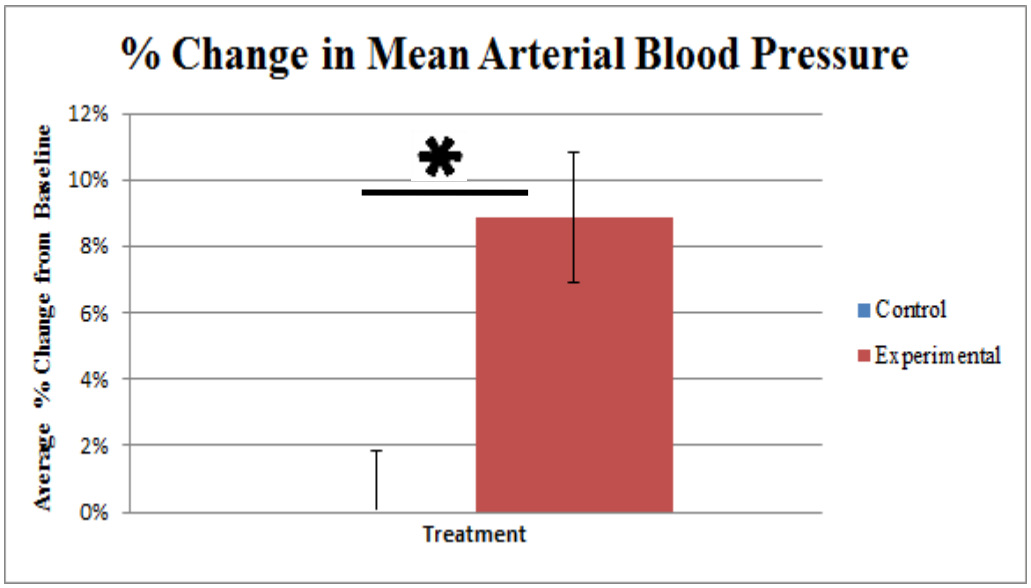


**Figure 6:** Bar graph depicting the average percent changes in mean arterial blood pressure for control and experimental subjects. The x-axis shows the Treatment group and the y-axis shows the average percent change from baseline. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

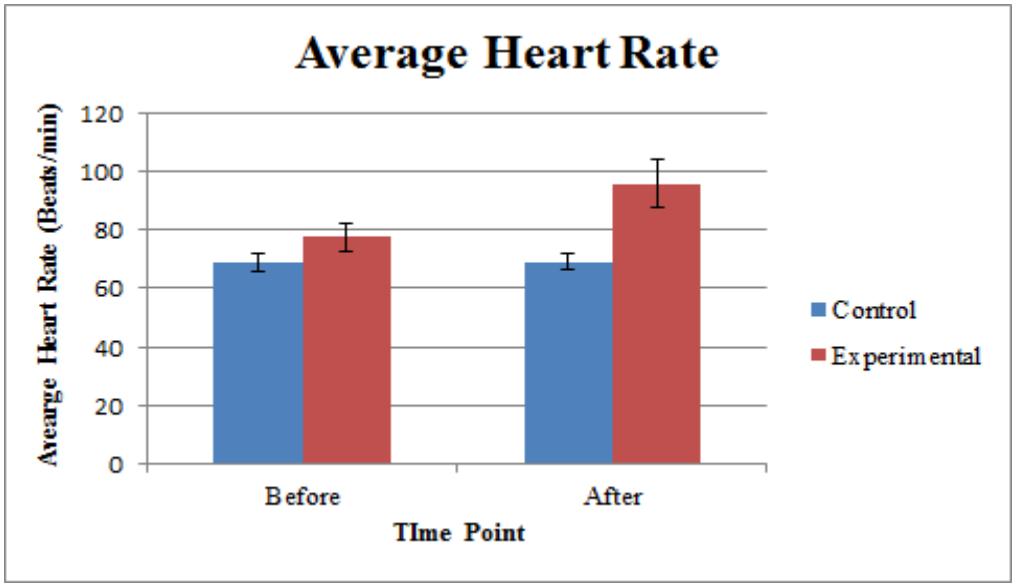


**Figure 7:** Bar graph depicting the average heart rates of control and experimental subjects. The x-axis shows the time point of the measurement and the y-axis shows the average heart rate in beats/minute. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

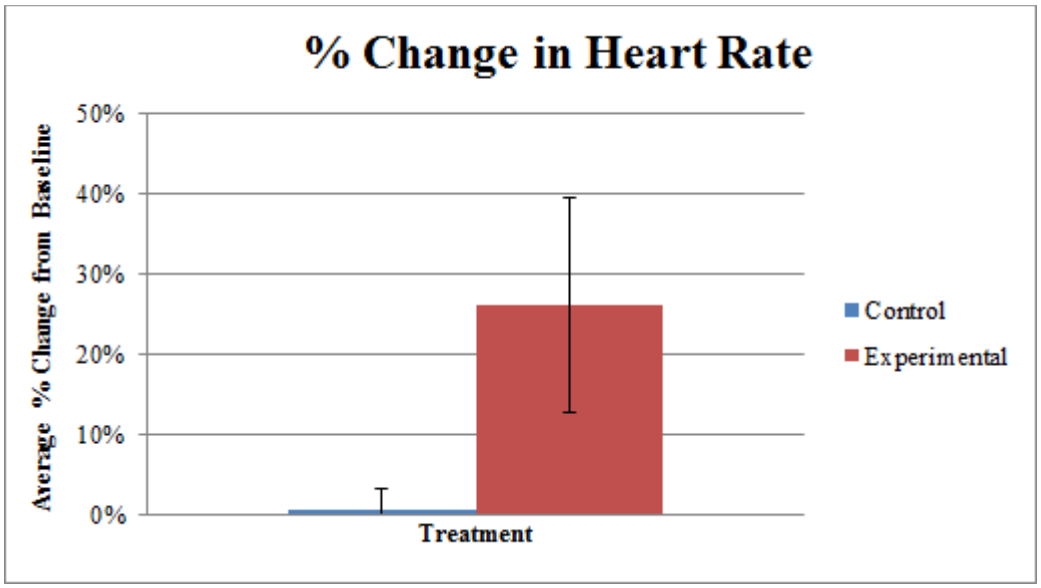


**Figure 8:** Bar graph depicting the average percent changes in heart rate for control and experimental subjects. The x-axis shows the Treatment group and the y-axis shows the average percent change from baseline. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

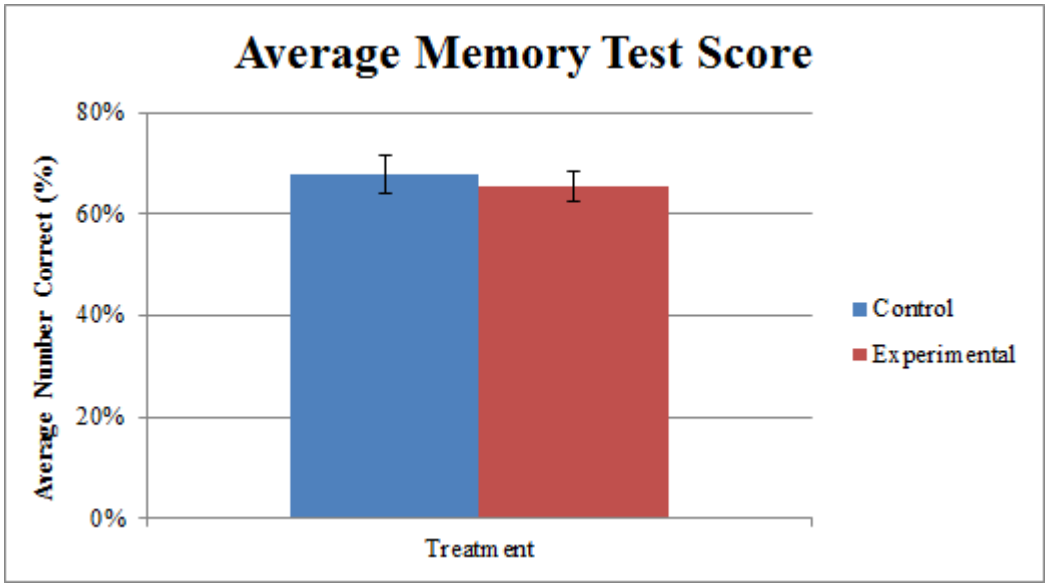


**Figure 9:** Bar graph depicting the average memory test score of control and experimental subjects. The x-axis shows the time point of the measurement and the y-axis shows the average number correct as a percent. The blue columns represent the control group and the red columns represent the experimental group. Values were calculated from n=8 for both the control and experimental groups.

# Appendix 1: Subject Consent Form

**UNIVERSITY OF WISCONSIN-MADISON**

**Research Participant Information and Consent Form**

**Title of the Study:** The Effects of an Interview Situation on Short Term Memory
**Principal Investigators:** Natalie Emholz, Eric Lardinois, Devon Miller, Shane Scott, Sarah Timmler, Chuan Shun Chen

**DESCRIPTION OF THE RESEARCH**
You are invited to participate in a research study about Short Term Memory.
You have been asked to participate because you are enrolled in Physiology 435.
The purpose of the research is to study the effects of interview situation on short term memory.
This study will invite the participation of all students enrolled in Physiology 435.
This research will take place within Physiology 435 laboratory sections.

**WHAT WILL MY PARTICIPATION INVOLVE?**
If you decide to participate in this research you will be asked to participate in an interview situation followed by a short term memory test.
Your participation will last approximately 30 minutes.
After the semester is completed, this data will be used in a paper that will be submitted to Journal of Advanced Student Science.
No credit will be assigned for your complete and voluntary participation. If you do not wish to participate, simply return this blank consent form.

.**ARE THERE ANY RISKS TO ME?**
No health related risk. There will be use of non-invasive equipment.

**ARE THERE ANY BENEFITS TO ME?**
The chance to be a part of a published research project.

**HOW WILL MY CONFIDENTIALITY BE PROTECTED?**
While there may be printed reports as a result of this study, your name will not be used. Only group characteristics will be reported – that is results with no identifying information about individuals will be used in any reported or publicly presented work.

**WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?**
If you are not satisfied with response of research team, have more questions, or want to talk with someone about your rights as a research participant, you should contact Dr. Andrew Lokuta, 608-263-7488, ajlokuta@wisc.edu.

Your participation is completely voluntary. If you decide not to participate or to withdraw from the study it will have no effect on your grade in this class.
Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research and voluntarily consent to participate.
Name of Participant (please print):_____

_____ _____
Signature Date

# Appendix 2: Memory Test

The memory test Power Point that we used on the test subjects. The test was performed in slide show mode, and set up so that the subject had 5 seconds to memorize each slide, followed by 10 seconds to write down what was on the previous slide. There were 11 number/letter strands to memorize, organized from shortest to longest.