Meditative breathing yields inconclusive results in stabilizing physiological variables following fear-induced acute stress in college students

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Abstract:

Many universities have turned to meditation and breathing exercises as a potential means to help students manage acute and chronic stress. We hypothesized that performing a short breathing exercise immediately after watching a horror clip would return physiological indicators of stress (including heart rate, electrodermal activity, and blood pressure) back to pre-video baseline levels faster than a control group who did not perform the meditation, as measured in university students. This was based on a rationale that a focused breathing exercise can increase parasympathetic activity and lower levels of cortisol and adrenocorticotropic hormone. The hypothesis was tested by having participants watch a short horror clip followed by a period of either a guided breathing exercise (experimental) or rest (control) while heart rate, electrodermal activity (EDA), respiration, and blood pressure were measured. No significant differences between the experimental and control group were supported, as p-values obtained from t-tests performed for all measurements were above a significance level of 0.05. With further study, we believe that significant data could be obtained supporting the idea that meditation can help relieve stress in college students.

Introduction:

Stress management is a battle that many college students face every year. According to the Anxiety and Depression Association of America, eighty percent of college students in the United States experience daily stress. This number is thought to be on the rise (Stress 2008). Cycles of exams throughout an academic semester create spikes of acute stress. Over time, these repeated bouts of acute stress can lead to chronic stress. Studies show that stress over an extended period of time can lead to headaches, high blood pressure, diabetes, heart problems, skin conditions, asthma, arthritis, depression and anxiety (Pruthi, 2013). Physiological changes associated with acute and chronic stress are thought to result from increased activation of the sympathetic nervous system that occurs when an individual is experiencing stress (McEwen et al., 1993). As universities look to combat this growing issue, many have turned to meditation and breathing exercises as a potential means to help students manage daily stress, as well as heightened stress that occurs when preparing for and taking exams.

Meditative breathing following fear-induced stress

Multiple studies have supported the use of a meditation program to manage both acute and chronic stress in college students (Janowiak and Hackman, 1994; Oman et al., 2008). One study of 45 college students found that meditation decreased levels of perceived stress. Stress levels remained reduced throughout the two month follow up period (Oman et al., 2008). Another study of 88 participants showed decreases in physiological variables associated with acute stress compared to the control group (Nyklíček et al., 2013). An additional study of 34 participants showed decreases in heart rate and galvanic skin response in the meditation group following induction of acute stress compared to the control group (Singh et al., 2012). Meditation is thought to accomplish this decrease in stress levels by increasing parasympathetic activity and decreasing circulating levels of cortisol and adrenocorticotropic hormone, which are integral to the flight or fight response that is induced in stressful situations (Deckro, 2002). This increase in parasympathetic activity can offset the physiological changes induced by stress, such as increases in heart rate, respiration rate, blood pressure, and changes in electrodermal activity (EDA), accelerating these variables' return to a resting baseline. Spending even a few minutes performing a meditation exercise can help promote feelings of relaxation after a stressful event (Pruthi, 2014).

We investigated the ability of a short breathing exercise to bring study participants back to baseline vital measurements (heart rate, EDA, blood pressure, and respiration) following a fear-induced stress response stimulated by viewing a horror film clip. While we realize that the acute stress response experienced while watching a horror film is different than that created by daily student life, both situations lead to activation of the sympathetic nervous system, resulting in increased heart rate, electrodermal activity and blood pressure (Janowiak and Hoffman, 1994; Tovian et al; Iwata and Mikuni, 1980). Because of the expected decrease in sympathetic activity, we expected the electrodermal activity of the meditation group to return to the participant's baseline levels faster than the control group. Based on data supporting the use of meditation as a stress management technique, we hypothesized that performing a short breathing exercise immediately after watching a horror clip would return physiological indicators of stress (including heart rate, EDA, and blood pressure) back to pre-video baseline levels faster than a control group who did not perform the meditation, as measured in university students.

The hypothesis was tested by having two groups of college students watch a video composed of horror clip followed by a guided breathing exercise video for the experimental group, or a rest period for the control group. Participants' heart rate, EDA, and respiration rate were measured continuously throughout each trial. Blood pressure was measured before, during, and after each trial. These physiological variables were selected for measurement because they are under direct sympathetic control and are therefore indicators of stress. Elevation of these variables indicated an increase in sympathetic nervous system activity. A survey was administered following participation in the study to qualitatively supplement the data and gather relevant background information on study participants such as past meditation experience, perceived daily stress levels, and current stress management techniques (Appendix A).

Materials and Methods:

Participants in this study were gathered on a voluntary basis and they gave informed consent. All participants were current college students at the University of Wisconsin-Madison, ages 20 to 22. Twenty-four participants were gathered; however, data was only successfully collected for nineteen participants due to technical difficulties. Of the nineteen participants, there was a total of 12 experimental subjects and 7 control participants. Participants were assigned to experimental or control groups by flipping a coin, where "heads" was assigned to watch the experimental video and "tails" was assigned to the control video. The control video consisted of a two-minute horror clip followed by a three minute recovery period, while the experimental video was the same short horror clip followed instead by a three minute meditative breathing video.

Subjects were given a consent form explaining what their participation would entail. After the form was signed, the researchers began connecting the respiratory transducer and EDA transducer to the BIOPAC® Analog to Digital Converter Model MP36. Setup and placement of devices was done following the Biopac Student Lab Manual 4.0. A SS5LA Respiratory Transducer was fastened just below the subject's armpit. Respiration data was gathered solely as a way to monitor the compliance of the experimental group during the guided breathing portion of the video. A Nonin Pulse Oximeter Model 9843 was placed on the right index finger of the participant. Because the pulse oximeter does not connect directly to the computer, its monitor screen was videotaped throughout the duration of the experiment. This allowed us to continuously monitor heart rate while allowing the participant to be alone in the room, rather than having an investigator present. To measure electrodermal activity, EDA Transducers (SS3LA) with Isotonic Recording Electrode Gel (GEL101) were wrapped around the index and middle finger of the participant's left hand. The Omron Digital Automatic Blood Pressure Monitor and ComFit™ Cuff Model BP791IT were wrapped around the participant's left bicep, with their arm flat on the desk, and palm facing up throughout the duration of the experiment. The software used to collect data was BIOPAC® Student lab system: BSL 4 software.

Baseline EDA, respiration, and heart rate measurements were obtained by having all devices running for one minute prior to starting the video. A baseline blood pressure was taken before the video as well. All measurements, except for blood pressure, were measured continuously throughout the study. Blood pressure measurements were taken before the video began, immediately after the scary portion of the video, and again after the guided breathing exercise or rest period. During the video, the participant wore noise canceling headphones to minimize distractions.

The researcher began the video, turned off the lights, and exited the room, leaving the participant alone for the duration of the study. Instructions were given on the monitor at the beginning of the video instructing the participant to focus on the content of the video and minimize distractions. The experimental and control videos both consisted of the scary *Lights Out* video created by Youtube subscription channel, Ponysmasher. Following the two and a half minute horror film, the video transitioned to text that instructed the participant to press the start button on the blood pressure cuff to record the measurement. After blood pressure was taken, the experimental video contained a guided meditative breathing exercise featuring clips taken from the *5 Minute Calming Meditation with Guiding Voice* film created by Youtube subscription channel, The Honest Guys. The control group was instructed to sit for a few minutes as the video played white noise until a researcher returned. After completion of the horror film and period of either guided breathing or rest, the researchers re-entered the room, disconnected all devices, and administered a short post-study survey to collect more data that may have helped explain the results of the experiment. Following the completion of the survey, the subject was then allowed to leave. A complete timeline of participant events is shown in Figure 1.

Statistical analyses were performed in order to investigate the significance of the data. To analyze the heart rate data, a two sample t-test was performed at every ten second interval to see if the average heart rates of the experimental or control group were statistically different. P-values were obtained and compared using a significance level of 0.05. In addition, standard deviations at each ten second interval were computed along with the maximum, minimum, range, and baseline average heart rates of each group. Blood pressure data was analyzed by performing two sample t-tests using the average systolic and diastolic blood pressure of each group for the measurements taken before, during, and after the video. P-values were obtained and compared at a significance level of 0.05. For the electrodermal activity, the recorded measurements were averaged over four second periods in order to condense the data. Two sample one-sided t-tests were performed at each time interval to see if the EDA averages of the groups were significantly different when p-values were compared at a significance level of 0.05.

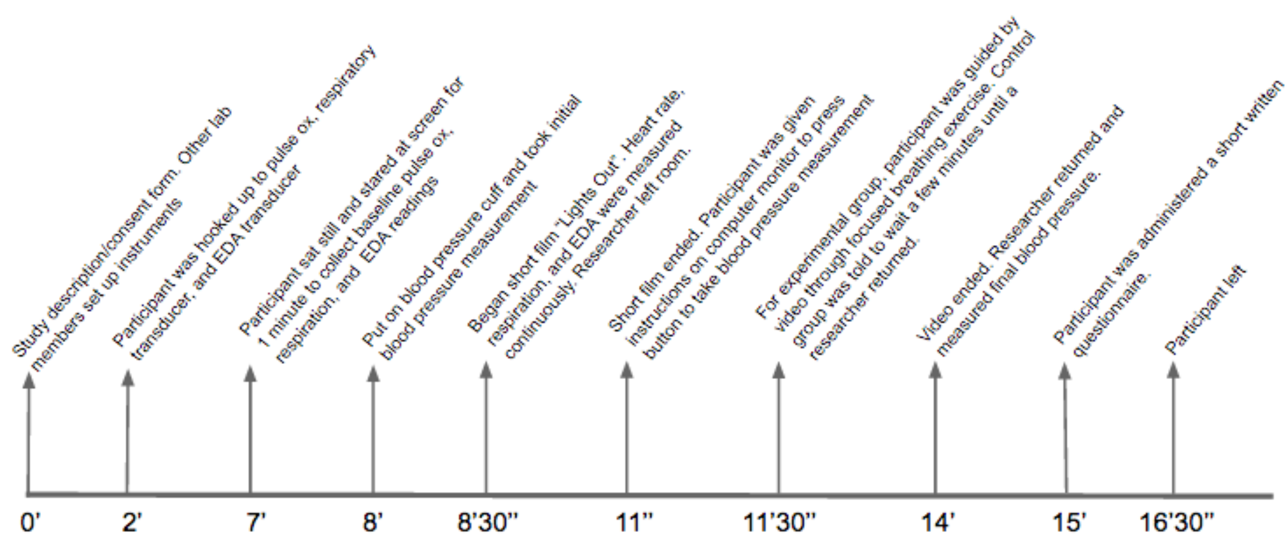

Figure 1: Timeline of volunteer experience showing when specific events and measurements occurred throughout the study. Total volunteer time was 16.5 minutes, and the video duration was 6 minutes.

Results:

Heart Rate

Average heart rates for both the control and experimental groups were calculated at ten-second intervals and plotted over time (Figure 2). T-tests between control and experimental groups at each time interval produced p-values ranging from 0.204 to 0.499. Standard deviations ranged from 7 to 26 for both experimental and control groups. Maximum, minimum, range, and baseline heart rates of the groups were compared and p-values of 0.4255, 0.4766, 0.3729, 0.4837 were obtained respectively (Figure 3). Figure 4 shows the heart rate data for a single participant in the experimental group, where maximum heart rate was 109 beats/min, minimum was 75 beats/min, and their end heart rate was 81 beats/min.

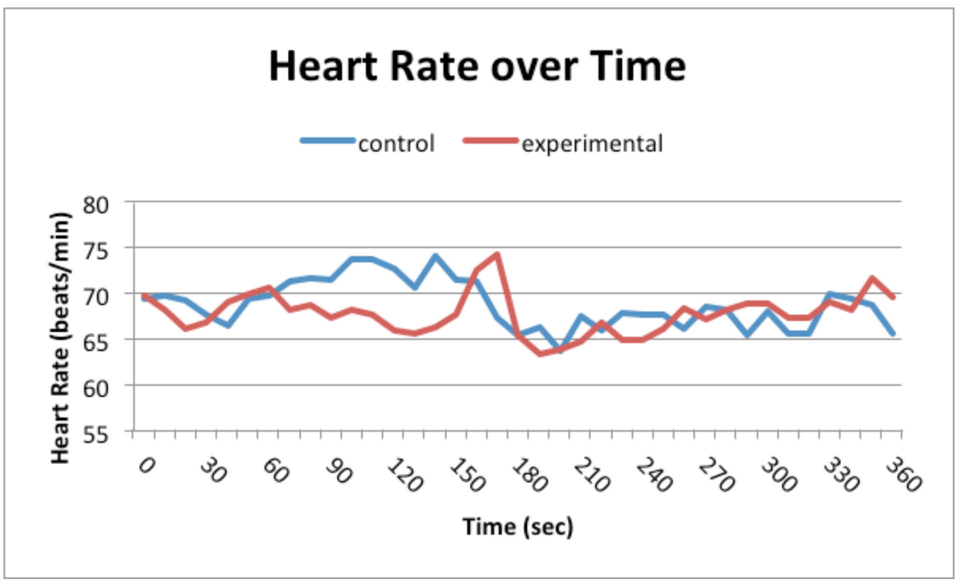

Figure 2: The average heart rates of the experimental and control groups plotted over the 6 minute video time (scary video + meditation or rest video).

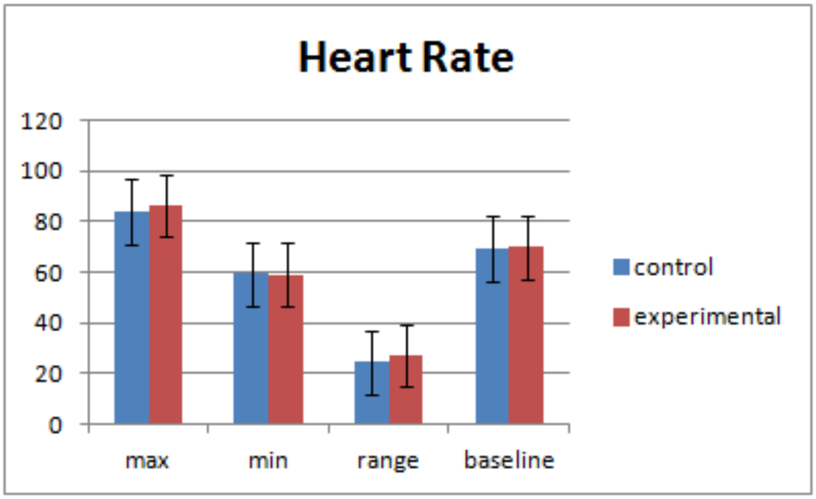

Figure 3: The maximum, minimum, range, and baseline heart rates of the experimental and control groups were calculated and represented in a bar graph along with error bars. P-values were calculated using t-tests.

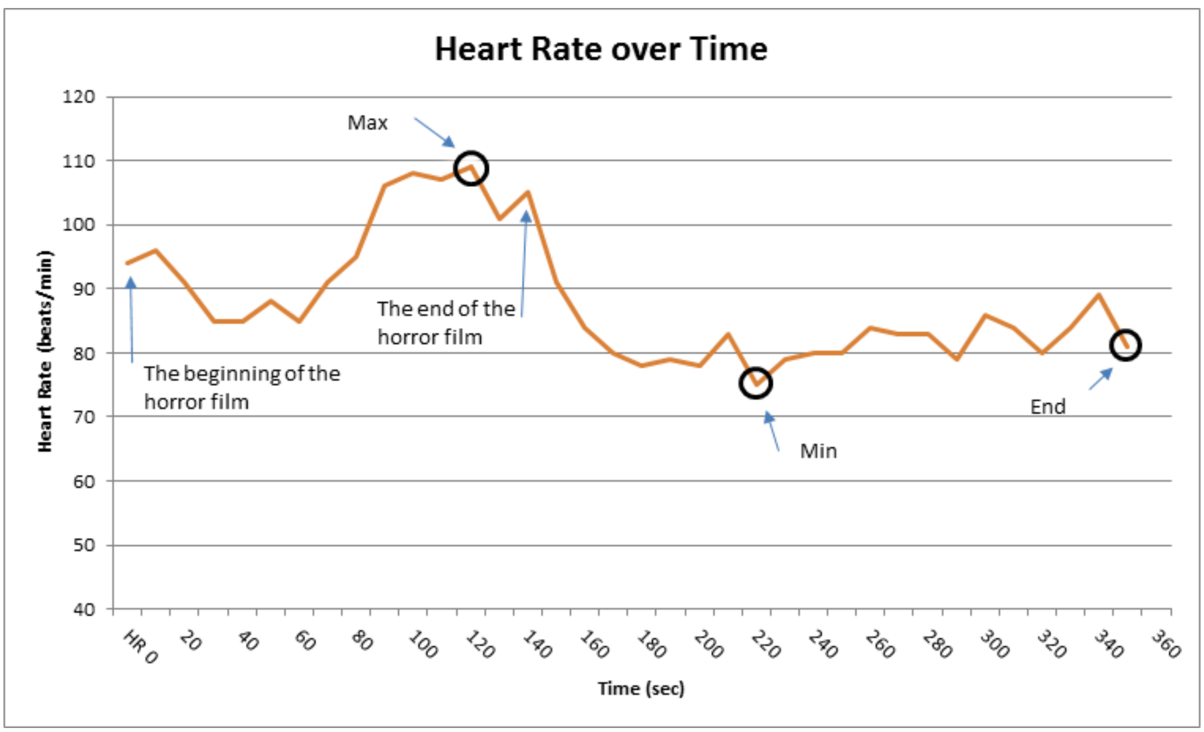

Figure 4: Example of an individual experimental test subject's heart rate response to stressful stimuli and subsequent guided meditation during the 6 minute video (scary video + meditation or rest video).

Blood Pressure

Group averages for each blood pressure reading over the course of the experiment were plotted over time (Figure 5). P-values comparing the average systolic and diastolic blood pressures between groups ranged from 0.2118 to 0.4860 at various time points. Figure 6 shows blood pressure data for a single participant with a baseline reading of 105/65, post-horror film reading of 109/60, and final reading of 98/65.

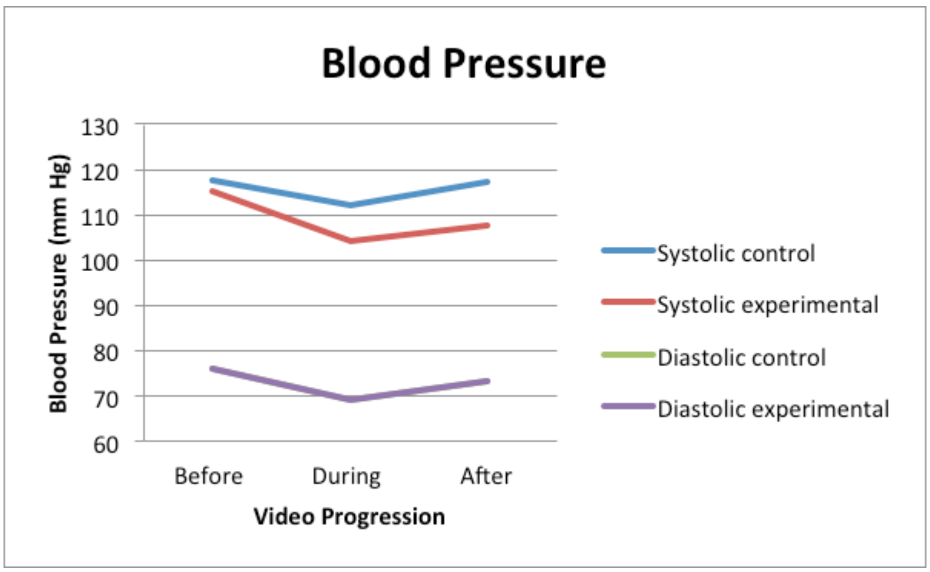

Figure 5: Average systolic and diastolic blood pressures for the experimental and control groups plotted over time. The diastolic values for control and experimental overlap and are both represented by the purple line.

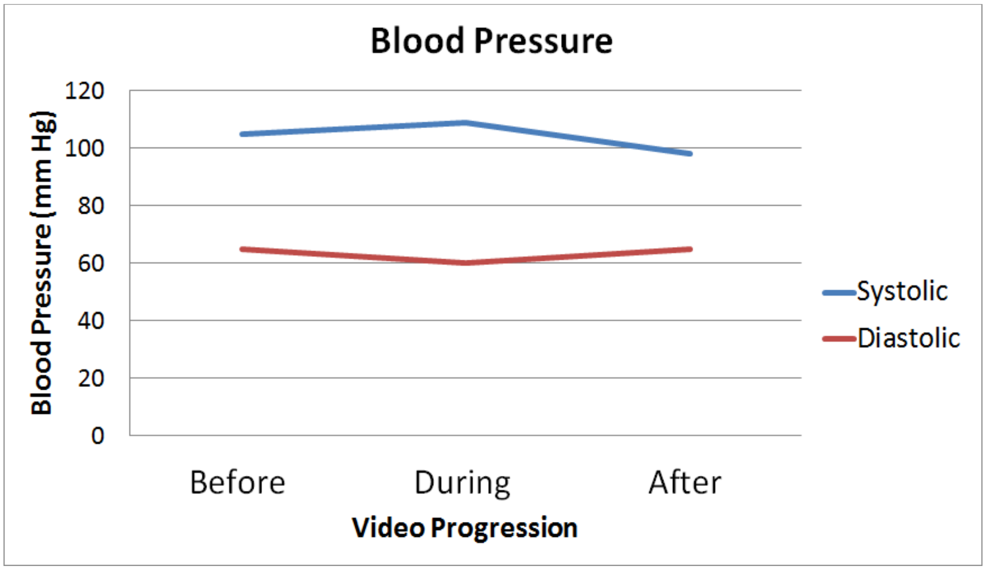

Figure 6: Example of an individual experimental test subject's blood pressure response to stressful stimuli and subsequent guided meditation.

Electrodermal Activity

Averages of electrodermal activity over 4 second periods were calculated for the control and experimental electrodermal activity and plotted over time (Figure 7). P-values ranging from 0.095 to 0.383 were calculated at each time interval using a two-sample t-test. Figure 8 shows the electrodermal activity data for a single participant in the experimental group, where maximum conductance was .91 microsiemens, minimum was -.18 microsiemens, and their end conductance was 0.0 microsiemens.

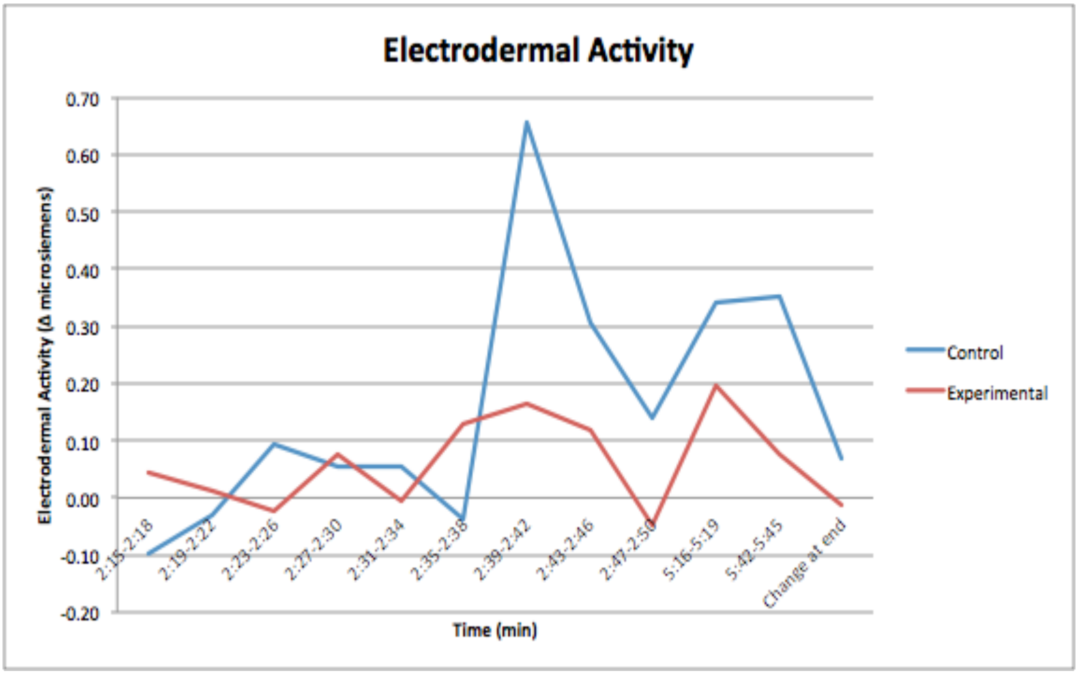

Figure 7: Average electrodermal activity of control and experimental groups over the course of the 6 minute video (scary video + meditation or rest video). Electrodermal activity mimics the sympathetic response of participants.

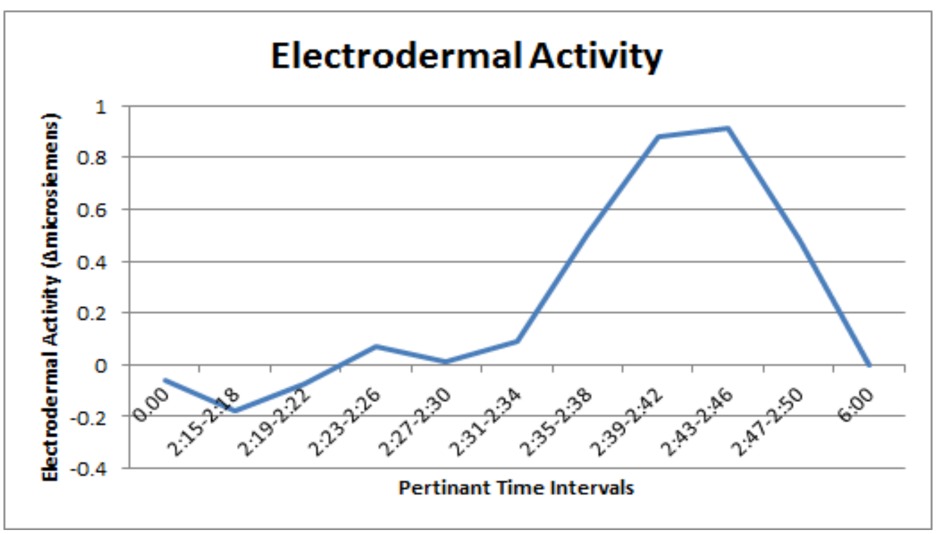

Figure 8: Example of an individual experimental test subject's electrodermal activity response to stressful stimuli and subsequent guided meditation during the 6 minute video (scary video + meditation or rest video). Electrodermal activity, which indicates sympathetic nervous system activity, spiked around the scariest parts of the video (around 2:40), and steadily decreased throughout the meditation portion of the video (3:00-6:00).

Survey responses

In a post-video survey, each participant was asked how much they like scary movies and how scary they thought this video was (Appendix A). This was asked in order to help explain any differences in physiological variables that might be seen among participants. Evaluation of survey responses showed that differences in participant preferences--how much they like horror movies and how scary they found the video--did not correlate to increases or decreases in physiological variables (data not shown).

Discussion:

Data Interpretation

After analyzing data for heart rate, blood pressure, and electrodermal response, there was no statistical evidence to support the hypothesis that performing a short breathing exercise immediately after watching a horror clip would return physiological indicators of stress back to pre-video baseline levels faster than a control group who did not perform the meditation.

<u>Heart Rate</u>

Figure 2 shows some differences between the experimental and control groups at certain time points, but the lowest p-value calculated at a single point was 0.204. Therefore, these differences were not significant, as defined using a significance value of 0.05. To further solidify this conclusion, we analyzed the p-values from the data shown in Figure 3 and saw that there were no statistically significant differences between groups at a significance level of 0.05. This conclusion is also shown visually in Figure 3 by portraying minimal differences in bar height between control and experimental groups. Although the cumulative data was inconclusive, some participants produced heart rate data trends that aligned with the results that we expected. For example, in the results of the subject depicted in Figure 4, the max heart rate was observed in close alignment with when the horror film ended. As the guided breathing portion began, a steady decline in heart rate was observed until the end of the video suggesting that the meditation played a role in lowering the heart rate of that participant.

Blood Pressure

Analysis of the blood pressure data of each group also did not produce p-values below 0.05 at any of the three time periods that the measurements were taken. Therefore, the results showed no statistical importance. However, there were individual participants that showed expected trends in blood pressure data. For example, in the results from the subject depicted in Figure 6, the maximum systolic measurements were seen immediately after the scary film, followed by a decrease in systolic pressure, leading back to the original value or lower. This suggests that the meditation played a role in lowering the participant's blood pressure.

Electrodermal Activity

Data obtained from EDA transducers were perhaps the most relevant when trying to support our hypothesis as it directly measured the participants' sympathetic activity. However, the data still showed no statistical significance across all time points, with all p-values being greater than the significance level of 0.05. Figure 8 displays data from a participant whose data are similar to what was expected. There was a greater change in electrodermal conductance throughout the horror film, but as the guided breathing portion of the video began, changes in electrodermal activity decreased. This lower rate of change suggests the participant's return to baseline values following the guided breathing.

Our initial intent was to calculate the difference between the maximum and minimum values within the control and experimental groups individually, and then for this difference to be compared between the experimental groups. This comparison would allow us to analyze which group had a greater decrease in stress variables following the scare during their period of either meditation or rest. It's important to note that because no time points showed a significant difference between groups for any of the physiologic measurements, we determined that comparing changes between time periods within each group would also yield no significant differences and therefore no further statistical analysis was pursued.

Errors/ Limitations

There were many factors that may have contributed to the lack of significance in the data. First, it is possible that the scary video did not elicit a large enough stress response. Although the participants rated the video to be fairly scary (average scariness was rated a 6.7 on a scale of 1 to 10), this stress did not result in large enough spikes in heart rate, blood pressure, or EDA. In addition, some previous studies investigating the use of meditation as a stress relief technique looked at stress caused specifically by a test-taking environment, whereas our study investigated fear-induced stress (Nyklíček, 2013). It is possible that stress felt by college students in an exam setting is greater than stress felt while watching a short scary video. The induced stress from the scary video may have also been so brief that we were unable to capture the sympathetic effects that were expected. Furthermore, because the fear-induced stress was so brief, the participants recovered from the acute stress relatively quickly. Participants' recovery to baseline values could have been too rapid for the breathing exercise to make a statistically significant impact.

The lack of significant difference between the control and experimental group measurements during the meditation or rest period could also be attributed to lack of compliance of the experimental group. While respiration data showed that all but one of the participants' breathing rate slowed during the video, there are limitations to what can be shown by this type of data, so it may not be indicative of full compliance. It is also possible that the meditation period was not long enough to result in significant differences between the control and experimental groups. The meditation period was relatively short due to time constraints. Had the meditation period been longer, it is possible that the meditation group's values may have been further reduced past original baseline levels.

In addition, there could have also been some variation in data due to technical or human error. The average blood pressure measurements of both the experimental and control taken immediately after the video were lower than the measurements taken before the video and after the meditation or rest period, the opposite of what we expected to happen (Figures 5, 6). These low blood pressure readings could be due to the manner in which the measurement was taken. The participant was alone in the room and took their own blood pressure, unlike the other two. It is possible that the participant did not position their arm palm up and rested on the desk as they were required to when investigators were in the room taking the other two measurements. This technique error may explain the low blood pressure values seen immediately after the scary video. Participants also had different thickness of clothing, which could have affected the accuracy of the blood pressure readings. The galvanic skin response kit could have also resulted in some technical error, as it tended to detect even small finger movements, potentially contributing false readings to the data and therefore diluting the true sympathetic response occurring.

A final factor that could have contributed to the lack of statistical significance is that the number of participants tested was small (n=19) and may not have been large enough to show the trends that were expected. With a larger sample size, observed standard deviations would likely be lower, making it more probable that results would be significant.

Conclusions/Further Research

Although there were no statistically significant differences in physiological indicators of stress between experimental and control groups, we still feel that this study is relevant to college students. Seventy-three percent of the experimental group participants circled "yes" in response to the survey question asking whether or not they felt the guided meditation helped to alleviate the acute stress caused by the video. This provides evidence that meditation may still be an effective way to alleviate acute stress in college students. Because participants felt that the meditation helped to alleviate their stress, this suggests that the meditation had value even though it did not have a statistically significant measurable effect on physiological variables. These survey responses coincide with previous studies that found that meditation decreased levels of self-reported perceived stress in college students (Oman et al. 2008).

Based on the results of prior studies, as well as the large percentage of participants who felt the meditation was useful, we feel that there is justification for further studies to be done regarding stress management through meditation. Repeating this study with a larger sample size, as well as an exam-induced stress setting, would provide interesting insight into the use of meditative breathing as a mechanism to cope with acute stresses associated with exams on college campuses. If a larger study was conducted, an additional control group could be added that could be hooked up to the biopac devices and left alone in the dark room, rather than be shown the scary video. This would allow researchers to investigate whether exposing participants to the scary video is a necessary part of the study, or if the desired stress response can be elucidated with less stimulus. This would be useful information for future studies that could use the "dark room" stimulus rather than making participants watch the scary video.

While our study looked at the use of meditation following an acute stressful event, future studies could investigate the effects of meditating before acute stress takes place. This could provide a better understanding of the practice of breathing exercises before an exam to lessen test taking anxiety. In addition to evaluating the use of meditation in management of acute stress, investigation into the use of meditation in managing chronic stress would also be valuable. These studies would provide more insight into the ability of meditation to decrease acute and chronic stress among college students, as well as decreasing the effects of stress-related illness. The association of stress with high blood pressure, diabetes, cardiovascular problems, and other conditions gives research of this nature clinical importance (Pruthi, 2013).

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Appendix A

SURVEY   Last 4 digits of Student
ID___________

On average, how stressed do you feel daily?

No stress **Extremely stressed**

0 1 2 3 4 5 6 7 8 9 10

What stress management techniques do you use? (circle all that apply)

Alcohol consumption
Exercise
Eating
Hanging out with friends
Meditation
Talking to family
Yoga
Other (explain)___________________________________

Have you ever meditated before?

Yes No

If yes, briefly describe your practice and how often.

____
____

How scary did you find the video?

Not scary at all **Extremely scary**

0 1 2 3 4 5 6 7 8 9 10

Do you like watching scary movies?

Yes No

Do you feel the guided meditation helped alleviate this stress?

Yes No