The Physiological Effects of Stress Induced by the Distraction of a Ringing Cell Phone

Group 16/Lab 601

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Key Words: Auditory, Cell Phone, Electrodermal Activity (EDA), Distraction, Stress, Heart Rate, Respiration Rate

ABSTRACT

Stress in everyday life is associated with many adverse health effects. A variety of studies have explored specific triggers for a stress response, and have identified cell phone use as a potential cause of stress. The objective of this study was to observe the stress response caused by a cell phone ringing while taking a written multiple choice test. The subjects of the study were young adults. The test served as a distraction from each participant's cell phone by requiring the participant to focus their attention on the test questions. During the test, electrodermal activity (EDA), heart rate, and respiration rate were recorded. It was hypothesized that there would be an increase in EDA, heart rate and respiration rate when a subjects' personal cell phone rang while they were focused on completing the test. The data displayed a statistically significant increase in EDA activity after the phone rang, however; a significant increase was not observed in heart rate or respiration rate. Overall, the results of this study suggest that there is a significant physiological stress response to the distraction of a ringing cell phone when measured in terms of EDA.

INTRODUCTION

Stress can be defined as a physical, mental, or emotional factor that causes bodily or mental tension and endangers homeostatic mechanisms. A stressor is an external event or condition that affects an organism. The subjective experience of stress itself lies between the stressor and its effects. In humans, a host of emotional and physical disorders have been linked to stress. Some of these disorders include depression, anxiety, heart disease, and immune system disturbances (Goldberger and Breznitz, 1982).A variety of stressors can be experienced in everyday life. Currently in the literature, cell phones are being examined as potential stressors.

A study performed on Louisiana State psychology students assessed the distracting effects of a ringing cell phone. The study hypothesized that a ringing cell phone in the environment is likely associated with an involuntary attentional orienting response. The study showed that when a cell phone ring is unexpected, in an environment such as a classroom, the disruptive effects may be sustained for a relatively long duration. In addition, findings from students pre-conditioned to university fight songs indicated that familiar songs used as cell phone ringtones have the potential to cause more disruptions. Overall, the study demonstrated that cell phone rings interfere with cognitive performance, and certain factors affect the level of disruption experienced (Shelton et. al., 2009).

In a different study conducted by the Chinese University of Hong Kong, university students were sampled to identify smartphone addiction symptoms. The symptoms were found to be: disregard of harmful consequences, preoccupation, inability to control craving, productivity loss, and feeling anxious and lost. The study found clear evidence that the use of smartphones accompanied with the exhibition of different addiction symptoms (such as preoccupation and feeling anxious and lost) significantly impacted social capital building (Bian and Leung 2015).

These two studies demonstrate a need to delve deeper into research pertaining to cell phone usage. More specifically, cell phones need to be studied as a potential stressor. Based on the conclusion from the study conducted at Louisiana State University, that cell phones have the ability to demand students' attention, and that of the study conducted at the Chinese University of Hong Kong, that feeling anxious and lost are symptoms associated with smartphone addiction, we theorized that the feelings of anxiousness and distraction could be physiological. From this we raised the question: will there be a physiological stress response to a college student's cell phone ringing while completing a motivational task?

To examine this question, we first defined a physiological stress response as a significant increase from baseline values of electrodermal activity, heart rate, and respiration rate. The sympathetic division of the nervous system is what acts in response to stress through what is commonly referred to as the "fight or flight" response. When the body is preparing for fight or flight, sympathetic innervation causes heart rate to increase, increasing cardiac output. Blood is then directed away from the internal organs and toward muscles of the extremities. Respiration rate is also increased. The combined effect of these two processes provides the extremities with enough oxygen to perform at a higher rate to overcome the stressor (Tsigos, 2002). Sympathetic neurons also innervate the skin. Stress affects the activity of sympathetic nerves in the skin by stimulating sweat release (Brown, 2012). By measuring these three involuntary responses to a stressor, we were able to determine whether or not an involuntary stress response was activated due to participants' cell phone ringing.

After defining physiological stress, we defined what our motivational task would be. According to a study on noise and stress, higher levels of stress occur while complex activities are being performed as opposed to monotonous, everyday type tasks (Westman and Walters 1981). Based on this, we designed a test to require large amounts of concentration. The majority of the questions on the test were fairly difficult, with some questions not providing the correct answers. The test was presented to the subjects as a "general high school information test". Presenting the test in this manner, as well as making the test difficult, ensured that the subject will be fully focused and motivated to succeed.

With the parameters of our experiment defined we formulated our hypothesis. We hypothesized that a physiological stress response, as defined by a significant increase from baseline values of electrodermal activity, heart rate, and respiration rate would be induced when subjects heard their phone ring while completing a motivating task.

MATERIALS & METHODS

Research was conducted under the guidance of Physiology 435 faculty at the University of Wisconsin in Madison, Wisconsin. Human participants were examined to determine if the distraction of a cell phone ringing during a task induced a physiological stress response. The experiment was conducted on 21 subjects that were between the ages of 20 and 29. Participants were tested in a room with minimal distractors. All personal belongings were removed from the participant's pockets and placed on a table before beginning the experiment. On their non-dominant hand, a NONIN Model 9843 pulse oximeter/CO2 detector (SN 118103096) was attached to the ring finger and a BIOPAC EDA Finger Electrode Model SS3LA (SN 13013862) was attached to the pointer and middle fingers. The subject's hand was then left in place so that movement would not disrupt the data collection. A BIOPAC Respiratory Transducer Model SS5LB (SN 13116914) was fitted around participants' chest. Respiration and EDA data was recorded using the BIOPAC software system (Figure 2). Heart rate data was recorded by taking a video of the pulse oximeter during the experiment and entering the heart rate at each second into Excel after the conclusion of the experiment (Figure 3).

Next, the researchers conducted a brief verbal technology personality test on the participant. Participants were asked a series of technology related questions in order to ensure that their cell phone was turned on. The specific questions asked can be found in Appendix A.

Based on whether or not their phone was with them, subjects were placed into the experimental (had cell phone with them) or negative control group (did not have cell phone with them). The participant was then given a test and told that it tested general high school information. The specific test questions can be found in Appendix B. Data collection began when the subject was instructed to begin the test. If the subject was part of the experimental condition, after three minutes of taking the test, a researcher called the subject's cell phone and it rang. If the subject was part of the negative control, the subject took the test without any interruptions. For both conditions, the test was terminated by the researcher after four minutes, as adequate data was collected by this time. Figure 1 shows a brief outline of the experimental timeline.

Data analysis was conducted on the time points before and after the cell phone stimulus. To analyze respiration rates, breaths per minute (BPM) values were obtained from the Biopac data for the five respiratory cycles before and after the stimulus. Before and after average BPM values were then calculated and used in the statistical analysis. For EDA, the mean EDA values could be obtained directly from the Biopac data. Mean values for ten seconds before and after the stimulus were used in the statistical analysis. Several time points went into the analysis of heart rate. Baseline heart rates were calculated by taking the average of the heart rates at the first seven seconds in the experiment. Average heart rates before and after the stimulus were also calculated from the seven seconds before and after the stimulus. An average of the heart rates over the last seven seconds was taken as well. Finally, the minimum and maximum heart rates were obtained. Once all of these values had been obtained for each subject, means were calculated to give one average for each value.

A statistician was consulted to analyze the data. P-values were calculated from paired one end tailed t-tests for both the respiration and EDA data. In both cases, the p-values of the experimental and negative conditions were measured to see whether one was greater than the other. In the experimental conditions, the test was whether the after mean values were higher than the before mean values. In the negative conditions, the test was whether the before mean values were higher than the after mean values. An ANOVA test was used to calculate the p-values for the heart rate data. ANOVA tested to see if the baseline, before, after, and end means were the same throughout both the experimental and negative conditions.

Preliminary data was collected on 5 positive controls. Positive controls were monitored using a NONIN Model 9843 pulse oximeter/CO2 detector (SN 118103096), a BIOPAC Respiratory Transducer Model SS5LB (SN 13116914), and a BIOPAC EDA Finger Electrode Model SS3LA (SN 13013862). The equipment was attached to their non-dominant hand and around their chest. Subjects sat still for two minutes and watched a video. The video showed pictures of calm scene and asked the viewer to find what was wrong with it. After 84 seconds, the video showed a scary face in conjunction with a screaming sound. This data was statistically analyzed under the method described above to give p-values of .0142 for EDA, .53 for heart rates, and .0067 for respirations. These results show that there is sufficient statistical evidence of increases in EDA, heart rate, and respirations following the positive stimulus. More simply, the change in physiological activity upon presentation of the scary face and scream demonstrated that the equipment detects stressful responses.

RESULTS

Electrodermal Activity Results

Table 1: Electrodermal Activity Results

EDA	**Before**	**After**	**p value**
Experimental	0.0199	0.1875	0.0000412
Negative	0.0535	-0.0021	0.0429

Table 1 displays the average value of electrodermal activity 15 seconds before and 15 seconds after the cell phone ringing. This was measured in terms of delta microsiemens. The results from the paired one end t-test were p-values of .0000412 for the experimental data and .0429 for the negative data.

Heart Rate Results

Table 2: Heart Rate Results

HR Group Means	**Baseline**	**Before**	**After**	**End**	**p value**	**Significant differences between:**
Experimental	80.4	78.1	77.1	78.6	0.907	None
Negative	75.9	77.9	78.1	78.7	0.908	None

Table 2 displays the mean heart rate values across seven seconds at different points during the experiment: the baseline data collected during the first seven seconds of the test, seven seconds before the phone call, seven seconds after the phone call and the final seven seconds of the experiment. Standard deviations within each of the experimental and negative data groups range from 12.87 to 15.99. The p-values were calculated from the ANOVA test were .907 for the experimental data and .908 for the negative data.

Respiration Results

Table 3: Respiration Rate Results

Respiration	**Before**	**After**	**p value**
Experimental	25.4	32.7	0.2326
Negative	30.4	20.7	0.0311

Table 3 displays the average of five complete respiration cycles before and after the cell phone ringing. Respiration cycles were measured in breaths per minute. The results from the paired one end t-test were p-values of .2326 for the experimental control and .0311 for the negative control.

DISCUSSION

From the EDA analysis results, the low p-value of 0.0000412 in the experimental data gives significant statistical evidence to suggest the before mean values are lower than the after values. The p-value of 0.0429 for the negative data does not provide overwhelming evidence to suggest that one group is higher than the other (See Figure 4).

From the heart rate analysis results, the p-values indicate if there are statistically significant differences between observations at each of the different time periods for both the experimental and negative controls. With very high p-values, there is no statistically significant difference between the heart rate readings at any of the time periods in either condition (See Figure 5). Though there are small observable trends in the heart rate data, the differences are not statistically significant and are instead likely due to random chance. It is likely we did not find a significant difference between heart rates at different time points throughout the experiment because the standard deviations were high, due to a lot of variability in the data. Finding more participants in the future would help reduce the standard deviation and increase the chances of finding statistically significant differences.

From the respiration rate analysis results, there was no statistically significant evidence to support that the respiration rates were higher after the stimulus than before. Some differences could be seen in the data, however; due to the large p-value of .2326 these must be attributed to random chance. A p-value of 0.0311 for the negative data is sufficient statistical evidence to suggest the respiration rates were lower for the after mean value (See Figure 6). Because the "after" mean value, in the case of the negative control did not occur after any stimulus at all, this result must be attributed solely to random chance.

A previous study performed by researchers affiliated with the Massachusetts Institute of Technology measured EDA, heart rate, and respiration rate in conjunction with a stress metric. In the study, EDA was shown to be the best correlating signal to the stress metric, which was defined by an increasing mental task load and distraction while driving a car (Healey and Picard, 2005). This supports our conclusion that there was a significant difference in EDA between the control and experimental groups, as our study also involved a distraction (cell phone ringing) while performing a task requiring focused attention (general information test). This study also found heart rate to significantly increase in response to a stress metric. However, the researchers collected data over a 50 minute period, whereas we only collected data over four minutes in our study. This could explain why our subjects did not express a significant heart rate change, as they may not have had enough time to reach a baseline (calm state) before experiencing a stress response. In congruence with our study, there were no significant findings in relation to respiration rate in the MIT study (Healey and Picard, 2005).

In the literature, EDA has consistently served as a more superior indicator for physiological stress when compared to heart rate and respiration rate. We believe this is true because unlike the heart and the lungs, the sweat glands in the hands are solely innervated by the sympathetic nervous system. Therefore, an increase in EDA can be accredited to an increase in sympathetic activity. The heart and lungs, as well as the majority of other autonomic nervous system responses are duly controlled by the parasympathetic and the sympathetic division. In the relaxed state, the parasympathetic nervous system works to decrease heart rate and respiration rate. Because of these contrasting inputs, the effects of the sympathetic nervous system may not be as immediately detected in heart and respiration rates (Berntson, et. al, 2007).

In addition to being under autonomic control, breathing can be controlled voluntarily. The diaphragm has a sheet of skeletal muscle and is innervated by somatic motor neurons starting in the motor cortex (McKay, et al. 2003). This voluntary control may have had an impact on subjects' breathing when they were made aware that their respirations were being monitored. This might account for variability in respiration rate across the experiment contributing to results that were not significant.

Based on the overall results of the experiment it can be concluded that a cell phone ringing caused an increase in electrodermal activity as hypothesized. Contrary to our hypothesis, both heart rates and respiration rates were not found to increase with this stimulus. Because of these results, we cannot draw a full conclusion on whether or not a cell phone ringing induces a physiological stress response while focused on another task because we defined a physiological stress response as an increase in heart rate, electrodermal activity, and respiration rate. However, it we define a physiological stress response as an increase in EDA alone, we can conclude that a cell phone ringing induces the response.

In order to further test this hypothesis, future experiments should be conducted with a larger number of participants, better equipment to obtain more precise data, and a greater time frame for data collection. All of these factors could have contributed to the inconclusiveness of this study. Different parameters defining physiological stress should also be examined in future studies.

It was suggested that our experiment was conducted in too little time. This suggestion was based on the assumption that the EDA transducer needed a minimum of five minutes to stabilize before starting to record data. This suggestion is justified as it would allow for the participants to fully be at a baseline before they are subjected to the stressful stimulus and would potentially influence the results of the experiment. However, our experiment was under strict time constraints and waiting a full five minutes before starting our experiment was not realistic. To avoid this problem in future experiments, a transducer that takes less time to stabilize should be utilized.

FIGURES

Figure 1: Experimental Timeline

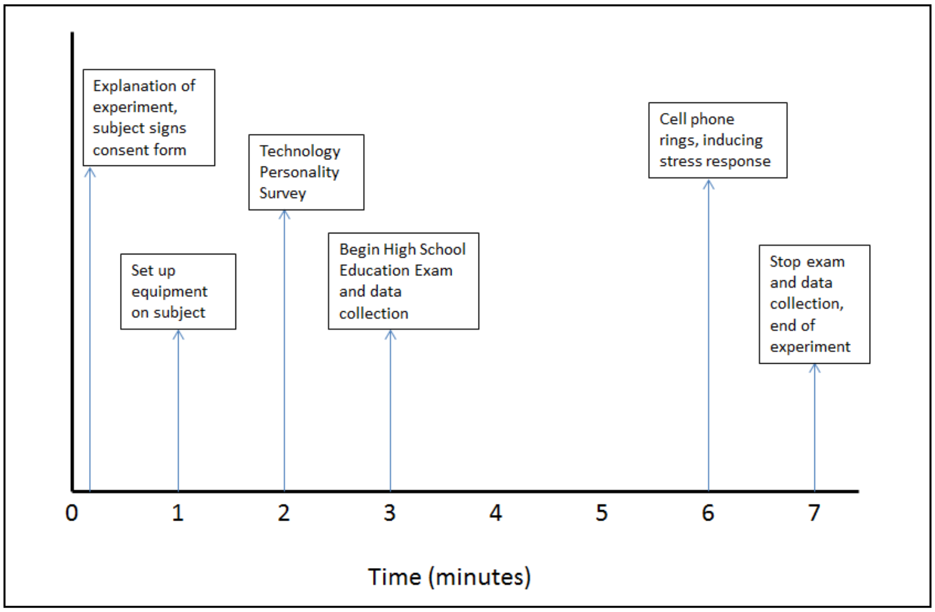

Figure 1 shows a brief timeline of the experimental procedure. The details of the procedure are explained in the Materials & Methods section of this report.

Figure 2: Respiration and EDA Data from BIOPAC System

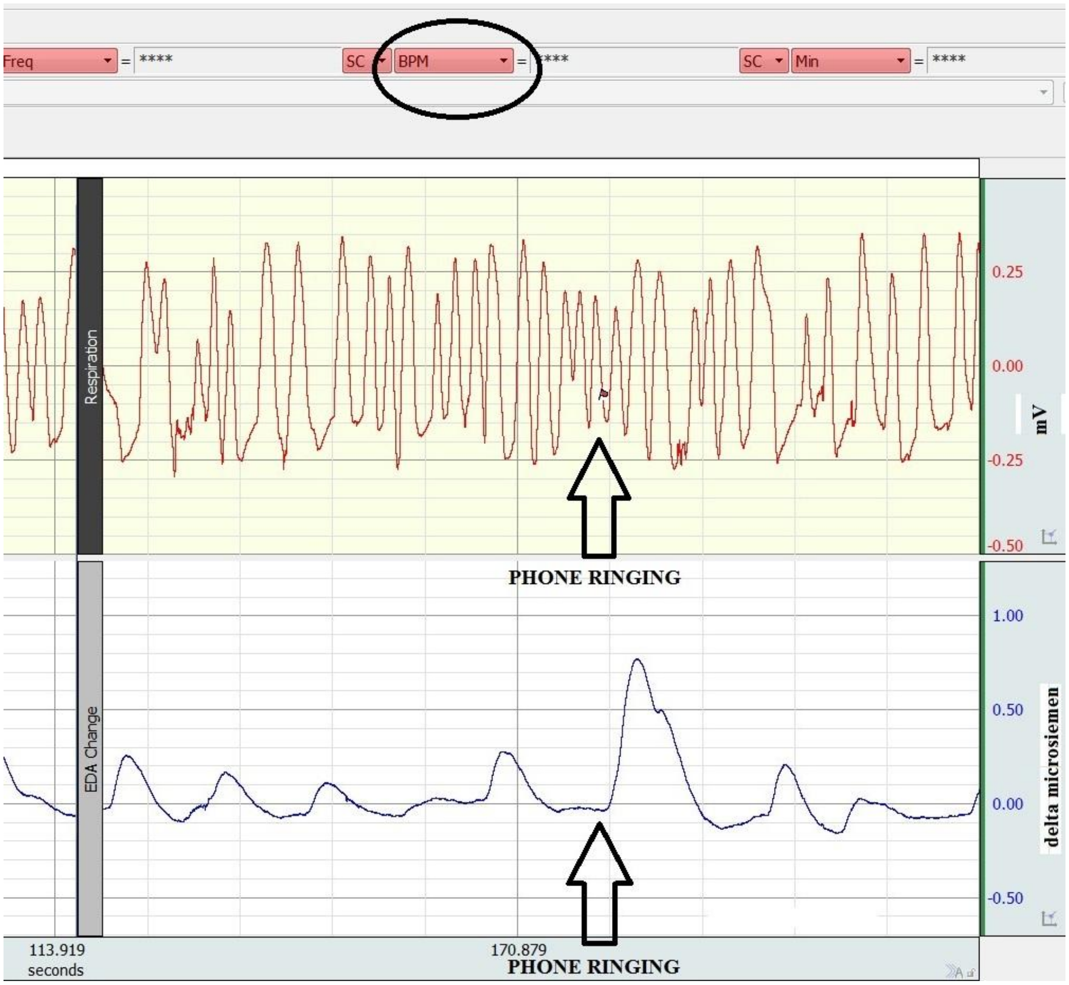

Figure 2 demonstrates the data collection of respiration rate (top) and EDA (bottom). Respiration rate was measured in millivolts (mV) and breaths per minute (BPM) were calculated. EDA was measured in microsiemens. The circled area was set to BPM when collecting respiration data and set to MEAN when collecting EDA data. The arrows point to the time when the cell phone began ringing.

Figure 3: Heart Rate Data from Excel

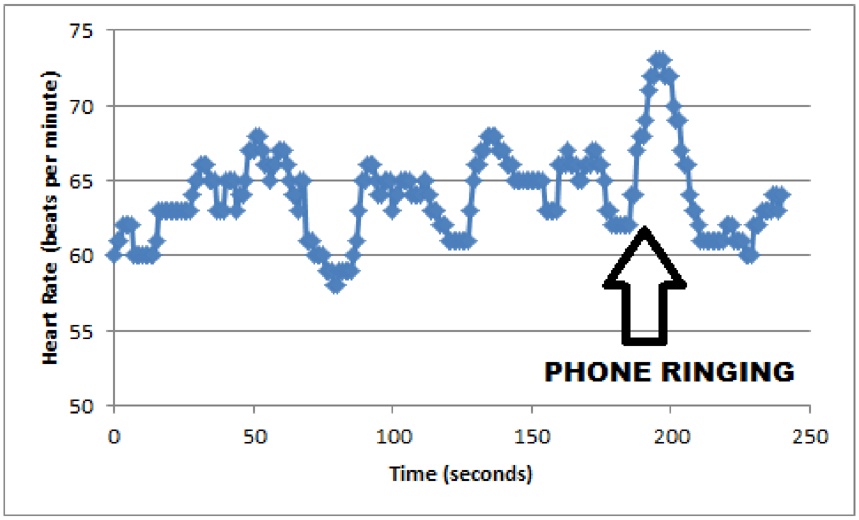

Figure 3 shows a graph of heart rate measured in beats per minute versus time measured in seconds. The heart rate data was obtained from a pulse oximeter and recorded by video. The data was then entered into excel. The arrow points to the time when the cell phone began ringing.

Figure 4: Electrodermal Activity Results

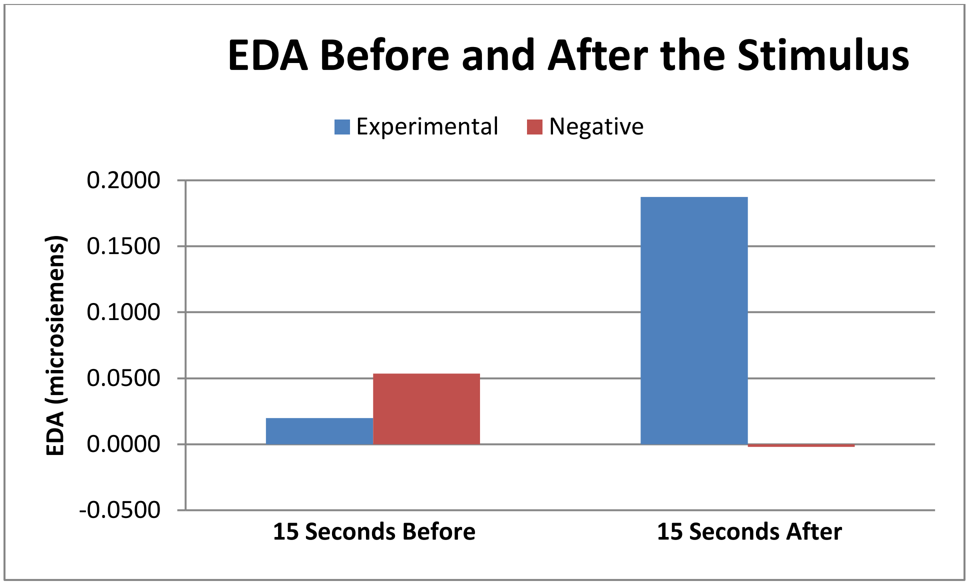

Figure 4 shows the EDA measured in delta microsiemons during the experiment. The average EDA for 15 seconds before the stimulus and 15 seconds after the stimulus are plotted. The graph shows a significant increase in EDA after the stimulus during the experimental condition.

<u>Figure 5</u>: Heart Rate Results

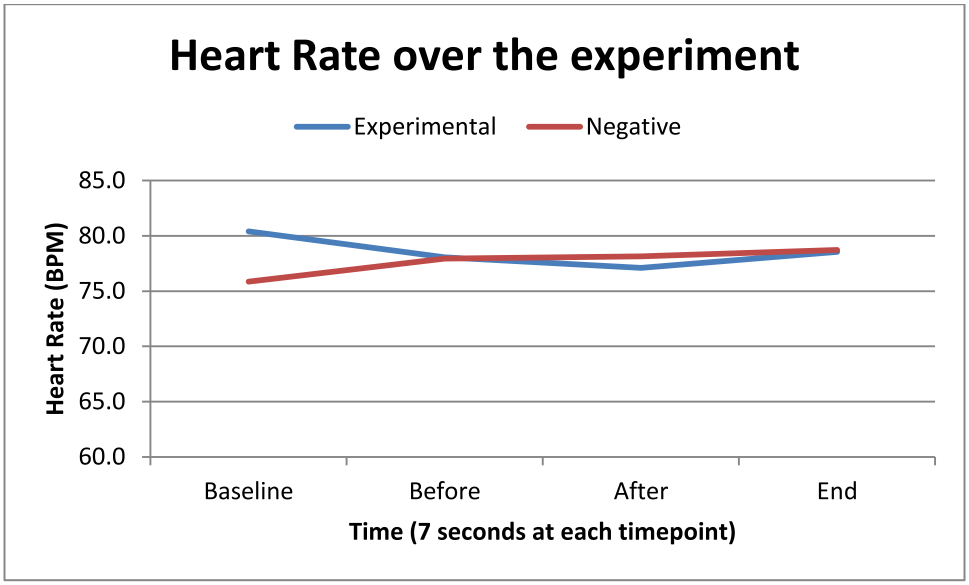

Figure 5 shows average heart rates measured in beats per minute over seven seconds at different time periods in the experiment. As shown, no significant increase was seen before and after the stimulus or between any of the time points examined.

<u>Figure 6: </u>Respiration Rate Results

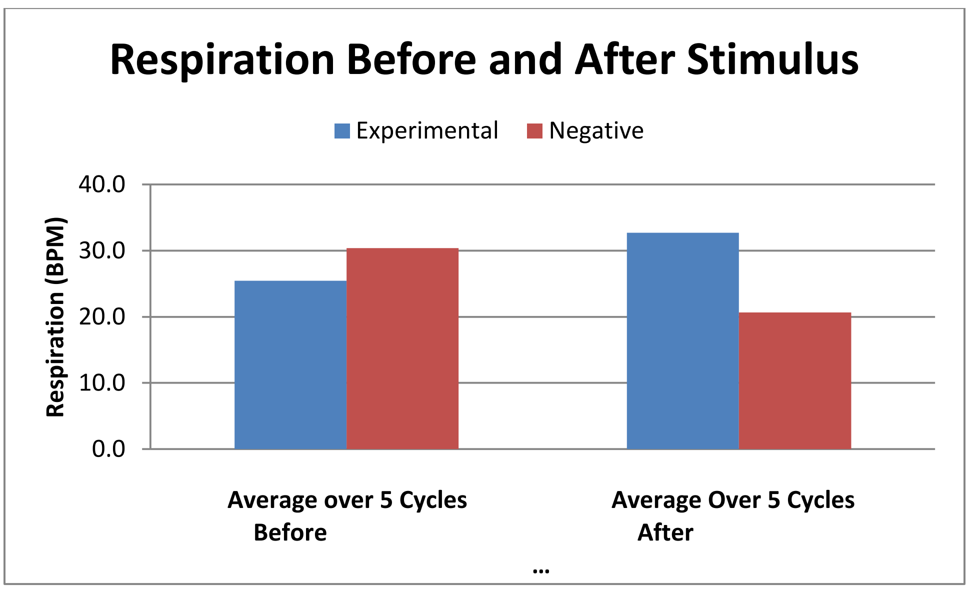

Figure 6 shows mean respirations measured in breaths per minute over the course of the experiment. The average of 5 respirations before the stimulus and 5 respirations after the stimulus are plotted. The graph shows there was no significant difference in BPM before or after the stimulus.

Appendix A: Technology Personality Survey Questions

1. How do you listen to your music? (iPod, MP3 player, phone etc.)

2. Do you have a mac or a PC or some other type of computer?

3. What was your first instant messenger screenname and provider?

4. Can we call your cell phone to hear your ringtone?

5. If you were traveling to a deserted island which of your electronics would you take with you?

Appendix B: High School General Information Exam Questions

1. Which of these animals is not like the others?
    a. Pig
    b. Monkey
    c. Kangaroo
    d. Dolphin
    e. Frog

   Which number comes next in this sequence: 1,1,2,3,5,8, __
    a. a. 21
    b. 13
    c. 20
    d. 9
    e. 8

   Chris, who is twenty years old, is four times older than his sister, Sue. How old will Chris be when he is twice as old as his sister?
    a. 25
    b. 28
    c. 30
    d. 32
    e. 35

   Which one of the five choices makes the best comparison? Cold is to Snowman as Warm is to:
    a. Beach
    b. Sand
    c. Sun
    d. Sand Castle
    e. Ocean

   If you rearrange the letters "HANIGMCI" you would have the name of a(n):

. City
    a. State
    b. Animal
    c. Country
    d. Town

Billy needs 17 snack bags for his camping trip. Billy has to carry these snacks from the garage to the trunk of his car however, he can only carry 3 at a time. What's the maximum number of trips Billy needs to fully pack his car?

   a. 6
   b. 6 ½
   c. 8
   d. 17
   e. 18

If all Meeps are Moops and all Moops are Loops, are all Meeps definitely Loops?

   a. Yes
   b. No

Choose the word most similar to "intelligent"?

   a. Penetrating
   b. Alive
   c. Witty
   d. Typical
   e. Perceptive

9. If you rearrange the letters "KOPCECA" you would have the name of a(n):
   a. City
   b. State
   c. Animal
   d. Country
   e. Town
10. Joey likes 35 but not 34; he likes 500 but not 400; he likes 244 but not 245. Which does he like:
    a. 20
    b. 60
    c. 224
    d. 300
    e. 1700
11. What is the missing number in the sequence shown: 1-6-18-?-324-1944
    a. 54
    b. 72
    c. 108
    d. 162
    e. 236
12. Which one of the following things is least like the other?
    a. Van Gogh
    b. Maroon 5
    c. Guggenheim
    d. Aldo Leopold
    e. Vera Wang
13. What is ½ of ¼ of 1/10 of 640?
    a. 8
    b. 12
    c. 6
    d. 10
    e. 14

14. One word in this list doesn’t belong in this group:
    a. Racecar
    b. Train
    c. Civic
    d. Deleveled
    e. Kayak
15. I’m a female, if Mary’s daughter is my daughter’s mother, what is the relationship between Mary and I?
    a. She is my sister
    b. She is my mother
    c. She is my grandmother
    d. She is my aunt
    e. She is unrelated to me
16. There are 15 candies on the table, you take 4, how many do you have?
    a. 19
    b. 11
    c. 9
    d. 4
    e. 0
17. Which one of the five choices makes the best comparison? Smile is to Teeth as Frown is to:
    a. Pout
    b. Closed
    c. Lips
    d. Sad
    e. Wrinkles
18. If you rearrange the letters “GAYPAURA” you would have the name of a(n):
    a. City
    b. State
    c. Animal
    d. Country
    e. Town
19. Choose the word most similar to “aggressive”?
    a. Combative
    b. Attacking
    c. Offensive
    d. Complaisant
    e. Pugnacious
20. One word in this list doesn’t belong in this group:
    a. Tomato
    b. Beet
    c. Apple
    d. Radish
    e. Blood Orange

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