The Effects of Distraction on Galvanic Skin Conductance, Heart Rate, and Alpha, Beta, and Delta Wave Amplitude

PHYSIOLOGY 435, LAB 603, GROUP 12

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Key Words

Alpha Wave, Autonomic Nervous System, Beta Wave, Brain Wave, Cell Phone, Delta Wave, Distractions, ElectroDermal Activity (EDA), ElectroEncepholoGram (EEG), Galvanic Skin Response (GSR)

6279 words

Abstract

Over the past few years, cell phone usage has become more frequent and compulsive, particularly in young adults. The effects of cell phone usage on task performance, focus, and cognition has been a topic of debate among many scientific studies. Some studies have concluded that the presence of a cell phone can result in decreased task-performance and attention. This experiment was designed to explore this theory among college-aged students: to see if a ringing or vibrating cell phone would result in changes in a student's heart rate, brain wave activity, or Galvanic skin response. Three groups were tested: a control group, with no distraction, a group with distractions from a vibrating cell phone, and a group with distractions from a ringing cell phone. Participants were tasked with completing a word-search. The two experimental groups were exposed to three staged calls: one at five minutes, and two subsequent ones at eight minutes and eight minutes and twenty seconds after beginning the word search, either hearing a vibration or ringtone from an experimenter's phone. The control group was not exposed to distracters. The difference between measurements after the test was administered, and after the distractions took place were compared. The results showed that there was no significant change in Galvanic skin conductance or heart rate between the control, vibrate, and noise groups. Electroencephalogram data showed that participants exposed to a ringtone distractor did show an increase in the standard deviation of delta waves relative to the control and vibrate groups.

Introduction

According to the "Mobile Fact Sheet" published by the Pew Research Center in 2017, 95% of Americans own a cell phone of some kind. Cell phone users can cause distractions for both themselves and others around them. Studies have shown that even the presence of a cell phone can cause diminished attention and a decrease in task-performance, particularly when the tasks have greater attentional and cognitive demands (Thornton et al., 2014). One study found that a notification, even without an interaction with the mobile device, can negatively impact one's performance on a task (Stothart, Mitchum, and Yehnert, 2015). It is a commonly held belief between students and faculty that the ringing of a phone (Chen and Yan, 2016) as well as the vibration tone (Burns & Lohenry, 2010) are major distractions in the classroom. Phone ringing triggers additional thoughts about the identity of the caller, causing a diversion of attention. When a phone rings while focusing on a task, the mind multitasks as these thoughts occur, which has been linked to decreased productivity and hindered scholastic performance (Walsh et al. 2010).

The purpose of this study is to determine what kind of physiological changes occur when there are distractions caused by phones. To do this, participants' skin conductance, heart rate, and brain activity were recorded when resting, when actively completing a word search, and when distracted by a phone call during this word search. Using these measures, we aim to examine the activity of the sympathetic nervous system as well as the activity of the alpha, beta, and delta brain waves that are active during rest, alertness, and in distraction.

In a study conducted by Dolce & Waldeier in 1974, they found that the intensity of alpha, beta, and delta waves differed depending on if a person was concentrating on a task. Alpha waves decreased in intensity when the eyes were open and during cognitive tasks. Beta waves increased during a reading cognitive task. Delta waves also increased during cognitive tasks. Additionally, a study done by Klimesch and associates in 2007 discussed how the amplitude of alpha waves decreased when a person had their eyes open compared to when they were closed. As an analog for this intensity change, and change in amplitude, we will examine the standard deviation of these brain waves.

We hypothesize that the ringing of a cell phone will be more distracting than a vibration, leading to a greater increase in heart rate and skin conductance when compared to the vibration as a distraction or no distraction. In addition, we expect to see the participant's alpha waves increase, beta waves decrease, and delta waves decrease in standard deviation when distracted.

Materials

Before the experiment began, participants were given a consent form (Appendix A) that was reviewed by the Physiology Department at the University of Wisconsin-Madison. The

Biopac Student Laboratory System software was utilized to record the physiological responses of the participants. To assess brain wave activity, heart rate, and galvanic skin conductance, BIOPAC Electroencephalogram (BSL TP Electrode Lead Adapter, SS1LA, BIOPAC Systems, Inc. Goleta, CA, USA), Pulse Oximeter/Carbon Dioxide detector (Model: 9843, Nonin, Plymouth, MN, USA), Electrodermal Activity Transducer (BSL EDA Finger Electrode Xdcr, SS3LA, BIOPAC Systems, Inc., Goleta, CA, USA) along with electrode gel (Gel 101, BIOPAC Systems, Inc. Goleta, CA, USA) were used respectively. The EDA transducer and EEG both used MP3X Acquisition (MP36, #MP36E1204002773, BIOPAC Systems, Inc., Goleta, CA, USA) to connect to the software. Participants worked on a Word Search (Capital Cities of Europe, Livewire Puzzles, 2007) (Appendix B) while their brain waves, heart rate, and skin conductance data were collected using Biopac Student guidelines. The stressors were created using iPhones owned by the experimenters.

Method

Participants were UW Madison Students enrolled in physiology 435. These students had ages ranging from 19-22 years old. Of the total participants (n = 22), 6 were male and 16 were female. To recruit these participants, students were approached within the physiology labs and discussion sections by word of mouth.

Participants were randomly assigned to one of three groups. The first group was the control group, where participants completed a word search without any distractions. The second group (the vibrate condition) heard vibrations from an experimenter’s phone at three points throughout the experiment. The third group (noise condition) heard a ring tone from an experimenter’s phone at three points throughout the experiment.

Upon arrival to the quiet testing room, consisting of two tables and several chairs, experimenters started reading from the script detailed in appendix C. Participants then completed a consent form detailing the risks and benefits of the study. After the consent form was placed into a manilla envelope to maintain anonymity, the experimenters connected the participants to the Electroencephalogram (EEG), Pulse Oximeter/Carbon Dioxide Detector, and the Electrodermal Activity Transducer (EDA). The EEG was placed on the participant’s head in three locations: one above the ear (VIN +), one behind the ear (VIN -), and one below the ear, on the neck (ground). The experimenters then asked the participant which hand was their dominant hand. The experimenter followed this by placing the EDA on the index and middle finger of the participant’s non-dominant hand. The pulse oximeter was then placed on the ring finger of the participant’s non-dominant hand.

After attachment of the physiological measurement devices, the experimenters instructed the participant to sit with their eyes closed, feet flat on the floor, and hands flat on the table. The experimenters then gave the participant a face-down word-search and an un-capped highlighter. A timer was started once the instructions were completed. Baseline measurements for alpha, beta, and delta wavelengths, heart rate, and skin conductance were gathered from 0:30 to 0:40 after the timer started, as the participants were in the resting position. After one minute, the experimenters told the participant to flip over and begin the word search. Measurements were taken again from 2:00 to 2:10 and from 4:00 to 4:10 after the start of the experiment to assess values after starting the word-search. At 5:00, the experimenter’s phone made noise from across the room: vibrating in vibrate condition and sounding a ring tone in the noise condition for 8 seconds, after which the experimenter would stand up, cross the room saying “sorry”, silence the phone, and sit back down. The control group would hear neither vibrations nor tones from the experimenter's phone. The participant's physiological measurements were recorded every 2 seconds during the distractor, and this continued for 12 seconds following the distractor. After the 20 seconds of recording, each group was exposed once again to their respective stressors at 8:00 and 8:20. The vibrate group heard two subsequent vibrations lasting 8 seconds each from the experimenter's phone. The noise group heard two subsequent ring tones for 8 seconds each from the experimenter's phone. The control group was not exposed to a noise from the experimenter's phone. In all but the control condition, the experimenter would once again get up and cross the room to silence the phone, taking it back to their seat during the stimulus at 8:00. The phone went off again at 8:20, while next to the experimenter. Measurements were taken at 2 second intervals during the 40 seconds from 8 minutes to 8:40. At 10 minutes, the participants were told that they could stop work on their word-search, thanked for their participation, and told how to follow up with the experimenters if the participants had any questions.

The average skin conductivity, peak-to-peak values for skin conductivity, and the standard deviations of the alpha, beta, and delta brainwaves were averaged over the time periods 0:30 - 0:40 (baseline), 2:00 - 2:10 (test), 5:00 - 5:10 (first distraction), and 8:20 - 8:30 (third distraction). To account for individual differences, a percentage change was calculated between the test and baseline, the first distraction and test, and the third distraction and test measurements. These percentage changes were then averaged across all participants within each condition (control, vibrate, and noise). These averaged percent changes were then compared using a one-factor ANOVA at the $\alpha = 0.05$ level between the control, vibrate, and noise groups.

To assess the differences in heart rate between groups, the heart rates were averaged across all participants in each condition (control, vibrate, and noise) over the time periods described above. The raw numbers were used to calculate the heart rate differences between the test and baseline, the first distraction and test, and the third distraction and test. These averaged changes in heart rate were then compared using a one-factor ANOVA at the $\alpha = 0.05$ level. Following the ANOVAs, Tukey's honestly significant difference was used to examine any differences found.

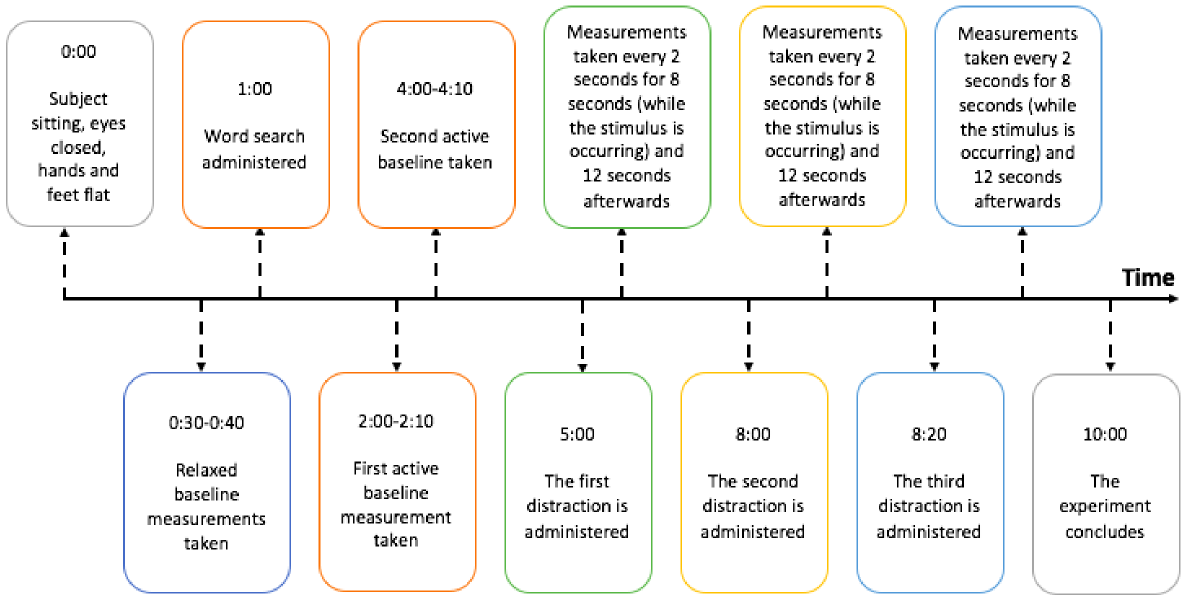

Figure 1. The experiment began with participants sitting in a resting position, and data was collected every 2 second from 30 seconds to 40 seconds after the start of the experiment. Participants started the word search at 1 minute, and "test" values were taken every 2 seconds from 2:00 to 2:10 and 4:00 to 4:10. The first distractor occurred at 5 minutes, lasting 8 seconds. Data was collected every 2 seconds from 5:00 to 5:20. The second and third distractors occurred at 8:00 and 8:20 for 8 seconds each. Data was collected every 2 seconds from 8:00 to 8:40. The experiment ended at 10 minutes.

Results

Two participants' data were excluded from the brain wave analysis due to a malfunction of the EEG during the experiment: one from the control group and one from the vibrate group. This malfunction caused the EEG to go entirely flat, making every reading zero for the duration of the experiment. No other participant data was excluded from the analysis.

The average heart rate across all participants was assessed using a paired t-test. This showed that the heart rate of all participants increased from 72.48 (SD = 13.26) to 77.78 (SD = 13.32) beats per minute between the baseline and test measurements ($p < 0.01$).

The average change in heart rate between the baseline and test measures for the control, vibrate, and noise groups were 5.38 (SD = 5.85), 3.85 (SD = 5.53), and 6.86 (SD = 3.67) beats per minute respectively. The average change in heart rate between the test and first distraction measures for the control, vibrate, and noise groups were 0.88 (SD = 5.04), -1.31 (SD = 6.10), and -0.86 (SD = 3.55) beats per minute respectively. The average change in heart rate between the test and third distraction measures for the control, vibrate, and noise groups were 0.43 (SD = 5.78), 0.83 (SD = 5.02), and -0.19 (SD = 7.85). Figure 2 displays and compares these values. There was not a significant difference between the control, vibrate, and noise conditions for the percent change of the baseline to test measures ($p = 0.60$), test to first distraction measures ($p=0.60$), and test to third distraction measures ($p = 0.96$).

The average skin conductance value between the baseline and test measurements was assessed using a paired t-test. This showed that the skin conductance of all participants increased from 9.17 (SD = 7.04) to 9.98 (SD = 7.94) microsiemens between the baseline and test measurements ($p=0.02$).

The average change in the skin conductance between the baseline and test measures for the control group, vibrate group, and noise group were 9.66% (SD = 16.04%), 10.70% (SD = 7.52%), and 10.64% (SD = 19.98%) respectively. The average change in skin conductance between the test and first distraction measures for the control, vibrate, and noise groups were 0.029% (SD = 6.28%), 0.29% (SD = 6.28%) and 1.70% (SD = 6.38%) respectively. The average change in skin conductance between the test and third distraction measures for the control, vibrate, and noise groups were 5.09% (SD = 18.40%), 3.61% (SD = 18.05%), and 5.09% (SD = 18.41%) respectively. Figure 3 displays and compares these values There was not a significant difference between the control, vibrate, and noise conditions for the percent change of the baseline to test measures (p = 0.99), test to first distraction measures (p=0.89), and test to third distraction measures (p = 0.89).

The average change in the peak to peak measure of the Galvanic skin conductance between the baseline and test measures for the control, vibrate, and noise groups were 52.46% (SD = 89.09%), 33.96% (SD = 90.23%), and 52.97% (SD = 176.05%) respectively. The average change in the galvanic skin conductance peak to peak between the test and first distraction measures for the control, vibrate, and noise groups were -23.85% (SD = 53.84%), 66.89% (SD = 125.40%), and 152.96% (SD = 221.23%). The average galvanic skin conductance peak to peak between the test and third distraction measures for the control, vibrate, and noise groups were -27.74% (SD = 39.60%), 3.48% (SD = 69.31%), and 23.04% (SD = 94.45%). Figure 4 displays and compares these values. There was not a significant difference between the control, vibrate, and noise conditions for the percent change of the baseline to test measures (p = 0.73), test to first distraction measures (p=0.074), and test to third distraction measures (p = 0.35).

The average change in the alpha wave standard deviation between the baseline and test measures for the control, vibrate, and noise groups were 23.03% (SD = 31.44%), 4.83% (SD = 43.39%), and 77.97% (SD = 82.17%) respectively. The average change in the alpha wave standard deviation between the test and first distraction measures for the control, vibrate, and noise groups were 6.95% (SD = 53.84%), 10.58% (SD = 52.80%), and 26.85% (SD = 34.38%). The average change in the alpha wave standard deviation between the test and third distraction measures for the control, vibrate, and noise groups were -9.95% (SD = 38.08%), -5.13% (SD =

45.26%), and 63.00% (SD = 110.67%). Figure 5 displays and compares these values. There was not a significant difference between the control, vibrate, and noise conditions for the percent change of the baseline to test measures ($p = 0.077$), test to first distraction measures ($p=0.74$), and test to third distraction measures ($p = 0.14$).

The average change in the beta wave standard deviation between the test measure and baseline measure for the control, vibrate, and noise groups were 17.94% (SD = 26.32%), 13.79% (SD = 43.26%), and 91.31% (SD = 84.92%) respectively. The average change in the beta wave standard deviation between the test and first distraction measures for the control, vibrate, and noise groups were 14.46% (SD = 65.96%), 13.79% (SD = 49.25%), and 40.79% (SD = 36.76%). The average change in the beta wave standard deviation between the test and third distraction measures for the control, vibrate, and noise groups were -15.05% (SD = 27.55%), 3.83% (SD = 48.41%), and 44.42% (SD = 63.40%). Figure 6 displays and compares these values. There was not a significant difference between the control, vibrate, and noise conditions for the percent change of the test to first distraction measures ($p = 0.61$) and test to third distraction measures ($p = 0.088$). There was a significant difference between the control, vibrate, and noise conditions in the average percent change in the beta wave standard deviation between the baseline and test measures ($p = 0.037$).

Tukey’s HSD was performed to assess the difference in the percentage difference in the beta wave standard deviation between the control, vibrate, and noise groups. The HSD was found to be 5.29, meaning that the noise group had a significantly larger percentage difference in the beta wave standard deviation compared to both the control and the vibrate group.

The average change in the delta wave standard deviation between the test measure and baseline measure for the control, vibrate, and noise groups were 18.47% (SD = 67.80%), 49.56%

(SD = 66.43%), and 147.61% (SD = 148.26%) respectively. The average change in the delta wave standard deviation between the test and first distraction measures for the control, vibrate, and noise groups were 26.96% (SD = 62.26%), 158.93% (SD = 286.25%), and 170.75% (SD = 258.75%). The average change in the delta wave standard deviation between the test and third distraction measures for the control, vibrate, and noise groups were 0.3811% (SD = 32.28%), -9.71% (SD = 52.09%), and 112.89% (SD = 114.82%). Figure 7 displays and compares these values. There was not a significant difference between the control, vibrate, and noise conditions for the percent change of the baseline to test measures ($p = 0.072$) and test to first distraction measures ($p = 0.39$). There was a significant difference between the control, vibrate, and noise conditions in the average percent change in the delta wave standard deviation between the test and third distraction measures ($p = 0.013$).

Tukey’s HSD was performed to assess the difference in the percentage difference in the delta wave standard deviation between the control, vibrate, and noise groups. The HSD was found to be 5.29, meaning that the noise group had a significantly larger standard deviation than both the control and vibrate group. The vibrate group also had a significant decrease in the average percentage change in delta wave standard deviation compared to the control group.

Discussion

Our hypothesis stated that the ringing of a cell phone would be a greater distraction, which would produce a sympathetic response when compared to the vibration of a cell phone. It was also hypothesized that both a ringing cell phone and a vibrating cell phone would produce a greater distraction and physiological response than a silent cell phone. However, the results of the experiment showed no significant change in Galvanic skin conductance and heart rate between the control, vibrate, and noise conditions. The Electroencephalogram data revealed no significant differences in the standard deviations of the alpha and beta waves between the time when the word search was administered and the first and third distractions. It also revealed that there was a greater increase in delta wave standard deviation when participants were exposed to the third phone ring-tone when compared to vibrations and no distractions.

Galvanic Skin Conductance (SC)

Although it was hypothesized that there would be an increase in skin conductance when the phone was ringing or vibrating, there was no significant difference in the skin conductance when the participants were exposed to these stimuli compared to when they were not. Galvanic skin conductance measures sweat that is created by autonomic nervous system activation, generally when there is a stimulus that elicits an emotion or stress (iMotions GSR Pocket Guide, 2016). Many studies show that an increase in skin conductance occurs when exposed to a cell phone, while others do not show this correlation. A study done by Owens *et. al* presented an argument that the conflicting results in the literature may be due to an individual's connection with their cell phone. It was hypothesized that individuals who self-reported a higher attachment to their cell phone would have higher skin conductivity response levels than those who self-reported a lower attachment. It was also hypothesized that individuals who were unable to access their phone while it was ringing would produce a higher skin conductivity response as well (Owens et. al, 2014). Although their study did not show any statistical significance, there is a slight correlation that can be observed in the data. Much like our experiment, it is thought that a more refined experiment with a larger sample size would be more effective at producing accurate results. It is also important to note that our experiment was conducted using the experimenter's cell phone, not the participant's. This could be a potential reason why subjects did not show a large response to the phone distractions.

Heart Rate (HR)

While it was hypothesized that there would be a greater change in heart rate for participants who heard a phone ringing as opposed to a phone vibrating, it was concluded that there was no significant difference between the control, vibrate, and noise conditions. While the phone distractors may have made the participant feel nervous or uneasy, it may not have been reflected in their heart rate response. Many studies indicate there may be a stress response due to hearing a cell phone, including a study conducted by Thorton et. al. This study showed that even the presence of a cell phone can cause diminished attention and a decrease in task-performance. This may lead to a stress response while performing a cognitive task, such as solving a word puzzle. While heart rate is often a response to increased stress, there is a large variation within the population, which may be why there was no direct correlation between the distraction type and the participants' heart rates.

Electroencephalogram (EEG)

It was hypothesized that there would be an increase in the amplitude of alpha waves, a decrease in the amplitude of beta waves, and a decrease in the amplitude of delta waves. These trends were not observed in the data. Overall, the vibrate and ring conditions did not significantly differ from the control condition in alteration of brainwave activity. However, it was found that the participants' delta wave standard deviation when exposed to a ringing cell phone increased significantly relative to the participants that heard vibrations or nothing. One possible explanation for this increased delta wave activity is that the participants were attempting to block out the distraction, which has been shown to be associated with increased delta wave activity (Harmony 2013). There was also a strange occurrence within the data: the test to baseline change in the beta wave standard deviation differed significantly between the ring, vibrate, and control conditions. This is an oddity, because this implies that there was a difference between the participants assigned to the ring condition and those assigned to the control and vibrate conditions. This trend is seen in the alpha and beta waves as well, which both approached significance. This may have been caused by outliers in the data, along with a small sample size.

Conclusion

Our findings indicate that participants already had a heightened physiological response due to stress of the word-search. This is evident from the increase in heart rate and average skin conductance. In addition, none of the participants completed the word-search, and many commented that it was very difficult. This may have lead greater sympathetic activation, which could mask the effects of the vibration or ringtone as distractors. Alternatively, the ring tone or vibration may not have been an effective enough stressor for their concentration to be broken. Lastly, the participants of our experiment may have been accustomed to cell phones in the background due to being in a peer group where cell-phone use is common, leading to very little distraction from their task.

If this experiment were to be replicated in the future, some improvements could be made to eliminate errors and possibly provide more significant results. Shifting of the participant’s body and head often disrupted the cords for the EEG. This lead to erratic brain wave signatures that may have confounded our data. Being extremely careful about the placement of the EEG leads or using more sophisticated forms of the EEG may eliminate these problems. In addition, more external distractions could be limited within the experimental room so that the ring or vibrate of the phone would be the only possible source of distraction. Oftentimes there was noise from outside of the room that could be heard during the experiment. It is also possible that people may have heard the rings of our phone outside of the room before they participated in the study, priming them for the experiment. An increased population size would be recommended as well, as the sample size we used was likely not large enough to accurately represent the total population. Also, the stakes for completing the experiment could be raised to simulate an exam or test-like state so that the participant is more invested in the word search. Lastly, different distraction methods could be used that the participants may not be normalized to.

Acknowledgements

We would like to thank Dr. Lokuta for his assistance and guidance while completing this study as well as the University of Wisconsin-Madison Department of Neuroscience for providing us with the tools and equipment that allowed us to collect our data. We would also like the thank the PLVs, and the teaching assistants who assisted us in developing the process and techniques for the experiment. Finally, we would like to thank the anonymous reviewer who took the time to read our article and provide helpful feedback, as well as the individuals who participated in our study.

Figures

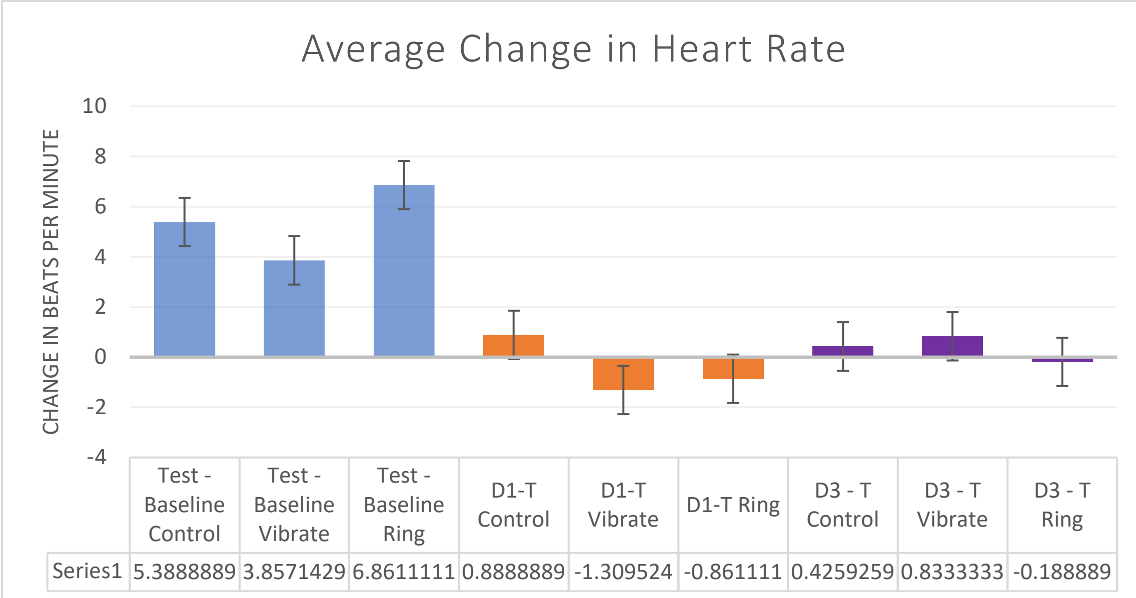

Figure 2. Participants were tasked with completing a word search. During the task, a phone would either ring, vibrate, or remain silent at three points throughout the experiment. The average change in heart rate between the measurements taken when the word-search was administered and before the word-search were compared between the control, vibrate, and ring conditions (Blue). This was also calculated between the measurements taken when the first distraction occurred and when the test was administered (Orange) as well as between the measurements taken when the third distraction occurred and when the test was administered (Purple) and compared between the experimental groups. Standard error bars are displayed.

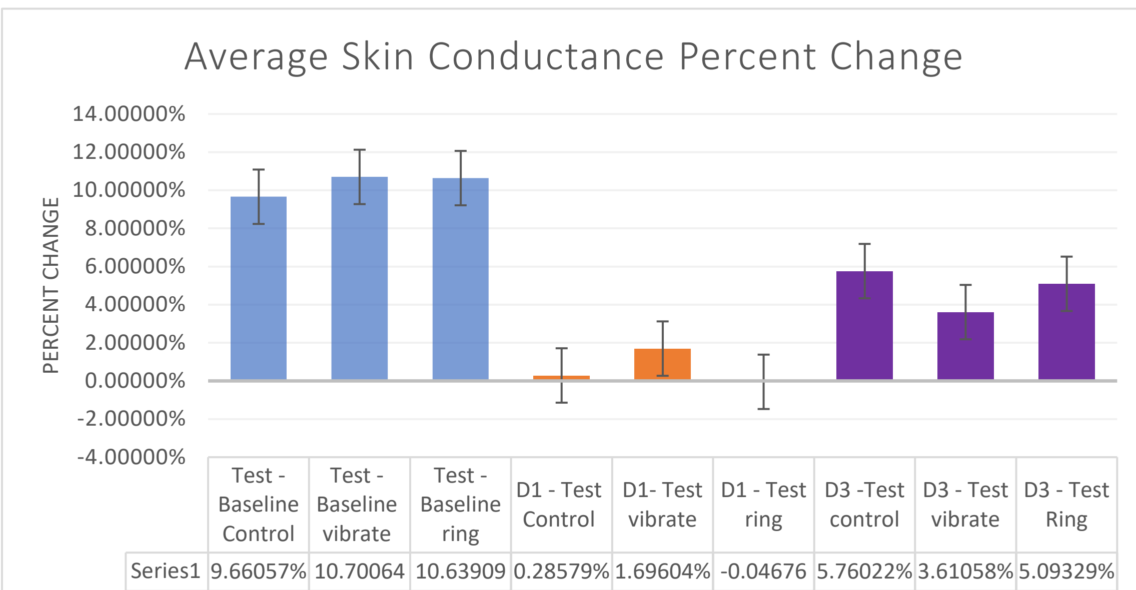

Figure 3. Participants were tasked with completing a word search. During the task, a phone would either ring, vibrate, or remain silent at three points throughout the experiment. The average percentage change in skin conductance between the measurements taken when the word-search was administered and before the word-search were compared between the control, vibrate, and ring conditions (Blue). This was also calculated between the measurements taken when the first distraction occurred and when the test was administered (Orange) as well as between the measurements taken when the third distraction occurred and when the test was administered (Purple) and compared between the experimental groups. Standard error bars are displayed.

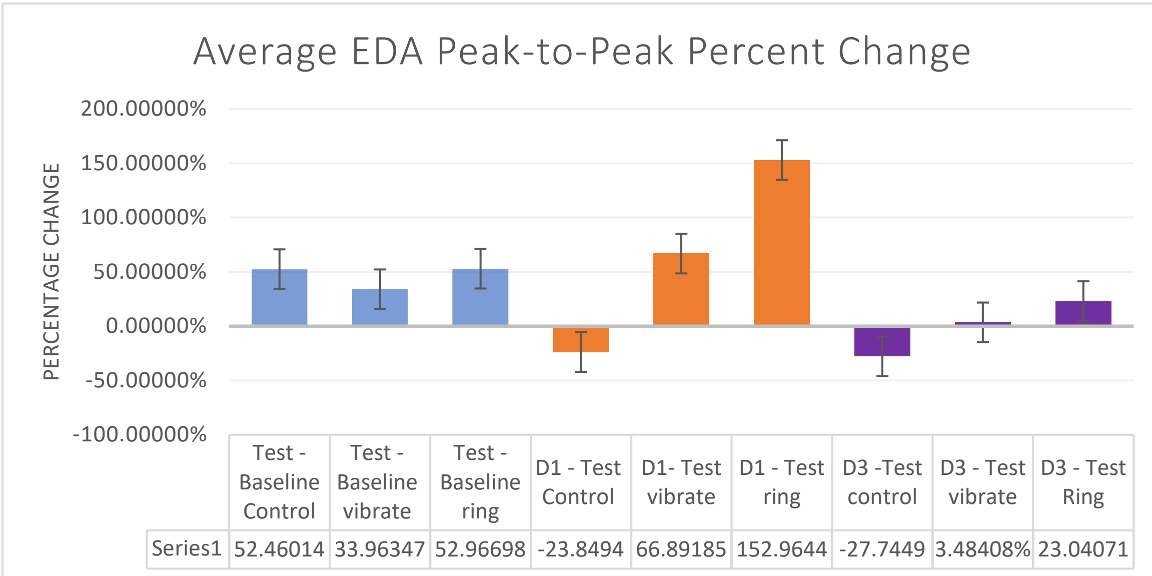

Figure 4. Participants were tasked with completing a word search. During the task, a phone would either ring, vibrate, or remain silent at three points throughout the experiment. The average percentage change in the peak-to-peak values between the measurements taken when the word-search was administered and before the word-search were compared between the control, vibrate, and ring conditions (Blue). This was also calculated between the measurements taken when the first distraction occurred and when the test was administered (Orange) as well as between the measurements taken when the third distraction occurred and when the test was administered (Purple) and compared between the experimental groups. Standard error bars are displayed.

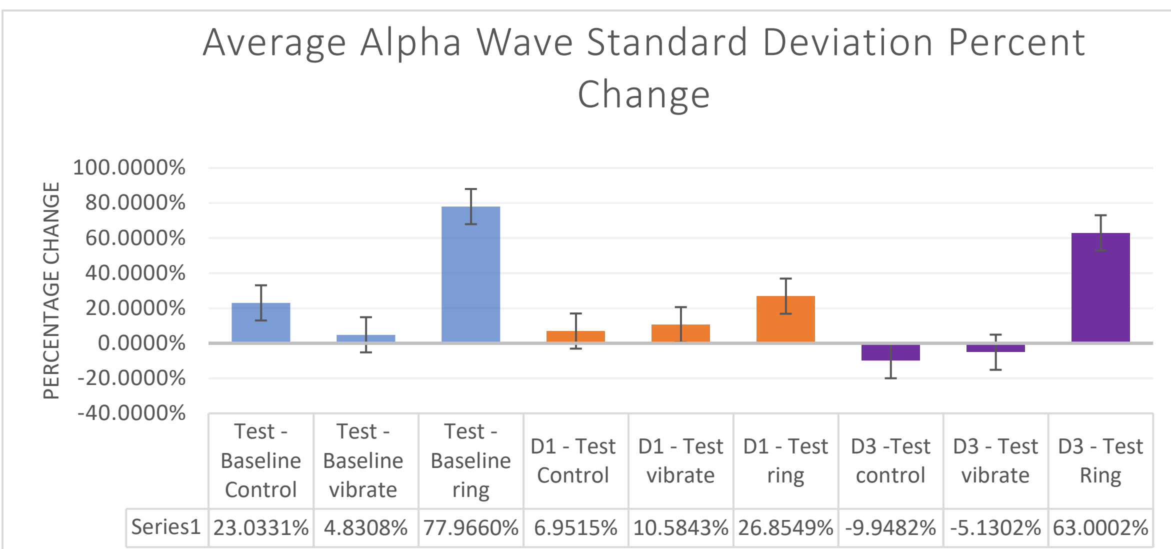

Figure 5. Participants were tasked with completing a word search. During the task, a phone would either ring, vibrate, or remain silent at three points throughout the experiment. The average percentage change in the alpha wave standard deviation between the measurements taken when the word-search was administered and before the word-search were compared between the control, vibrate, and ring conditions (Blue). This was also calculated between the measurements taken when the first distraction occurred and when the test was administered (Orange) as well as between the measurements taken when the third distraction occurred and when the test was administered (Purple) and compared between the experimental groups Standard error bars are displayed.

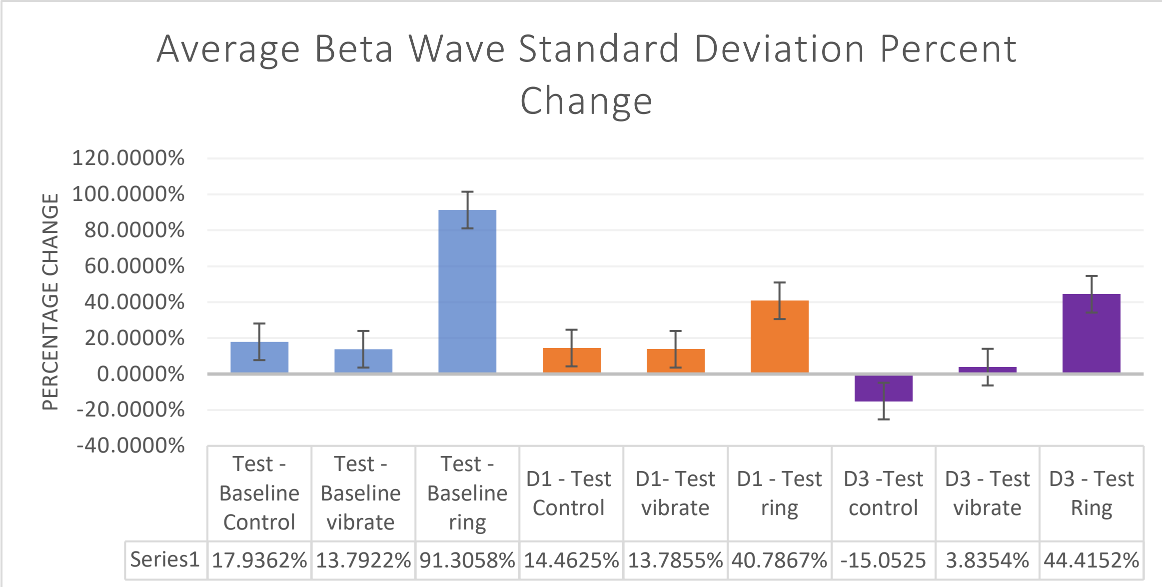

Figure 6. Participants were tasked with completing a word search. During the task, a phone would either ring, vibrate, or remain silent at three points throughout the experiment. The average percentage change in the beta wave standard deviation between the measurements taken when the word-search was administered and before the word-search were compared between the control, vibrate, and ring conditions (Blue). This was also calculated between the measurements taken when the first distraction occurred and when the test was administered (Orange) as well as between the measurements taken when the third distraction occurred and when the test was administered (Purple) and compared between the experimental groups Standard error bars are displayed.

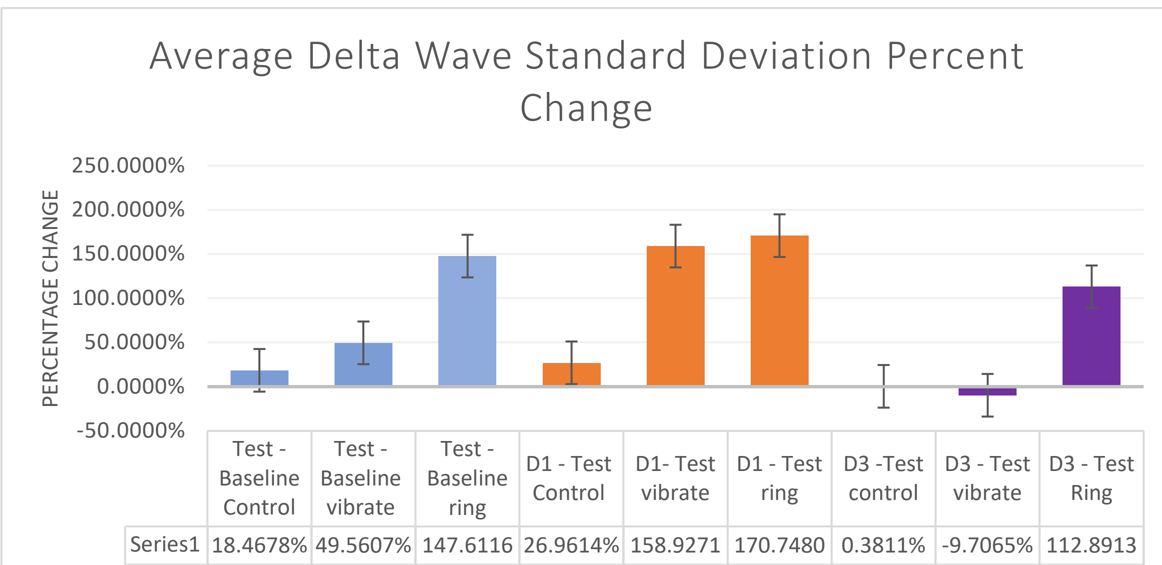

Figure 7. Participants were tasked with completing a word search. During the task, a phone would either ring, vibrate, or remain silent at three points throughout the experiment. The average percentage change in the delta wave standard deviation between the measurements taken when the word-search was administered and before the word-search were compared between the control, vibrate, and ring conditions (Blue). This was also calculated between the measurements taken when the first distraction occurred and when the test was administered (Orange) as well as between the measurements taken when the third distraction occurred and when the test was administered (Purple) and compared between the experimental groups Standard error bars are displayed.

References

Burns, S. M., & Lohenry, K. (2010, September). Cellular Phone Use in Class: Implications for Teaching and Learning a Pilot Study [Electronic version]. *College Student Journal, 44*(3), 805-810.

Chen, Q., & Yan, Z. (2016, January). Does multitasking with mobile phones affect learning? A review. *Computers in Human Behavior*, *54*, 34-42.

Dolce, G., & Waldeier, H. (1974). Spectral and multivariate analysis of EEG changes during mental activity in man. Electroencephalography and Clinical neurophysiology, 36, 577-584.

Galvanic Skin Response (GSR): The Definitive Pocket Guide. (2016, October 12). Retrieved April 05, 2017, from https://imotions.com/blog/galvanic-skin-response/

Harmony, T (2013). The functional significance of delta oscillations in cognitive processing. *Frontiers in integrative neuroscience*, *7,* 83.

Klimesch, W., Sauseng, P., & Hanslmayr, S. (2007). EEG alpha oscillations: the inhibition–timing hypothesis. *Brain research reviews*, 53(1), 63-88.

Mobile Fact Sheet (2017, January 12). In *PewResearchCenter*. Retrieved from ProQuest .

Owens, C. R., Decaro, J., Wolfgram, M., Lynn, C. D., Parmelee, P., & Brown, I. W. (n.d.). How smart phones affect skin conductance and social support networks among students at the University of Alabama. (Master's thesis). Retrieved from Primo.

Stothart, C., Mitchum, A., & Yehnert, C. (2015, August). The attentional cost of receiving a cell phone notification [Electronic version]. *Journal of Experimental Psychology: Human Perception and Performance*, *41*(4), 893-897.

Thornton, B., Faires, A., & Robbins, M. (2014). The mere presence of a cell phone may be distracting: Implications for attention and task performance [Electronic version]. *Social Psychology*, *45*(6), 479-488.

Walsh, S. P., White, K. M., & Young, R. (2010, November 5). Needing to connect: The effect of self and others on young people's involvement with their mobile phone [Electronic version]. *Australian Journal of Pscyhology*, *62*(4), 194-203.

Appendix A

UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Physiological Responses to Distractions
Principal Investigators: Katie Boden, Austin Jasniewski, Kristyn Paszkiewicz, Samantha Scheel

DESCRIPTION OF THE RESEARCH

You have been asked to participate because you are enrolled in Physiology 435.
The purpose of the research is to further look into several physiological responses while completing a word search.
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 complete a word search.
Your participation will last approximately 15-20 minutes.
Your results will be completely confidential.
Upon completion of the experiment, information about results of the study may be provided to you upon request.
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 significant risks have been identified in this research study.
I, the undersigned participant, agree to indemnify and hold harmless The University of Wisconsin-Madison and any of its agents, employees, or representatives for any injury or loss suffered by me due to my participation in the activities associated with the Physiology 435 laboratory project. I hereby agree that I have been fully advised of the nature and extent of the activity that may take place and represent to you that I am physically and mentally able to participate in the activity without special accommodations or additional supervision. I understand that the activity may present the risk of injury, or even death, to me, and I have been fully advised of those possibilities. I represent to you that I fully assume the risk of any such injury or death, and I hold you, your agents, employees, and representatives harmless from any liability or death to me while engaged in this activity that is caused or contributed to by my conduct or the conduct of any other participants. If I am not able to be consulted for any reason in the case of an emergency or necessity arising during the course of the activity or as a result of the activity, I authorize you to arrange for such medical and hospital treatment as you may deem to be advisable for my health and well-being.

ARE THERE ANY BENEFITS TO ME?

If you are willing and able to participate in our experiment, the members of our group will be more than willing to participate in yours.

Appendix A Continued

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):____

Email: _________________________ Phone Number: __________________________

Signature __________________________________

Appendix B

Free Printable Word Search Puzzles

Capital Cities of Europe

Find and circle all of the European capital cities that are hidden in the grid.
The remaining letters spell a secret message.

T	H	T	S	E	R	A	H	C	U	B	Z	A	G	R	E	B	E	M	Y
I	O	S	T	L	P	V	A	O	L	J	U	B	L	J	A	N	A	A	T
W	S	P	U	L	E	R	A	I	S	O	C	I	N	O	U	S	V	E	I
O	S	I	T	W	D	S	M	L	S	K	O	P	J	E	C	A	U	I	C
C	A	O	L	I	A	C	S	A	L	N	O	B	S	I	L	G	K	T	N
S	R	Y	F	I	R	S	O	U	D	E	I	N	E	S	A	S	I	H	A
O	A	F	M	I	B	A	R	P	R	R	T	D	I	R	I	E	E	U	C
M	J	L	R	L	A	T	N	A	E	B	I	T	P	R	O	L	V	B	I
V	E	Z	L	E	O	P	E	E	W	N	A	D	A	I	S	S	E	M	T
I	V	U	S	E	M	H	M	O	B	R	H	P	U	I	S	R	A	B	A
E	O	D	A	C	V	O	K	U	B	S	O	A	N	A	L	D	A	N	V
N	K	A	N	V	W	A	R	C	N	W	N	K	G	I	R	K	H	A	E
N	I	V	M	I	M	G	L	E	O	I	I	I	N	E	U	I	L	V	D
A	V	A	A	L	H	I	H	A	S	T	R	T	T	C	N	H	O	E	A
M	A	R	R	N	H	T	N	I	R	A	S	S	A	S	O	V	N	R	R
O	J	A	I	I	A	E	H	S	R	R	M	N	I	L	B	U	D	E	G
N	K	K	N	U	E	C	I	G	K	A	O	H	O	S	L	O	O	Y	L
A	Y	N	O	S	T	M	T	S	E	P	A	D	U	B	I	I	N	L	E
C	E	A	L	U	X	E	M	B	O	U	R	G	N	R	E	B	N	L	B
O	R	I	O	N	B	E	L	F	A	S	T	P	E	A	O	P	L	N	E

AMSTERDAM (Netherlands)
ANDORRA LA VELLA (Andorra)
ANKARA (Turkey)
ATHENS (Greece)
BAKU (Azerbaijan)
BELFAST (Northern Ireland)
BELGRADE (Serbia/Montenegro)
BERLIN (Germany)
BERN (Switzerland)
BRATISLAVA (Slovakia)
BRUSSELS (Belgium)
BUCHAREST (Romania)
BUDAPEST (Hungary)
CARDIFF (Wales)
CHISINAU (Moldova)
COPENHAGEN (Denmark)
DUBLIN (Ireland)
EDINBURGH (Scotland)
HELSINKI (Finland)
KIEV (Ukraine)
LISBON (Portugal)
LJUBLJANA (Slovenia)
LONDON (England)
LUXEMBOURG (Luxembourg)
MADRID (Spain)
MINSK (Belarus)
MONACO (Monaco)
MOSCOW (Russian Federation)
NICOSIA (Cyprus)
OSLO (Norway)
PARIS (France)
PRAGUE (Czech Republic)
REYKJAVIK (Iceland)
RIGA (Latvia)
ROME (Italy)
SAN MARINO (San Marino)
SARAJEVO (Bosnia-Herzegovina)
SKOPJE (Macedonia)
SOFIA (Bulgaria)
STOCKHOLM (Sweden)
TALLINN (Estonia)
TBILISI (Georgia)
TIRANE (Albania)
VADUZ (Liechtenstein)
VALLETTA (Malta)
VATICAN CITY (Vatican City)
VIENNA (Austria)
VILNIUS (Lithuania)
WARSAW (Poland)
YEREVAN (Armenia)
ZAGREB (Croatia)

Did you enjoy this puzzle? Visit: http://www.puzzles.ca/wordsearch.html

Appendix C

Experimenter Script

Thank you for participating in our study. We will be hooking you up to various physiological devices. The experiment should take between 10 and 15 minutes.

This is the consent form. Please read through it and sign when you are finished. If you have any specific questions regarding the consent form please let us know. When you have signed, we will start hooking up the equipment.

As we hook you up to the devices, please refrain from touching the cords.

Once we have connected all of the necessary devices, we will begin the experiment. We ask that you begin by placing your feet flat on the floor, and closing your eyes until we instruct you to open your eyes and begin the puzzle. Again thank you for participating, we will begin the experiment now.

At 1 minute: You may open your eyes and begin the puzzle.