Effects of an Auditory Stimulus on the Nervous System and Selective Attention

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Abstract:

Several theories have been proposed in an attempt to explain human attention, all accentuating the complexity in processing information. More specifically, the concept of inattentional blindness depicts how the limited number of cognitive resources of the human brain can be dominated by a specific stimuli, leading to an individual's failure to notice a second stimuli. This concept has been tested on its own, but not in conjunction with an onset of a stress response. During a stressful situation, the sympathetic nervous system looks to allocate the body's resources to eliminate the identified stressor. Based on the known physiological changes of an activated sympathetic response, electroencephalography, galvanic skin response, and a pulse oximeter were used in data collection. The hypothesis of this study was that an auditory stimulus of gunshots sounds would elicit an increase in heart rate, skin conductance, and beta wave frequency via an activated sympathetic nervous system, making one less likely to experience inattentional blindness. Two of the three physiological tests did not support the hypothesis, in that gunshots did not induce a statistically significant increase in heart rate or beta wave frequency; however, skin conductance did show a statistically significant increase as a result of the gunshots. Furthermore, there was no statistically significant difference between the experimental and control groups in their likelihood to experience inattentional blindness.

Introduction:

Humans have a limited number of cognitive resources, making them unable to process all the information that they are exposed to. A number of models have been produced attempting to explain attention: early selection theory posits that a filter does away with irrelevant information and only relevant information is processed to consciousness; late selection theory instead states

that all information is processed, but only information that one deems relevant is brought to consciousness; and the attenuation model of attention states that relevant information is processed and all other information is attenuated, unless that individual is primed to the outside information, making it personally relevant. (Driver, 2001). These models highlight the complexity in processing information. Expanding from the theories of attention, the concept of selective attention focuses on how a limited amount of cognitive resources, leads to an individual's experience being dominated by specific stimuli. In effect, this can lead to inattentional blindness, explaining why some things are left unseen (Driver, 2001). This concept is most famously demonstrated by Chabris' and Simons' "Invisible Gorilla" experiment (1999). The duo created a selective attention test in which a participant was instructed to watch a video and count the number of basketball passes between a group of men and women. During the video, a gorilla walked through the background and beat its chest before walking off camera. The results showed that 46 percent of the participants were subject to inattentional blindness, in that they were so concentrated on counting the number of passes, they did not see the gorilla appear on screen (Chabris & Simons, 1999).

The importance of the human body's dynamic response to stress cannot be understated. When a stressor acts as an adequate stimulus, neuronal signaling in the autonomic nervous system activates the sympathetic branch and inhibits the parasympathetic branch. The resulting physiological changes constitute the "flight or fight response": increased blood pressure, increased heart rate, increased blood glucose, decreased digestion, decreased bladder contraction, etc. Ultimately, the activated response of the sympathetic nervous system looks to allocate the body's resources to eliminate the stressful stimulus (Widmaier, Raff, & Strang, 2016, p. 182).

In addition to the neurological response, the sympathetic nervous system activates two hormonal pathways. The sympathoadrenal pathway (SAP) is responsible for the release of catecholamines from the adrenal medulla. The hypothalamo-pituitary-adrenal axis is resultant in the release of cortisol from the adrenal cortex (Mitrovich). As a result of hormonal activity body systems deviate from the controlled homeostatic balance.

A number of physiological devices exist that can be used to capture an activated sympathetic response. In Electroencephalography (EEG), alpha and beta waveforms, present during consciousness, have shown distinct patterns that are characteristic of the activation of the sympathetic nervous system. This is seen when an intense stimulus generates the transition to beta rhythms (Kisley & Cornwell, 2006). Furthermore, an increase in beta wave frequency accompanied by a decrease in alpha wave frequency is indicative of a fear response (Diaz & Bell, 2011). Using a galvanic skin response (GSR), increases in electrodermal activity (EDA) can be attributed to a sympathetic response, based on the solely sympathetic innervation of eccrine glands (Schütz et al., 2008). A pulse oximeter provides another measurement to quantify activation of the sympathetic nervous system, noting an increased heart rate resulting from the SAP. Evidence of limbic and hypothalamic mechanisms activating brain centers responsible for fear and emotion justify the use of an auditory stimulus in evoking a sympathetic response. Additionally, using an auditory stimulus minimizes the possibility of additional confounders, such as an increase of beta wave frequency from open eyes, false EDA generated by movement, or increased heart rate from exercise (Spreng, 2000).

Identifying a physiological response from the activation of the sympathetic nervous system and the existence of inattentional blindness have both been proven. The novel idea this

study hopes to investigate, draws on the relationship between having an activated nervous system and the resulting effect on inattentional blindness. Its relevance is found in the idea that experiencing inattentional blindness during a situation that elicits the "fight or flight" response could be detrimental. Investigating outcomes related to these circumstances could prove to have important societal implications.

The goal of the study is to further investigate this relationship, which will be done by creating a controlled environment. Participants' baseline readings of heart rate, EEG, and EDA will be taken during a control period, followed by a stressful auditory stimulus of gunshots, in an attempt to capture an activated sympathetic response. Immediately following the auditory stimulus, the participant will be subjected to a selective attention test and a qualitative response will be obtained. There are two parts to this study: activating the sympathetic nervous system via an auditory stimulus and completing a selective attention test. It is hypothesized that a strong auditory stimulus of gunshots will elicit an increase in heart rate, skin conductance, and beta wave frequency via an activated nervous system. In turn, an individual should be less likely to experience inattentional blindness.

Materials and Methods:

Participants:

The sample population for this study consisted of 28 (n=15 females and n=13 males) undergraduate students between the ages of 19 to 22, from the University of Wisconsin-Madison. No incentives were offered, such as monetary compensation or course credit. Participants were volunteers that signed a consent form detailing any possible risks involved in this study (Appendix A).

Materials:

- BIOPAC Student Lab System: Biopac BSL 4.0 MP 36 Unit # MP36E120400278, Manufactured by BIOPAC Systems, Inc. (Goleta, CA)
- Electroencephalogram (EEG), Model SS1LA Electrodes (#12092161), Manufactured by BIOPAC Systems, Inc. (Goleta, CA)
- Nonin Pulse Oximeter, Model Nonin Pulse Oximeter/ Carbon Dioxide Detector (#9843), Manufactured by Nonin Medical, Inc. (Plymouth, MN)
- Galvanic Skin Response (EDA), Model BSL EDA Finger Electrode Xdcr (#SS3LA), Additional Supplies GEL 101, Isotonic Recording Electrodes, Manufactured by BIOPAC Systems, Inc. (Goleta, CA)
- Sony MDR ZX110NC Over-Ear Headphones, Manufactured by Sony Corporation Tokyo, Japan
- dothetest.(2008, March 10). *Test Your Awareness: Do The Test* [Video file] Retrieved from https://www.youtube.com/watch?v=Ahg6qcgoay4, Published March 10, 2008
- Roses of Time. (2015, January 23). *Carlos Nikai Earth Spirit Music* [Video file]. Retrieved from https://www.youtube.com/watch?v=19nm5_nAwQg
- Syentifik Films. (2012, October 26). *Gunshots- sound effect* [Video file]. Retrieved from https://www.youtube.com/watch?v=uczvgWb-nP8
- Microsoft Office: Word, Excel, Microsoft Corporation (Redmond, WA)
- True Random Number Generator, random.org

Methods:

Prior to experimentation, each participant was briefed and asked a series of questions to determine if he/she was eligible to participate (Appendix B). Those not eligible were thanked for their interest and asked to leave, and those eligible proceeded in the experimental process. To obtain measurements a combination of BIOPAC software: an EEG to measure brain wave activity, Galvanic Skin Response (GSR) to measure electrodermal activity, and the Nonin Pulse Oximeter to monitor heart rate.

Prior to each data collection session, calibration of the EEG and GSR was completed using a designated researcher. Electrode leads on the EEG were cleaned, as well as the pads of the GSR to ensure proper conduction. Additionally, it is important to note that whenever the EEG was used, the participant was blindfolded to mitigate any visual stimulus that could have contributed to brain waves.

In order to randomly designate experimental versus control groups a random integer generator (random.org) was used. A list of 20 integers was randomly generated as either 1 (experimental group) or 2 (control group). This was carried out twice, once for the female group and once for the male group, leaving two lists that would be followed based on the order of participants. A briefing session was conducted, explaining a basic procedure and expectations of the data collection process, short of creating reactivity. After determining group distribution, only the participant actively undergoing data collection remained in the room, while all potential participants were sequestered to Room 2385 Medical Sciences Center, 1300 University Ave, Madison, WI 53706.

A timeline of the design for both experimental and control groups can be seen in Figures 3 and 4, respectively. In the proceedings for both the control and experimental group, the

participant was guided to a seat where testing was conducted. The index finger of his/her right hand was attached to the pulse oximeter. The index and middle fingers of his/her left hand were each snugly attached to the galvanic skin response, finger electrode model. The three leads to the EEG were placed: ground lead behind the mastoid process of the left ear, VIN + in the medial portion of the left temporal bone, and VIN - in the posterior portion of the left occipital bone. A blindfold was carefully wrapped around their head. Lastly, Sony noise-cancelling headphones were placed over their ears. Data was collected for the EEG and GSR via BIOPAC software system, and the pulse oximeter data was recorded in five second intervals by a stopwatch and observation from a researcher, which was later entered into Microsoft Excel.

In the control group, data collection began by establishing a baseline reading with 90 seconds of no sound. This decision in experimental design sought to maximize the difference in physiological data for comparison between the experimental and control groups. Immediately following the readings, the blindfold was removed and a cued video demonstrating a known selective attention test was presented. In response to the video, a researcher posed a yes or no question, with yes indicating a visual stimulus had been detected, or no, indicating the visual stimulus had not been detected.

In the experimental group, data collection was done through a progressive auditory sequence: 30 seconds no sound (negative control), 45 seconds of a rainforest track (positive control), and 10 seconds of gunshots. The volume remained constant throughout the sequence. [Note: explicit disclosure and screening was done to determine whether a participant deemed themselves able to participate and endure a stressful stimulus.] Immediately following the end of the sequence, the blindfold was removed and the participant was shown the same selective

attention test in an identical manner to the control group. Data was recorded using the same protocol.

After the selective attention test, participants from both the control and experimental group were disconnected from the physiological testing devices. The participants were thanked and appropriately debriefed. Finally, equipment was cleaned between participants to ensure proper sanitation, and accurate data collection.

With the resultant data, an analysis was conducted through a number of statistical tests. In order to quantify a sympathetic response, a series of paired t-tests were conducted for each participant. The population means used for the experimental group were based on the mean values taken from 10-30 seconds during the negative control, 50-70 seconds during the positive control, and from 75-95 during the stress inducing stimulus. The population means used for the control group were over the same time intervals, though it is important to note that only the negative control was present. A statistically significant difference in the experimental group participants versus the control group would be supportive of the hypothesis. This test was conducted for mean values on each physiological response, using alpha-wave and beta-wave frequency for EEG, EDA amplitude for the GSR, and heart rate for the pulse oximeter. For the selective attention test, the qualitative data was quantified, denoting a value of 1 for noticing the distractor and a value of 0 for experiencing inattentional blindness. With the resulting means from the experimental and control group, a standard t-test was run. Obtaining a statistically significant result would be supportive evidence of a difference in selective attention between those who had an activated sympathetic nervous system and those who did not.

To determine the validity of the choice materials, positive control tests were carried out. A 6 second recording of gunshots was used as a positive control to analyze the participant's response in EEG, Heart Rate, and EDA. As shown in Figure 1, gunshots played at 76 seconds showed a spike in EDA response, serving as evidence of the expected results. Similarly, there was an expected spike in heart rate following the sound of gunshots. The participant's initial heart rate was 65 bpm and following the positive control, was 76 bpm. Lastly, a positive control test for the EEG was conducted. As shown in Figure 2, a reading of beta waves that showed an increase in frequency due to a stimulus was captured. Through these three successful control tests, the ability to effectively collect and interpret data with the given devices was demonstrated.

Results:

For the statistical tests conducted, all p-values were compared to a critical value of α= 0.05. Three time intervals were used to test the physiological variables across all subjects. Time interval one was defined as 10-30 seconds, which was the negative control for both groups. Time interval two was 50-70 seconds, which was the positive control for the experimental group and negative control for the control group. Lastly, time interval three was 75-95 seconds, which was the experimental stimulus, gunshots, for the experimental group and negative control continued for the control group. The progression of events occurring within these time intervals for the experimental group (negative control; positive control; experimental stimulus) and control group (negative control; negative control; negative control) can be seen in the experiment timeline, figures 3 and 4, respectively. All calculated averages for experimental and control groups can be found in Table 1. Standard errors were calculated using the standard deviation of the population

for each respective physiological test divided by the square root of each sample size. Values are reflected in Table 2 and represented in Figures 5-8.

Galvanic Skin Response:

There was no significant difference (p=0.207) in the mean change in electrodermal activity (EDA) shown by a t-test between the experimental and control group for the second time interval. There was a significant difference (p=.010) when running a similar test for the third time interval. This test is resultant of an increase in mean EDA of 0.601 microsiemens (mS) in the experimental group and a decrease of 0.093 mS in the control group (Figure 7).

It is important to note that no significant difference (p=0.096) was found when conducting a paired t-test between the mean EDA values of the experimental group for time intervals two and one. However, a significant difference (p=0.010) was detected running a similar test using time intervals three and one. The change in mean EDA for time interval two was 0.065 mS and for time interval three was 0.601 mS. The resultant t-tests comparing time interval two to one and time interval three to one (p= 0.096, p=0.036) led to the rejection of the null hypothesis and the conclusion that an individual in the experimental group should experience an increase in EDA with exposure to the stimulus.

For the control group, the change in mean EDA decreased by 0.026 mS in time interval two and decreased by 0.094 mS in time interval three. No significant difference (p=0.425, p= 0.317) was found when conducting a paired t-test between the mean EDA values of the control group for time intervals two and one or time intervals three and one.

Electroencephalography (EEG):

There was no significant difference (p=0.229, p=0.388) in the mean change of alpha wave frequencies between the experimental and control groups over time interval two and time interval three.

For the experimental group, the change in alpha wave frequency decreased by 0.313 Hz in time interval two and decreased by 0.249 Hz for time interval three. No significant difference was detected (p= 0.135, p=0.278) in a paired t-test comparing the alpha wave frequencies between time intervals two and one or time intervals three and one for the experimental group. The study hypothesized a decrease in alpha wave frequency should be seen in the experimental group after the stimulus, but a nonsignificant p-value voids this.

For the control group, the change in alpha wave frequency increased by 0.003 Hz in time interval two and decreased by 0.444 Hz for time interval three (Figure 5). No significant difference was detected (p=0.497, p=0.065) in a paired t-test comparing the alpha wave frequencies between time intervals two and one or time intervals three and one,

There was a significant difference (p=0.044) in the mean change of beta wave frequencies between the experimental and control groups over time interval two. There was no significant difference (p=0.277) in the same comparison over time interval three. The experimental group experienced a decrease in beta wave frequency of 0.697 Hz in time interval two and decrease of 0.542 Hz over time interval three (Figure 6).

A significant difference was detected in a paired t-test comparing the beta wave frequencies between time intervals two and one for the experimental group (p=0.012). No significant difference was detected running the same test between time intervals three and one (p=0.098).

For the control group, the change in beta wave frequency increased by 0.416 Hz in time interval two and decreased by 0.101 Hz over time interval three. No significant difference ($p=0.287$, $p=0.445$) was detected in a paired t-test comparing the beta wave frequencies of time intervals two and one or time intervals three and one for the control group.

Heart Rate:

There was a significant difference ($p=0.020$) for the change in mean heart rate between the control and experimental group during the second time interval (Figure 8). This is reflective of a decrease in the change of mean heart rate of 1.5 bpm in the experimental group and an increase of 1.45 bpm in the control group. This data is supportive of the alternative hypothesis because as the experimental group exposed to the positive control during the second time interval indeed experiences a decrease in heart rate. Comparatively, there was no significant difference ($p=0.086$) when conducting a similar test between the control and experimental group for the third time interval.

For the experimental group, the change in mean heart rate decreased by 1.50 bpm for the second time interval and decreased by 1.52 bpm for the third time interval. A significant difference ($p=0.036$) was obtained for a paired t-test comparing the second and first time intervals. This result attests to the validity of the positive control. No significant difference ($p=0.070$) was obtained when running a similar test comparing the third and first time intervals. The study hypothesized that an increase in heart rate should have been noted in the third time interval for the experimental group, but the data resulted in failure to reject the null hypothesis.

For the control group, the change in mean heart rate increased by 1.456 bpm during the second time interval and increased by 0.900 bpm for the third time interval. There was not a

significant difference (p=0.072, p=0.287) when using a paired t-test to compare change in mean heart rate between the second and first time interval and third and first time interval.

Selective Attention:

The qualitative data obtained from the participant's response was first quantified, denoting a numerical 0 to represent an unnoticed distractor and 1 to represent a spotted distractor. A t-test was then conducted, comparing the results of the experimental group to the control group. There was no significant difference detected (p=0.131). Interestingly, only 3 of 20 spotted the distractor in the experimental group, while 0 of 8 spotted the distractor in the experimental. The study hypothesized that the experimental group would experience a greater ability to spot the distractor, however the data resulted in failure to reject the null hypothesis.

Discussion:

The hypothesis of this study was that an auditory stimulus of gunshots sounds would elicit an increase in heart rate, skin conductance, and beta wave frequency via an activated sympathetic nervous system, making one less likely to experience inattentional blindness. Two of the three physiological tests did not support the hypothesis, in that gunshots did not induce an increase in heart rate or beta wave frequency; however, skin conductance did increase as a result of the gunshots. Furthermore, there was no statistical difference between the experimental and control groups in their likelihood to experience inattentional blindness.

EDA Captures Sympathetic Response Elicited by Experimental Stimulus:

The majority of participants in the experimental group showed a significant increase in skin conductance during the time period in which they heard gunshots. The significant difference obtained between the control and experimental group leads to the rejection of the null hypothesis

and conclusion of the alternative hypothesis: that a stressful auditory stimulus is capable of inducing an increase in electrodermal activity. One must acknowledge that each participant will have an inherently different baseline value for electrodermal activity. For example, a participant in the experimental group exhibited extreme nervousness with a starting EDA of 13.44 mS in the first time interval, whereas another participant in the experimental group who was seemingly calm had an EDA value of 0.91 mS in the first time interval. To account for this difference, the study used the measurement in the first time interval as a baseline for each participant. The subsequent time intervals gave comparative values that normalized the data. EDA proved to be consistent and reliable in picking up a signal from each participant. This can be attributed to using the pads of the index and middle finger which provided ample surface area for the electrodes. Based on the results of this technique, EDA should be considered for use in studies of a similar nature.

Inconclusive Change in EEG Alpha/Beta Frequencies Did Not Convey Sympathetic Response:

The results showed no significant difference in alpha or beta wave frequencies between or within the experimental and control group during the stimulus time period. Obtaining a decrease in the experimental group beta wave frequency results in the failure to reject the null hypothesis. It is known that beta waves increase in frequency when one is alert, aroused, or focused (Teplan, 2002). The purpose of the positive control for the experimental group was to relax and calm the participant, which would be noted by a decrease in beta wave frequency. A significant decrease was noted between the two groups and within the experimental group during the second time interval, therefore the positive control results are supportive of its desired intentions. There was no significant difference for change in alpha wave frequency during the

second time interval. The data was again normalized by using the first time interval as a baseline, with subsequent time intervals giving comparative values.

This experiment relied on the idea that an auditory stimulus of gunshots would elicit a noticeable response from participants. However, after participating in data collection and obtaining the results, the possibility must be confronted that the stimulus did not have its intended effects. A wide range of both increases and decreases in wave frequency were noted depending on the participant, but ultimately no significance was found due to the gunshot stimulus. This may be a result of desensitization to gunshots from external exposure or insufficient volume. Using a three lead EEG proved to be difficult. It is unclear whether the neural responses in any given band generated by the experimental stimulus were too subtle to detect, or if the response is spread across different frequency bands. This physiological measurement carries important implications, yet there is reluctance to encourage use in future studies unless one is well versed in its methodology.

Conclusive Positive Control, Inconclusive Experimental Stimulus When Measuring Heart Rate:

The hypothesis stated that the control group should maintain a relatively constant heart rate. This was supported by the study as no significant p-values were obtained for any interval. In the experimental group, varying results were obtained (Figure 9). A significant decrease in heart rate was noted during the positive control, which is concurrent with the intentions of the calming music, to relax the participant. Following the experimental stimulus, few participants showed an expected increase in heart rate, some showed no change, while many others experienced a decrease. The inherent variability in individuals along with a number of confounding variables could influence the observed changes. These will be further discussed in the limitations section.

Heart rate data was normalized by using the first time interval as a baseline, with subsequent time intervals giving comparative values. Based on the reliability and results from the pulse oximeter, this device could serve well in studies of a similar nature.

Inconclusive Results in Applications to Selective Attention:

The study hypothesized the experimental group, subject to the gunshot stimulus, would be less likely to succumb to inattentional blindness and notice the distractor. There was no significant difference indicated in the comparison between the control and experimental groups. Therefore, the null hypothesis failed to be rejected. Using the *Do The Test* selective attention likely affected the results because several participants had already seen the video and others had seen different tests with a similar theme. It is also important to note that while a comparison can be done between the control and experimental group, there is no set rate at which a distractor should be notice, only the experimental data from past studies.

Limitations:

As with any experimental design, there are identifiable limitations and concerns with the experimental setup. Due to the limited availability of participants, all participants were similarly aged college students. Therefore the results from this study cannot be applied to a population outside of the age range studied here. Secondly, although the basic components of the sympathetic stress response are clear and well-studied, an individual's personal response to stress can be highly nuanced and variable (APA). While one volunteer may exhibit an increase in electrodermal activity but no change in heart rate, another volunteer may have an equal and opposite response. These types of differences between individuals present a clear limitation in deriving a broad explanation for the results.

Furthermore, a participant's short-term behavior prior to the experiment must also be considered. Exposure to caffeinated beverages have shown to cause a short-term increase in heart rate (Green, 1996). A 2013 study by the University of New Hampshire found that forty percent of 18 to 24 year olds drink coffee every day (Olsen, 2013). Because all participants (n=28) involved in this study can be placed within this age group, it is reasonable to consider caffeine intake as a confounding factor for heart rate measurements.

Another factor to be considered may be participant desensitization to the stimulus, the gunshot track. Due to the common use of gunshots in video games, action movies, and certain genres of music, participants who frequent these forms of media may be desensitized and show a less pronounced stress response. An additional desensitization to consider is exposure to the selective attention video. Had a participant seen the video before, they would be much more likely to not experience inattentional blindness and notice the distraction.

Lastly, a question from the consent form may have been a limitation. The question "Have you ever experienced a traumatic event?" (Appendix B) was asked in order to obtain informed consent. This question had the potential to prime participants to expect an upcoming event and/or create a resurgence of feelings from a past event. In the first case, there is the potential to eliminate a physiological response to the stimulus because the participant was expecting it. In the later case, one must consider a feedforward response causing an anticipatory increase in any of the three physiological measurements before the stimulus.

Future Studies:

The purpose of this study was to analyze the physiological effects elicited from a strong auditory stimulus, along with its effect on selective attention. The measured results did not show

many significant findings towards implicating a causal relationship. Despite no definitive conclusions, this experiment still begs a question with important societal implications. Further studies are warranted to provide support for our data, or to establish any link between selective and a sympathetic response.

In designing a future study, researchers may consider selecting a more representative and larger population sample to allow for a broader understanding of the human stress response. An expansion of this study may prove useful in studying differences in stress between age groups, gender, health disparities, etc… Researchers may also consider a more thorough vetting process to obtain a sample population that is not aware of the concept of selective attention. Additionally, there could be benefit in conducting a personal stress questionnaire prior to carrying out the experiment to identify participants whose data may be confounded by outside sources.

Tables:

	Time Interval 1				Time Interval 2				Time Interval 3			
	EEG Rate-Alpha Waves (Hz)	EEG Rate-Beta Waves (Hz)	Average EDA (mS)	Average Heart Rate (BPM)	EEG Rate-Alpha Waves (Hz)	EEG Rate-Beta Waves (Hz)	Average EDA (mS)	Average Heart Rate (BPM)	EEG Rate-Alpha Waves (Hz)	EEG Rate-Beta Waves (Hz)	Average EDA (mS)	Average Heart Rate (BPM)
Experimental Average	14.3285	25.1265	5.493	76.6	14.0155	24.43	5.558	75.1	14.08	24.585	6.094	75.08
Control Average	14.655	25.26	6.065875	74.75	14.6575	25.67625	6.039625	76.20625	14.21125	25.15875	5.97225	75.65

Table 1. Calculated averages for all participants within experimental and control groups for time intervals one, two, and three.

	EEG-Alpha Waves Time Interval 2	EEG-Alpha Waves Time Interval 3	EEG-Beta Waves Time Interval 2	EEG-Beta Waves Time Interval 3	EDA Time Interval 2	EDA Time Interval 3	Heart Rate Time Interval 2	Heart Rate Time Interval 3
Experimental Standard Error	0.2681	0.4013	0.2781	0.3932	0.0469	0.1542	0.7646	0.9602
Control Standard Error	0.2644	0.2418	0.6599	0.6635	0.1259	0.1758	0.8296	1.4252

Table 2. Calculated standard errors for each measurement during time intervals 2 and 3. Since time interval 1 served as the baseline, there was no standard error. Standard error values are reflected in Figures 5-8.

Figures:

Figure 1. Positive Control Test for Electrodermal Activity (EDA). This test was conducted by asking a participant to think of an embarrassing moment. The green spike, as indicated by the

black arrow, is indicative of an increase in microsiemens.

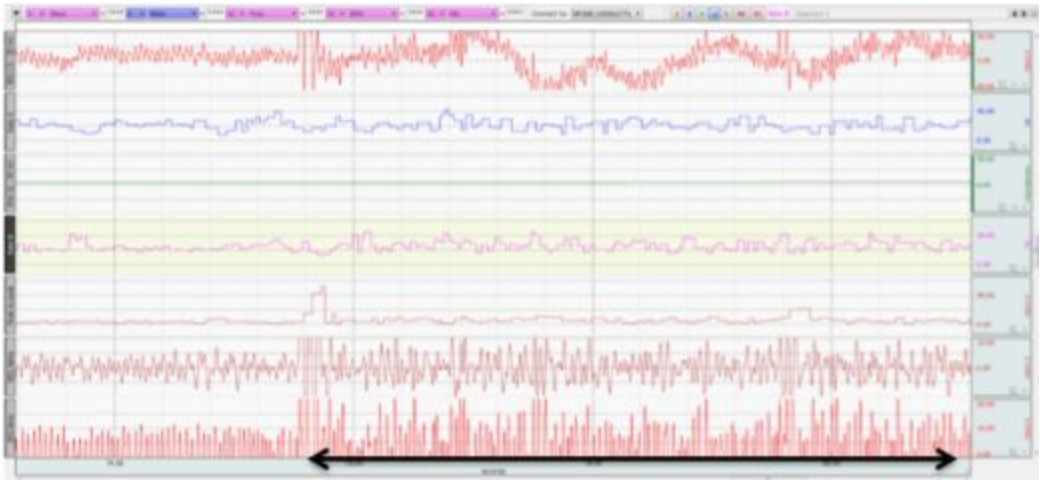

Figure 2. Positive Control Test for EEG Waves (Alpha and Beta). The lower two waveforms represent the alpha and beta EEG waves, respectively. A calibration was done to observe differences between the groups.

Pre-Experiment	Time Interval 1	Time Interval 2	Time Interval 3	Post-Experiment
• Have the participant read and sign the consent form. • Attach Elctroencephalogram. • Attach Nonin Pulse Oximeter. • Attach Galvanic Skin Response. • Attach blindfold.	• Beginning of experiment. • Participant hears silence.	• Participant listens to "Carlos Nakai: Earth Spirit".	• Participant listens to gun shots.	• Participant watches "Test Your Awareness: Do The Test" YouTube Video. • Remove equipment. • Thank the subject for their participation.

Figure 3. Timeline of events the experimental group experienced throughout the duration of the experiment.

Pre-Experiment	Time Interval 1	Time Interval 2	Time Interval 3	Post-Experiment
• Have the participant read and sign the consent form. • Attach Elctroencephalogram. • Attach Nonin Pulse Oximeter. • Attach Galvanic Skin Response. • Attach blindfold.	• Beginning of experiment. • Participant hears silence.	• Participant hears silence.	• Participant hears silence.	• Participant watches "Test Your Awareness: Do The Test" YouTube Video. • Remove equipment. • Thank the subject for their participation.

Figure 4. Timeline of events the control group experienced throughout the duration of the experiment.

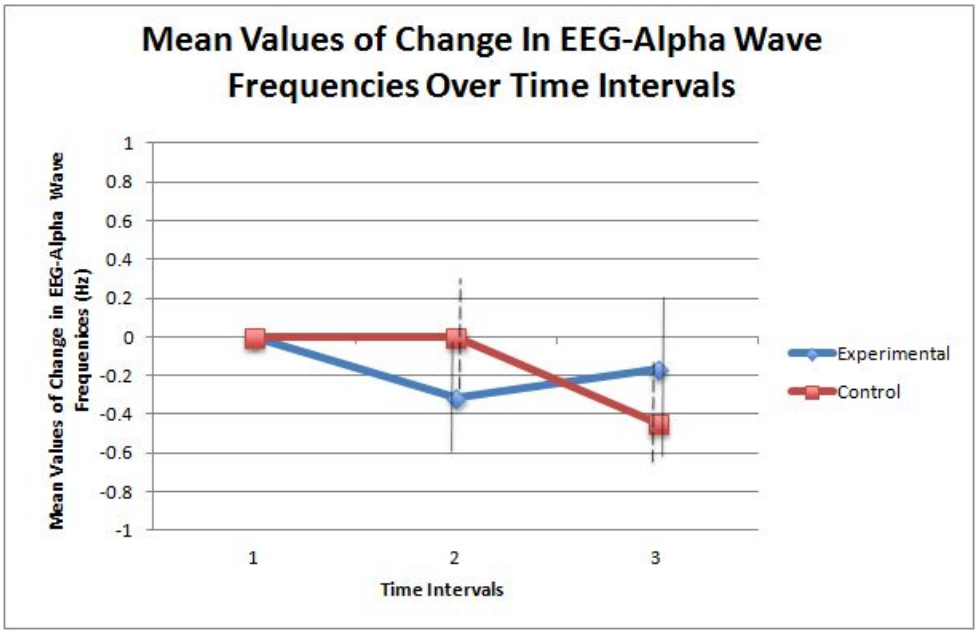

Figure 5. There was no significant difference (p=0.229; p=0.388) in the mean change of alpha wave frequencies between the experimental and control groups over time interval two and time interval three, when compared to the baseline time interval one. For the experimental group, the change in alpha wave frequency decreased by 0.313 Hz in time interval two and decreased by 0.249 Hz for time interval three. For the control group, the change in alpha wave frequency increased by 0.003 Hz in time interval two and decreased by 0.444 Hz for time interval three. Standard error for the experimental group is delineated by a solid line, representing a value of ±0.2681 for time interval 2 and ±0.4013 for time interval 3. Standard error for the control group is delineated by a dashed line, representing a value of ±0.2644 for time interval 2 and ±0.2418 for time interval 3.

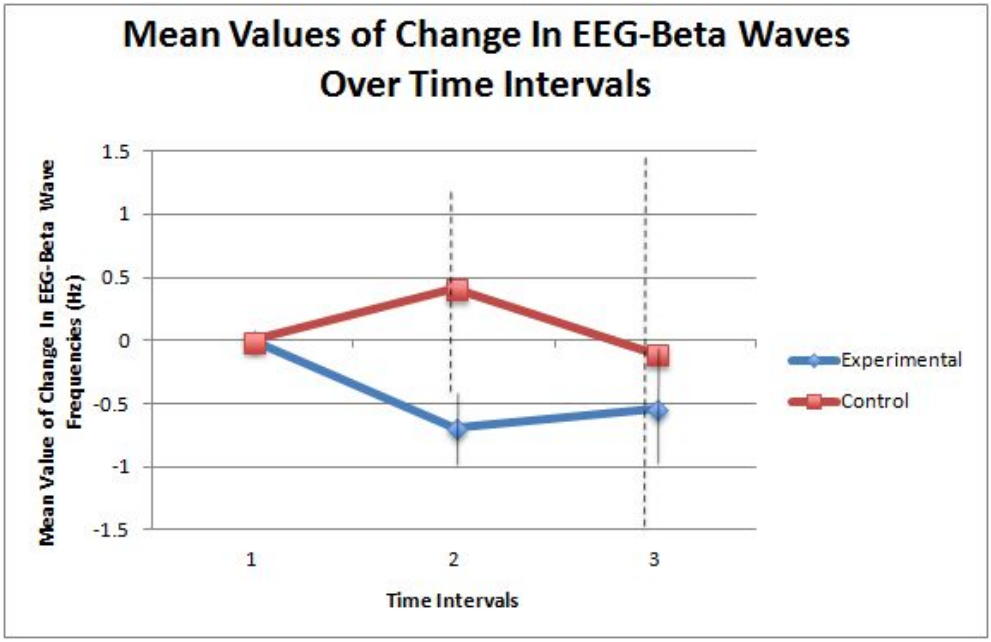

Figure 6. There was a significant difference (p=0.044) in the mean change of beta wave frequencies between the experimental and control groups over time interval two. There was no significant difference (p=0.277) in the same comparison over time interval three. For the experimental group, the change in beta wave frequency decreased by 0.697 Hz over time interval two and decreased by 0.542 Hz over time interval three. For the control group, the change in beta wave frequency increased by 0.416 Hz over time interval two and decreased by 0.101 Hz over time interval three. Standard error for the experimental group is delineated by a solid line, representing a value of ±0.2781 for time interval 2 and ±0.3932 for time interval 3. Standard error for the control group is delineated by a dashed line, representing a value of ±0.6599 for time interval 2 and ±0.6635 for time interval 3.

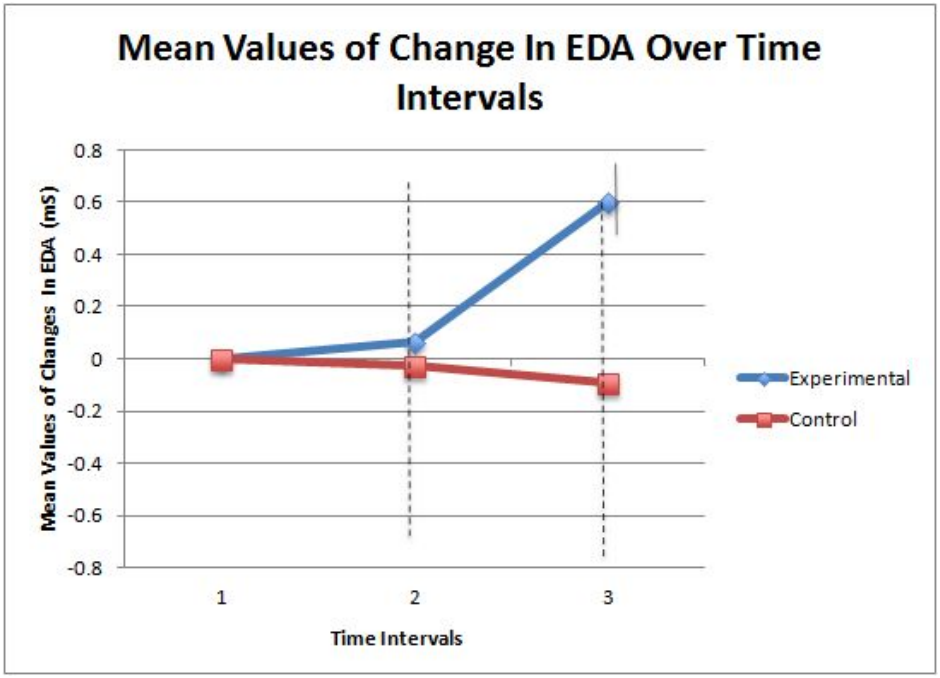

Figure 7. There was no significant difference (p=0.207) in the mean change in EDA between the experimental and control groups over time interval two. There was a significant difference (p=0.010) in the same comparison over time interval three. For the experimental group, the change in EDA increased 0.601 mS over time interval three. For the control group, the change in EDA decrease by 0.093 mS. Standard error for the experimental group is delineated by a solid line, representing a value of ±0.0469 for time interval 2 and ±0.1542 for time interval 3. Standard error for the control group is delineated by a dashed line, representing a value of ±0.1259 for time interval 2 and ±0.1758 for time interval 3.

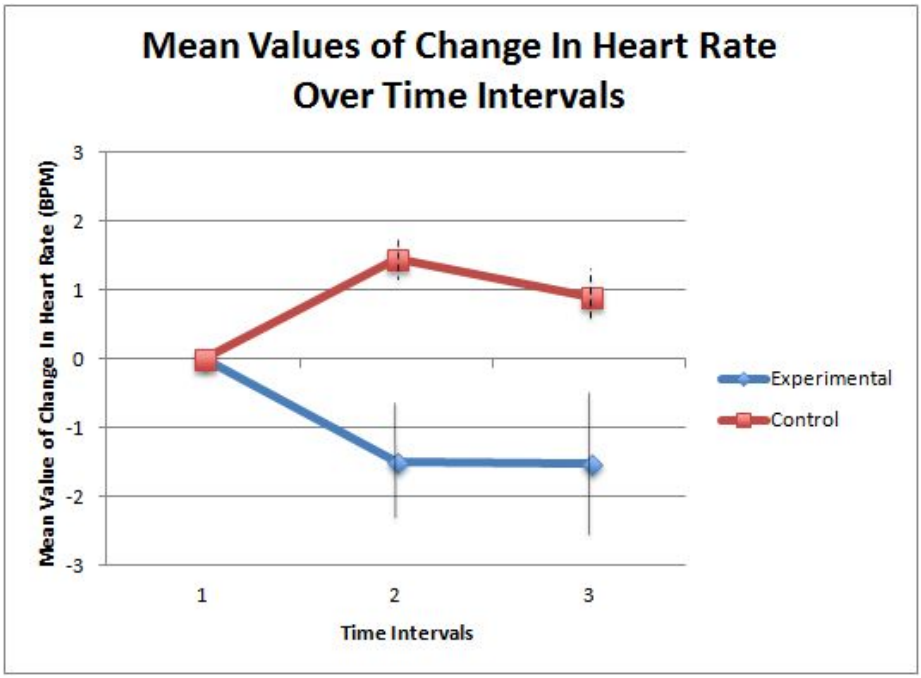

Figure 8. There was significant difference (p=0.020) between the experimental and control groups at time interval two. The experimental group showed a decrease of 1.5 bpm in the change of mean heart rate and an increase of 1.45 bpm in the control group. There was no significant (p=0.086) difference found between the experimental and control group found in the third-time interval. The experimental group decreased by 1.5 bpm for the second time interval and decreased by 1.52 for the third time interval. Standard error for the experimental group is delineated by a solid line, representing a value of ±0.7646 for time interval 2 and ±0.9602 for time interval 3. Standard error for the control group is delineated by a dashed line, representing a value of ±0.8296 for time interval 2 and ±1.4252 for time interval 3.

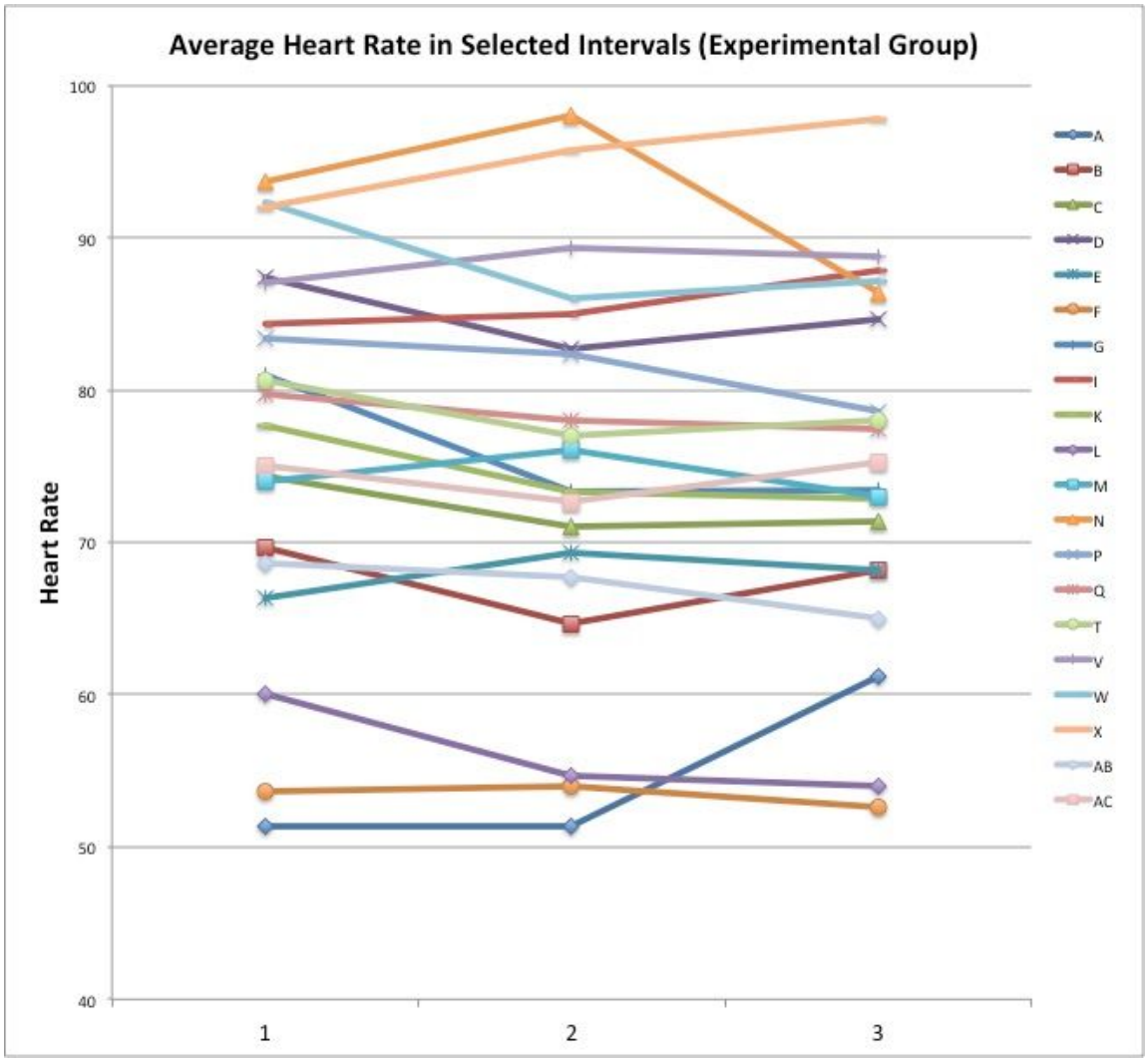

Figure 9. The heart rate data of the 20 participants of the experimental group show varying results in each time interval.

Appendix A

UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Effects of an Auditory Stimulus on the Nervous System and Selective Attention

Principal Investigators: Marjorey Razdolsky, Samuel Kefer, Nora Katib, Julie Zaifman, Alex Daneshgar

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study about how the body physiologically responds to an auditory stimulus and its effect on selective attention.

You have been asked to participate because you are enrolled in Physiology 435.

The purpose of the research is to measure physiological responses while receiving an auditory stimulus.

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 listen to various sounds, watch a selective attention video, and be measured via an Electroencephalogram, Nonin Pulse Oximeter, and Galvanic Skin Response.

Your participation will last approximately twenty minutes.

After the semester is completed, you will be contacted with access to view the completed study.

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?

As a participant, this study is designed to present minimum risks. However, it is disclosed that the study may involve exposure to an auditory stimulus of a nature that could retrigger past traumatic events. As such, the participant will be subject to a brief screen beforehand, allowing

you to disclose any information you deem relevant, or allowing you to use your judgement to forgo participation.

By signing this form:

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?

No individual benefit will be received, but you will aid in overall scientific advancement regarding how the body responds to auditory sounds and its relationship on selective attention.

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?

Please contact Alex Daneshgar at daneshgar2@wisc.edu if you have any questions.

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

Your participation is completely voluntary. If you decide not to participate or to withdraw from the study it will have no effect on your grade in this class.

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research and voluntarily consent to participate.

Name of Participant (please print):_____

_____ _____

Signature Date

Appendix B

1. Thank you for considering to participate in our experiment. At this time, we would like to ask you a few questions to determine if you are eligible to participate.
2. Have you ever experienced a traumatic event?
    a. If Yes: If you decide to participate, you understand that you may subject yourself to strong emotional responses. Would you still like to continue?
        i. If yes: Continue to 3.
        ii. If no: Your answers have deemed you ineligible to participate in our study. Thank you very much for your consideration. Have a great day.
    b. If No: Continue to 3.
3. During this experiment, will you be okay:
    a. Sitting for 10-15 minutes and remaining silent?
        i. If yes: Continue to 3b.
        ii. If no: Your answers have deemed you ineligible to participate in our study. Thank you very much for your consideration. Have a great day.
    b. Being hooked up to several devices?
        i. If yes: Continue to 3c.
        ii. If no: Your answers have deemed you ineligible to participate in our study. Thank you very much for your consideration. Have a great day.
    c. Being blindfolded?
        i. If yes: Continue to 3d.
        ii. If no: Your answers have deemed you ineligible to participate in our study. Thank you very much for your consideration. Have a great day.
    d. Having noise-cancelling headphones on?
        i. If yes: Hand the participant the consent form.
        ii. If no: Your answers have deemed you ineligible to participate in our study.
        Thank you very much for your consideration. Have a great day.

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