Effects of a Visual Distraction on Physiological Measures and Concentration

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Abstract

Multitasking has become a standard practice among college students. Technology plays an increasing role in modern multitasking as college students commonly use computers and phones while engaging in other activities. The goal of this study is to determine if there is any significant physiological difference in concentration when an individual multitasks with television. The study hypothesized that the distraction would produce a decrease in heart rate and an increase in alpha brain waves and eye movement. Twenty-four participants completed an eight question concentration task each assigned either the treatment, with the visual stimulus on, or the control, with no visual stimulus present. During each participant's respective treatment alpha brain wave activity, eye movement, and heart rate were measured. The analysis of the results did not indicate any statistical significance and therefore no conclusions on television distractions and concentration can be made.

Introduction

It has become the norm on college campuses for students to multi-task (Foehr, 2006), which is defined as engaging in several attention demanding tasks to attain multiple goals simultaneously (Sanbonmatsu et al., 2013). Engaging in multitasking demonstrates diminished focus on a singular task even though it is often perceived as an efficient use of time by the individual. (Sanbonmatsu et al., 2013). Multitasking in the college environment usually presents as academic work combined with phone and television usage. As student interest in completing routine homework and study assignments is minimal, screen and television usage during studying has become a relatively standard practice (Calderwood et al., 2014). However, student cognitive systems may be overloaded with the amount of stimuli they are trying to process at one time (Pool et al., 2003). Television presents a variety of different stimuli, creating a higher potential for an overload of information-processing and subsequently reduced concentration on academic work (Pool et al., 2003).

Concentration can be quantified using several physiological measurements. Alpha brain waves, eye movement, and heart rate are the selected parameters of concentration for this study. Previous research has indicated a negative correlation between alpha waves and attention (Reeves et al., 1985),

meaning lower frequencies of alpha waves are observed when a person is concentrating on a task. Alternatively, higher frequencies of alpha waves are associated with distraction. Specifically, the 8-14 Hz band has been shown to correlate with attention and working memory (Manza, Hau, & Leung, 2014). The literature also provides insight on increases in heart rate due to a "rejection of environment" for higher concentration tasks (Edwards & Alsip, 1969). This phenomenon occurs when an individual is so focused on their current task that irrelevant external stimuli are blocked out and is only associated with individuals who demonstrate thoughtful concentration. Researchers explained this as a normal response for concentrating individuals because they would have to exert more internal focus to block out external stimuli than someone who was multi-tasking. Therefore, if a person is more concentrated on a particular task, their heart rate would be predicted to be higher than if they were distracted. Lastly, attention has been defined as the amount of time an individual is looking at what they are doing compared to time spent looking at something else (Reeves et al., 1985). Measuring the participant's vertical eye movement using EOG data serves as an indicator of the individual's level of concentration on the task in front of them.

For this experiment a laptop playing 2015 Adblitz Super Bowl Ads was selected as the distraction stimulus due to the wide accessibility of commercials by college students (Foehr, 2006). Analysis of the current literature regarding physiological outputs for concentration and distraction type settings led us to hypothesize that an environment with a background television stimulus would produce higher frequencies of alpha brain waves, lower heart rate, and increased vertical eye movement compared to the control, where no laptop is playing and task is completed in silence. The question of how well an individual is able to concentrate in the presence of a background stimulus, particularly television, is limited in the literature. Therefore, this study has implications for student academic performance in a world where media is becoming increasingly commonplace.

Materials and Methods

Participants

This study was conducted at the University of Wisconsin-Madison under the supervision of the Physiology 435 laboratory staff. Study participants (N=24) were randomly selected from a sample of

students enrolled in Physiology 435. Prior to engaging in the study, subjects were given a written consent form that outlined all potential risks and gave them the opportunity to opt out of the study for any reason. Each participant was then given an identification number to ensure their information was kept confidential throughout the study.

Materials

Alpha brain wave activity, eye movement, and heart rate were recorded as participants sat in front of a laptop computer and completed a concentration test with or without the presence of a visual stimuli. The Biopac Student Laboratory software was used to collect electrooculogram (EOG) and electroencephalograph (EEG) data. Two Biopac Electrode Lead Sets (SS2L) were hooked into the first two channels of the computer and six BioPac disposable electrodes (EL503) were attached to the participant's face using Biopac electrogel (Gel1) and an abrasive pad (ELPAD), made by Biopac Systems, Goleta, CA. In order to measure EEG, one Biopac electrode lead set (SS2L) was hooked into channel three and three Biopac disposable electrodes (EL503) were attached to the participant's head using Biopac electrogel (Gel1) and an abrasive pad (ELPAD), made by Biopac Systems, Goleta, CA.

In order to measure heart rate, a NONIN Pulse oximeter was attached to the participant's non-dominant index finger (NONIN: Pulse Oximeter and Carbon Dioxide Detector, Model 9843, Nonin Medical Inc., Plymouth, MN). Data for eye movement and brain activity was collected using BIOPAC software (MP36, BIOPAC Systems, Inc) on one Dell Inspiron 530 Desktop Optiplex 7020 Computer. Data for heart rate was recorded using Microsoft Excel 2011. For the distraction stimulus, a series of 2015 YouTube AdBlitz Super Bowl Ads (tinyurl.com/distraction-vids) were played for a total of 10 minutes. To display the distraction stimulus, a 2013 Apple MacBook Air (Apple, Inc. Cupertino, CA) was used with the volume of 50% and the brightness on 100% (as per Apple settings).

Positive Control

In order to ensure physiological changes were experimentally attainable, a positive control for each measurement was established. EEG testing was conducted on one group member to establish baseline measurements (Figure 1). The EEG positive control demonstrated that a higher frequency in

alpha waves is indicative of increased arousal and of lack of focus, which will be used to understand the participant's EEG readings in this study.

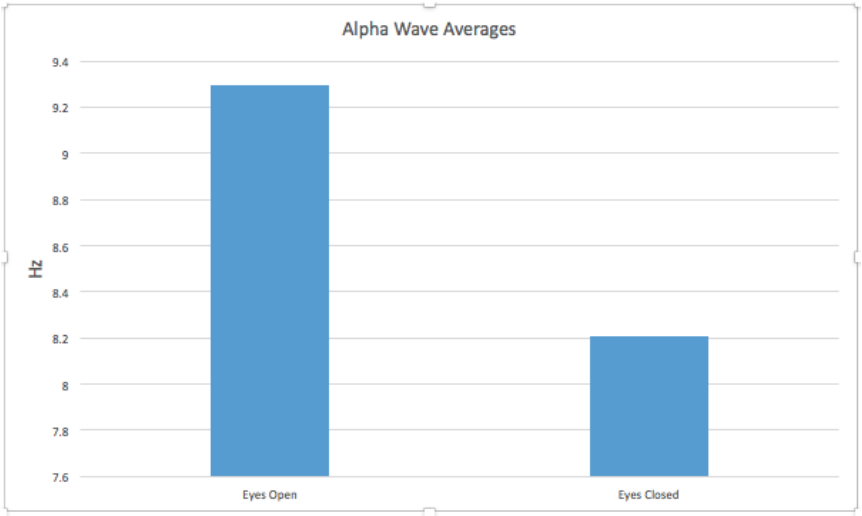


Figure 1: A representative graph of an individual's alpha wave activity. The subject was directed to close their eyes for one minute and open their eyes for one minute and an average of alpha wave frequencies was calculated for each condition. An average of 9.293 Hz was measured when the participant had their eyes open, while an average of 8.206 for eyes closed.

Baseline heart rate testing was established by measuring a group member's heart rate in two conditions, resting and elevated (Figure 2). This test demonstrated that the NONIN pulse oximeter could confidently measure a change in heart rate.

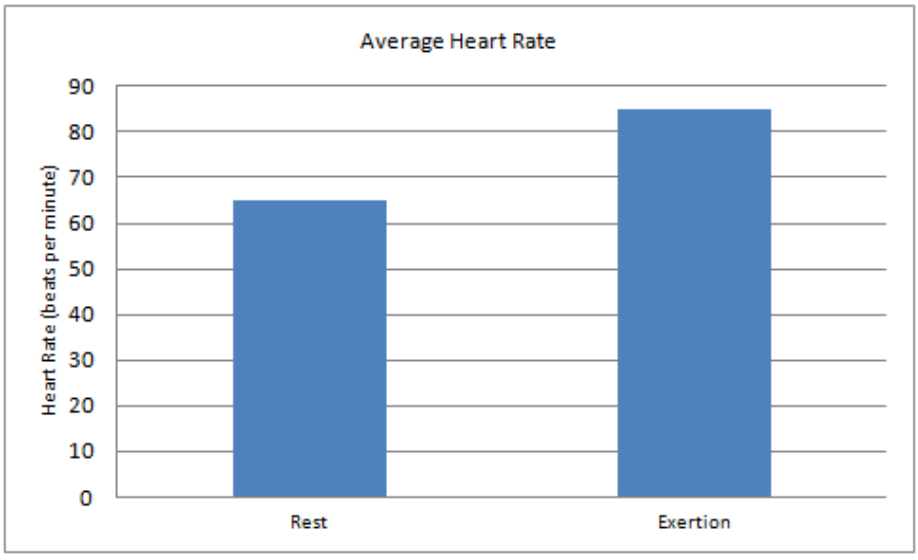


Figure 2: Average resting and active heart rate, taken every thirty seconds over a span of two minutes. During the resting condition, the group member rested for 5 minutes before their heart rate was recorded every thirty seconds for two minutes. During the elevated condition, the group member did two minutes of jumping jacks with their heart rate measured every thirty seconds.

In addition an EOG positive control was established by hooking up one group member to the EOG electrodes and directing them to look from the table up to the laptop screen and down again. This was to ensure that the primary parameter of eye movement could be measured and the Biopac software could detect the direction of eye movement.

Experimental Procedure

The question regarding the physiological effects of distraction on concentration will be investigated by exposing participants to a visual/auditory distraction and measuring their alpha brain waves, eye movement, and heart rate. Each participant was brought into a small test room and directed to sit down at a desk with a laptop in the left hand corner. While seated the participant was given a consent form that outlined the description of the experiment along with the duration and any potential risks the subject could experience. Every other consent form was labeled with a C to represent control or a D to represent distraction and the consent forms were distributed to ensure an equal number of control and test subjects. After the participant agreed to continue the study, recording equipment was positioned on the subject. Six EOG electrodes were placed on the subjects face as seen in Figure 3a.

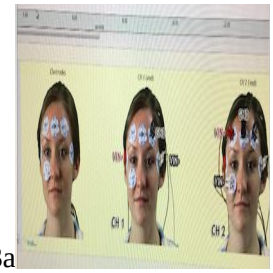
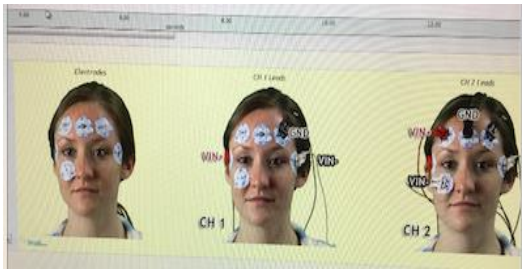
3a  3b 

Figure 3: Placement of EOG electrodes on participant's face. Six electrodes were placed on the subject's face in order to measure both horizontal and vertical eye movement (3a). The electrodes were given time to attach to the subject's face and shortly after each electrode was attached to their respected lead (3b).

The EOG electrodes were given 5 minutes for adhesion, during this time the subject's non-dominant index finger was attached to the NONIN pulse oximeter. In addition, three EEG electrodes were attached behind the left side of the subject's ear as seen in Figure 4.

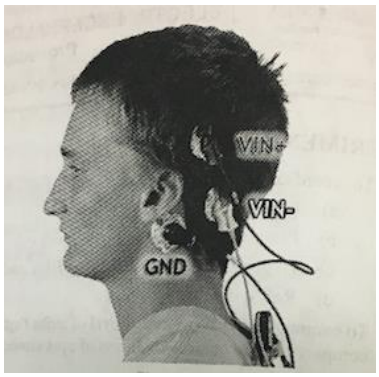


Figure 4: Placement of EEG electrodes on the left side of the subject's head. In order to ensure clear data was being collected the subject's hair was parted and each electrode was attached to the scalp.

Following set up, participants were instructed to sit facing towards the computer screen with their legs uncrossed, hands in their lap, and feet flat on the floor. The participants were then told to stare at their consent form on the desk for one minute while baseline measurements of EEG and EOG were recorded by the computer. During the minute of baseline measurement heart rate was recorded in thirty second increments by looking at the pulse oximeter. After baseline data was recorded the participant was given the following directions, "We are now ready to begin the experiment. Please fill out the exam to the best of your ability. You will be graded on accuracy and completion, but you will not be graded on time. Notify a research assistant if you have any other questions or issues." For participants assigned to the "D" group, a person from the research team pressed play on the laptop and the written concentration test was then administered to the participant. For participants assigned to the "C" group the test was administered in a silent room with no additional stimulation. The written concentration test consisted of eight questions that required the individual to focus by attending to a variety of different tasks including math, word, and geographic problems (Appendix A).

EOG and EEG measurements were recorded once the participant began the concentration test. Heart rate was recorded by the experimenter every thirty seconds throughout the test and later entered into a Microsoft Excel 2011 spreadsheet where the heart rate was averaged. The participant was told they were not timed on the concentration test but if they took longer than ten minutes they were asked to stop due to the limited amount of time for the study. After the participant completed the test for group "D", a person from the research team stopped the series of Ads. In both groups, the participant was then unhooked from

the testing equipment. The participant was excused from the testing room and asked not to discuss the experiment with their peers. A timeline of the experimental procedure can be seen in Figure 5.

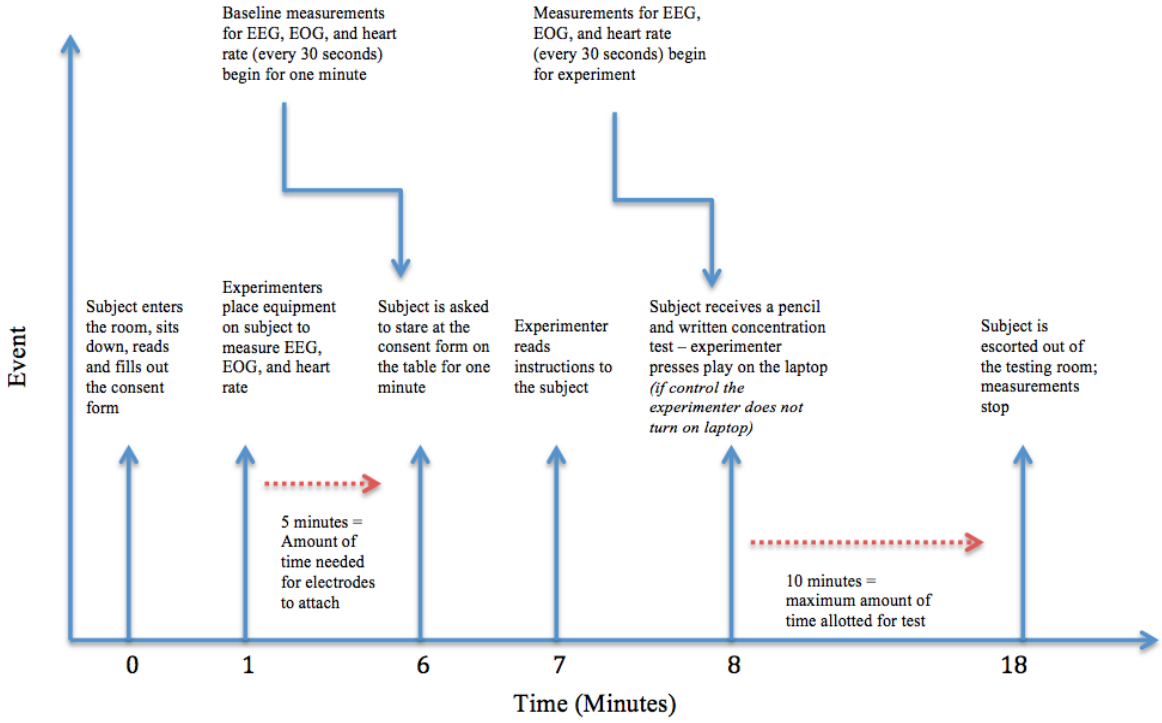


Figure 5: The experimental procedure timeline. The experimenter began the study by attaching all electrodes to the subject's face and head and waited five minutes. During the five minutes of electrode adhesion, the experimenter attached the subject's finger to the pulse oximeter. The control procedure timeline was identical, however, at minute 8 there was no laptop turned on.

Data Analysis

Data analysis was conducted using Microsoft Excel 2011. An unpaired t-test was used to analyze the relationship between the experimental treatments and the physiological measurements (heart rate, EEG, and EOG). In order to measure the difference between baseline and experimental treatment data, values were calculated to represent percent change from baseline. These values were then used to perform unpaired t-tests to determine if the differences in EEG, EOG, and heart rate between the control and experimental groups were significant.

Results

Heart Rate

When testing the control group (N = 10) and the experimental group (N = 11) all participants displayed an increase in heart rate. The average percent increase in heart rate was 14.655% for the control group (N = 10) with a standard deviation of 8.7041. The average percent increase in heart rate was 9.49% for the experimental group (N = 11) with a standard deviation of 4.3775 (Figure 6). An unpaired t-test on the percent change showed that there was no significant difference between the experimental treatments and the percent increase in heart rate (p-value > 0.05).

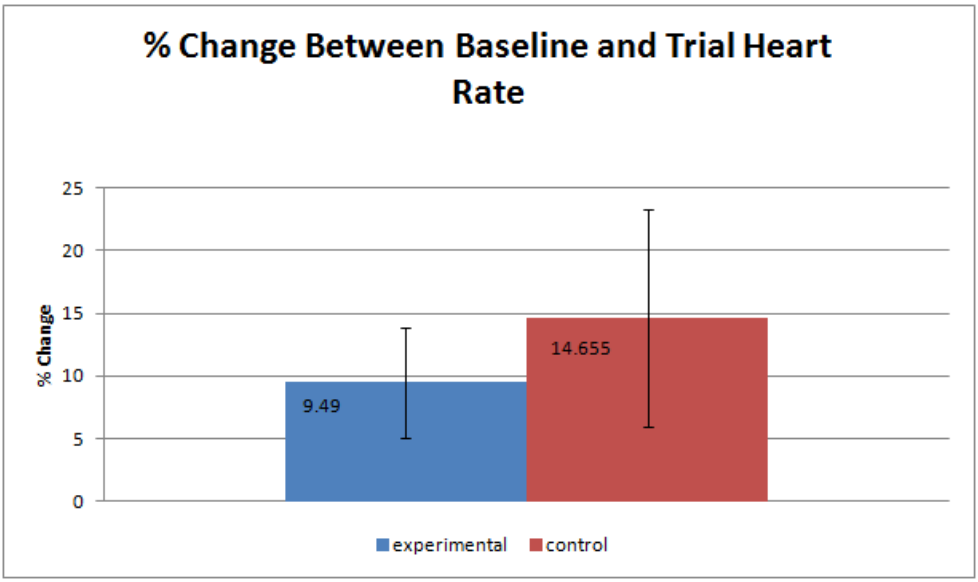


Figure 6: Average percent change between baseline heart rate and trial heart rate for the control and experimental trials. The control group had a higher percent change in heart rate than the experimental group did. A p-value of 0.1214 was obtained from an unpaired t-test.

Electroencephalogram (EEG)

Unpaired t-tests were used to analyze the percent change in alpha waves between the subject's baseline test and concentration task. The average percent increase in alpha brain waves for the control group was 1.576% (N=10) while the average percent increase for the experimental group was 7.929% (N=11). The average percent change in the control group was compared to the average percent change of the experimental group. The standard deviation for the experimental group was 13.91 and the standard

deviation for the control group was 7.15 as seen in Figure 7. The difference between the two groups was not statistically significant (N=22, P=0.1931).

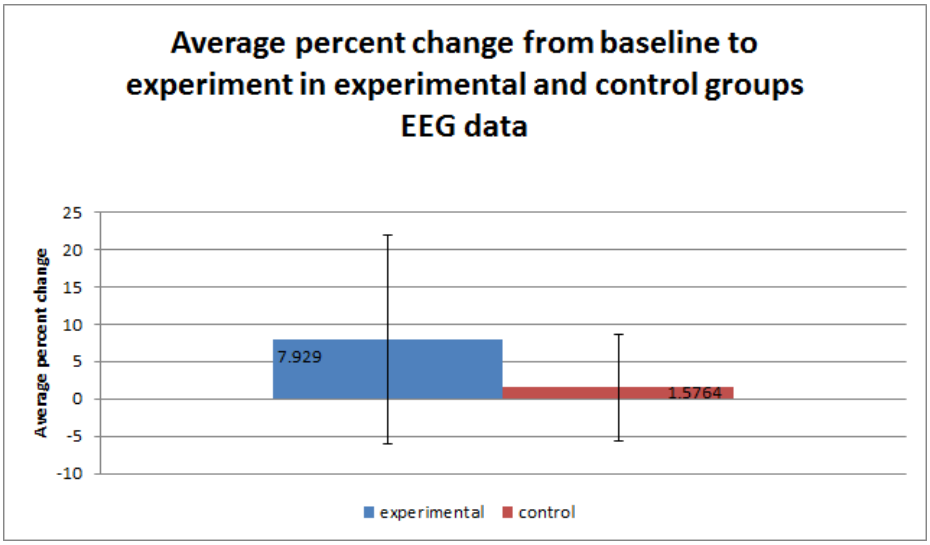


Figure 7: This figure shows the average percent change of all the participants in the experimental group and control group respectively from their baseline alpha waves to their concentration task alpha waves. The error bars are included. A p-value of 0.193 was obtained through an unpaired t-test.

Electrooculogram (EOG)

To analyze EOG data, wave signals from the electrodes were averaged for the vertical axis. Due to the laptop being in the subject's vertical direction the study ignored all horizontal data points for eye movement. After the alpha waves were averaged, standard deviations from the control and experimental groups were calculated to be 0.163072727 and 0.1831245455 respectively (Figure 8). The standard deviation between the averages was selected as a the measurement of study, as this would reveal the variance between the control and experimental subjects. An unpaired T-test between the averaged variances from the vertical EOG axis of the control and experimental groups revealed there is no evidence to suggest a significant difference between these groups (p=0.4073).

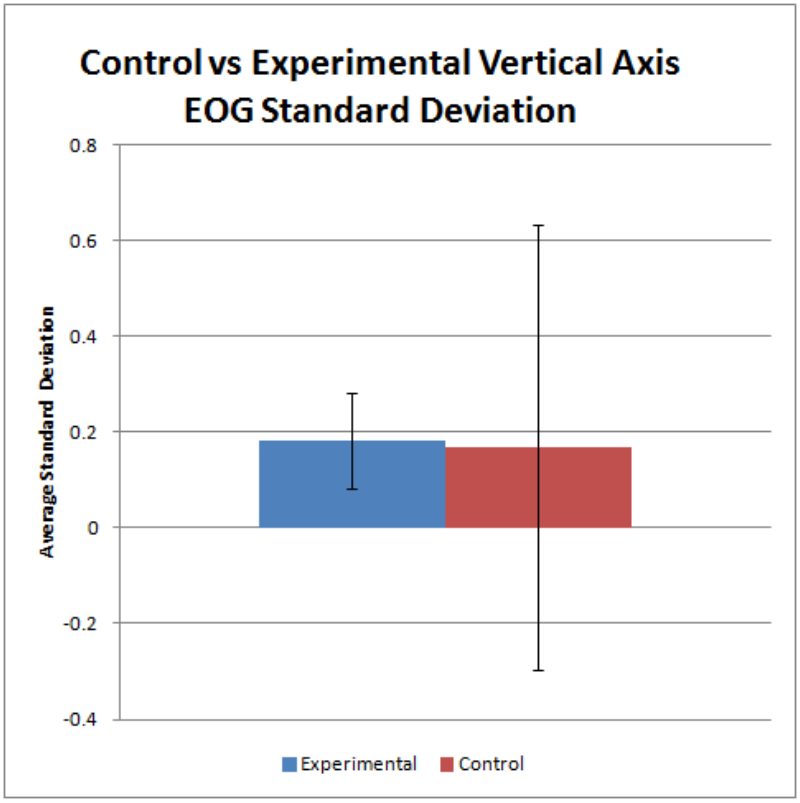


Figure 8: This figure illustrates the variance between the averaged x-axis EOG standard deviations for the experimental and control group respectively. The error bars are included in the graph. The experimental group showed a slightly higher amount of variance in its averaged standard deviation. A p-value of 0.4073 was obtained from an unpaired t-test.

Discussion

Based on the results, none of the study's hypotheses were supported, meaning no significant conclusions can be drawn to determine how a distraction affects an individual's ability to concentrate. This data indicates a failure to reject the null hypothesis for heart rate, alpha brain wave activity, and eye movement.

Heart Rate

The study hypothesized that subjects in the experimental group would demonstrate a lower relative heart rate compared to the control because individuals who are more concentrated on a task exhibit relatively higher heart rates than those who are given distractions (Edwards & Alsip, 1969). Data collected showed that subjects in the experimental group, on average, had a lower percent increase in heart rate than the control group. However, nothing can be concluded because the results showed no

significant difference between heart rate and experimental condition ($p > 0.05$). The concentration task in itself could account for the lack of correlation, as heart rate tended to consistently spike in each participant as they began the test regardless of what group they were assigned to. The participants nature regarding stress and test taking may have had more of an effect on heart rate than the distraction or lack of distraction, although further study is needed to explore this.

Alpha Brain Wave Activity

It was hypothesized that the experimental group would produce a higher frequency of alpha waves compared to the control. This is due to the fact that increased alpha waves have been found to correlate with decreased concentration (Reeves et al., 1985). The experimental conditions did not show significant effects on alpha brain wave activity ($p > 0.05$) of participants. Although the results are insignificant, the data collected did show that the experimental group experienced a higher percent increase in alpha wave frequency (7.929%) compared to the control group (1.576%). We hypothesized this trend to be observed in the data according to past literature. As stimuli increase, especially audio and visual, alpha wave activity should increase (Foxe & Snyder, 2011). Furthermore, it was expected that there be would minimal difference for the control group as they shifted from simply staring at a paper during the baseline to doing task in the trial. This is because there is was not a significant change in stimuli participants were exposed to in the control compared to the baseline.

If the study would have used more participants a larger difference between the two groups could have been observed. Additionally, as shown in Figure 8, there is a large standard deviation of the data. This could be due to different participants having varying experience multi-tasking, including some who may have practice multi-tasking regularly. It could also be due to variation in subjects and their ability to concentrate or become distracted while doing tasks. This would cause an increase or decrease in their measure alpha brain waves depending on their level of concentration. These confounding variables should be accounted for in future studies via a survey of multi-tasking experience.

Eye Movement

Any data from the horizontal axis for EOG were disregarded for this study, with the knowledge that vertical data would indicate the participant was shifting their gaze up or down from the paper in front of them. Horizontal data from reading the paper could not be differentiated from horizontal data due to the distraction. We expected to see a greater degree of variance for the experimental group indicating the subject was looking up or down for a longer period of time during the duration of the test. Although the experimental group did show a greater degree of variance, our p-value ($p=0.4073$) indicated this difference was insignificant between the two groups. If there was an instrument that could isolate large changes in horizontal eye movement, this may be helpful for further study. Confirmation bias may have played a role in our data, as students attempted to focus harder when presented with a visual distraction. It was noted several students avoided looking away in the experimental group even when contemplating an answer for the task. Furthermore, control subjects did not feel this pressure to focus and often looked away when formulating an answer for the task. Future studies should aim to reduce this bias, possibly by better enforcing the non-disclosure agreement.

Overall our results showed no correlation between a visual distraction and an individual's ability to concentrate. However, given various confounding variables and potential sources of error, additional studies should be completed to better understand media's effect on concentration and understanding. Such studies should control for extraneous variables by eliminating background noise, screening for participants who regularly engage in multitasking with media, and acquiring more precise equipment. These improvements would further define the relationship between media multitasking and concentration.

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Appendix A

Concentration Task:

Participant Number:

Name: _____ Date: _____

Instructions: Please fill out this exam to the best of your ability. You will be graded on accuracy and completion, **not on time.** Notify a research assistant if you have any questions or issues.

1. List all the U.S. states starting with M (there are 8)

   _____

   _____

   _____

   _____

   _____

   _____

   _____

   _____

2. Do the following multiplication problems:

   14 x 39: _____

   56 x 88: _____

   79 x 43: _____

3. Write the alphabet backwards.

4. Count up to 100 by 7.

5. Unscramble these words.
   OOTATM
   NOWRABI
   ZILRDA

6. Count the dots in the brackets [.....]: _____

7. If 1=A, 2=B, 3=C, etc., what is 1,823 + 6 - 1,823 (answer should be in letters)

8. Write out what ate for breakfast, lunch, and dinner yesterday in as much detail as possible.