Physiological Responses to Isolated Auditory and Visual Stimulus versus the Combination of Auditory and Visual Stimulus

Lab 602 Group 5

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Abstract:

A variety and multitude of stimuli elicit a fear response in humans, including horror films. Fear responses include various physiological alterations such as an increase in heart rate, changes in electrodermal activity (EDA), and an increased respiration rate. The type and intensity of sensory intake from a fear inducing stimulus determines the extent of physiological alterations. In order to understand the effects of auditory and visual stimuli on the fear response, a five minute horror film clip was played for 24 participants. Participants were randomly selected to participate in one of three groups: Group 1 watched the clip with audiovisual stimulus, Group 2 watched the clip with visual-only stimulus, and Group 3 watched the clip with audio-only stimulus. Since the combination of both an auditory and visual stimulus is the most intense form of sensation, it was hypothesized that participants in Group 1 would demonstrate the greatest fear response and show the largest rate of physiological change in EDA, respiration rate, and heart rate. Paired two sample t-tests and one-way ANOVA tests showed there was some statistical significance in the resulting data. Overall, this study supported the hypothesis that bimodal audiovisual fear inducing stimulus would lead to a larger physiological response.

Introduction:

A variety and multitude of stimuli elicit a fear response in humans. Fear is an activated emotional state with the purpose to motivate the human body to cope with threatening events (Ohman 2000). This emotion is demonstrated through physiological, emotional, and behavioral responses. These responses act to alert the body to a particular threat or stress and prepare the it for a potentially life threatening situation. People of all ages, genders, races, and ethnicities experience fear: from a child getting frightened from a bad dream to an adult experiencing fear when encountering a bear in the middle of the woods. People can undergo fear from a near death experience, but fear can also be elicited in other situations as well. On average people respond similarly to fearful stimuli by attempting to prepare for the potentially life threatening or stressful event about to occur (Yang *et.al* 2007). It is important to understand how the body responds to fearful stimuli because of its ongoing relevance and frequency in society. In order to elicit a full fear response in an individual, both auditory and visual cortices must be activated. This

bimodality of stimuli is important to fully activate the brain and in turn evoke a strong physiological response (Collignon 2008).

It is widely known that many people enjoy some of these physiological responses associated with fear and, therefore, voluntarily participate in activities that elicit the "fear response" (the sympathetic nervous system). This willingness to activate the sympathetic nervous system in response to a voluntary activity is known as sensation seeking. Although skydiving and base jumping are some of the most widely known sensation seeking activities, it is not entirely necessary to go to such extremes in order to cause an adequate response from the sympathetic nervous system. Horror films are created to trigger a "fear response" from the viewer, but without actually putting the viewer in immediate danger (Tamborini 1987). There are many ways to stimulate this kind of physiological response, but filmmakers have traditionally used visual and auditory stimuli in synchrony to induce a response from the sympathetic nervous system.This allows people who enjoy sensation seeking to enjoy this physiological response without going to such extreme measures.

When a person experiences a fearful stimulus such as a horror film, the amygdala, the region of the temporal lobe responsible for fear control, regulates the fear response by signaling to the hypothalamus, which in turn activates the sympathetic nervous system. (Phan *et.al* 2003). A study on adolescents was carried out in order to determine the heart rate response while doing a facial expression activity and concluded that there was a strong relationship between the amount of amygdala activation and the heart rate (Yang *et.al* 2007).

The sympathetic response allows for the body to prepare for physical activity in a threatening situation (Yang *et.al* 2007). The adrenal glands are also stimulated as a result of

amygdala activity and secrete epinephrine into the blood, which circulates and results in an increased heart rate. Stimulation of vascular muscle leads to vasoconstriction of vessels of metabolically inactive organs in order to utilize blood in a more effective manner for muscle contraction. Additionally, the sympathetic response leads to bronchodilation to allow increased oxygen to the lungs. Lastly, the sympathetic response leads to sweating, which allows for thermoregulation and maintenance of homeostasis (Kerieberg, 2007).

Multisensory perception of emotions and the humans' ability to integrate two sources of sensation is important in provoking a full fear response. The simultaneous use of both visual images and audio soundtrack in horror films is a necessary component that captures the audience's attention. A study, examining the audiovisual integration of emotional expression, shows that both auditory and visual stimulus and thus the simultaneous stimulation of auditory and visual cortices results in a full fear response (Collignon 2008). In this experiment, participants were asked to categorize fear expressions displayed auditorily, visually, or both audio-visually. Results showed categorization was most accurate in bimodal situations (with both the auditory and visual stimulus). However, in unimodal situations, participants demonstrated visual dominance in emotional processing as they were better at categorizing the isolated fear visual stimulus than the isolated fear auditory stimulus in the experiment. These results demonstrate that the perception and response to fear is of multisensory nature (Collignon 2008).

Because fear is a complex, multisensory situation, it is important to understand the effects of each of the stimulus pathways individually and how they interact. The following experiment was performed in order to understand the effects of auditory and visual stimulus on the fear response. In this study, a short clip from a horror film was played with either a unimodal visual

or auditory stimulus or bimodal auditory and visual stimulus. We hypothesized that horror clips played with bimodal auditory and visual stimuli will evoke a greater physiological response as compared to the horror clip played with a unimodal auditory or visual stimulus. In order to quantify these physiological responses, the rate of respiration, electrodermal activity, and heart rate were monitored and measured.

Materials and Methods:

Participants

Participants for this experiment were selected from students enrolled in Physiology 435 at the University of Wisconsin-Madison in the spring of 2018. A consent form was signed by each subject, informing them that they would be participating in an experiment that tests for variation away from baseline physiological values after exposure to emotionally provoking stimulus. Upon completion of the form, each subject was randomly assigned to a treatment group.

Equipment and Measurements

Heart rate was measured continuously throughout the study using a BIOPAC Lead Set, Shielded, BSL (Part#SS2LB, BIOPAC Systems, Inc., Goleta, CA). The leads with three separate disposable electrodes were attached to the participants' right and left wrists and left ankle (Part#EL500, BIOPAC Systems, Inc., Goleta, CA). The ECG electrical measurements were converted to a pulse measurement using BIOPAC Student Lab 4.1.2 Software (BIOPAC Systems, Inc., Goleta, CA). Electrodermal activity (EDA) was measured using a BIOPAC BSL EDA Finger Transducer (Part #SS3LA, BIOPAC Systems, Inc., Goleta, CA). The two finger transducers were placed on the palmar side of the distal phalanges of the index and middle finger

on the participants' dominant hand. A small amount (enough to cover the sensors) of BIOPAC Systems, Inc. Isotonic Recording Electrode Gel (Part# GEL101, BIOPAC Systems, Inc., Goleta, CA) was placed between the transducers and the participants' fingers in order to produce accurate data. Rate of respiration was measured using the BIOPAC BSL Respiratory Effort Transducer (Part#SS5LB, BIOPAC Systems, Inc., Goleta, CA). The respiratory transducer was placed directly over the participants' sternum and then tightly fastened in this position with the attached belt. All data taken using BIOPAC equipment was processed by a Dell Optiplex 7020 (Dell Inc., Round Rock, Texas) and BIOPAC Systems, Inc. MP36E-CE (BIOPAC Systems, Inc., Goleta, CA), and recorded with BIOPAC Student Lab 4.1.2 Software (BIOPAC Systems, Inc., Goleta, CA). The auditory and visual stimulus was provided by a five minute clip (time 25:00-30:00) from the horror film, *The Strangers* (written and directed by Bryan Bertino, 2008, United States) and shown on an Apple MacBook Pro (Model A1502 [EMC 2875] Cupertino, California).

Heart Rate was measured in beats per minute (BPM), EDA was measured in microsiemens, and respiration rate was measured in millivolts (mV). The respiration strap transforms changes in pulmonary inflation and deflation to voltage changes, which has a wave like pattern. An increase in voltage is observed with an inhalation and a decrease in voltage is observed with an exhalation (Biopac manual). The average and maximum of each physiological response were recorded. The maximum showed the extreme of each physiological response, which we expected to occur at the peak of fear in the clip, whereas the average showed the trends throughout the clip.

Experimental Design

The experiment consisted of three groups. Each group (Groups 1, 2 and 3) consisted of eight participants. Group 1 was measured for physiological responses while watching the five minute horror film clip with sound and picture at 75% volume. Group 2 was measured for physiological responses while watching the same horror film clip without sound. The screen brightness was set to full brightness for both groups. Group 3 was measured for physiological responses to just the auditory component of the horror clip. A black screen played the sound of the clip at 75% volume.

After giving consent, participants were taken into a quiet, dim room with only the experimenters present. They were instructed to sit in a chair at a table's edge with a laptop computer facing them. The computer was initially black. A desktop computer, used for recording physiological responses, was facing away from the participant. Subjects were instrumented with: respiration strap, electrodermal activity electrodes (EDA), and electrocardiogram (ECG). The respiration strap was tightly wrapped around the subject's sternum. Upon complete set up, each subject was instructed to remain still for one minute before their baseline measurements for respiration, EDA, and heart rate were taken for 60 seconds by the Biopac System. The maximum and average of heart rate, EDA, and respiration were recorded. This baseline data was used as the negative control in the experiment.

Once baseline measurements were recorded, participants were asked to close their eyes until instructed otherwise. The experimenter turned on the computer and set the volume to 75% or 0%, depending on the trial, and the computer brightness was set to the highest level or to black, depending on the trial. The video clip was opened on the screen and the subject was

instructed to open their eyes and watch the computer screen as the 5 minute clip played. The experimenters were not in the visual field of the subject and remained silent during the duration of the clip. Respiration, heart rate and EDA were recorded by the Biopac System throughout the duration of the 5 minute clip. The maximum of each physiological response was recorded to compare to the baseline.

As the participant watched the clip, they were observed by an experimenter out of the participant's visual field to ensure the subject watched the entire clip and did not close their eyes other than to blink. After the clip was finished, the participant was asked to allow the experimenters to assist in removing the Biopac equipment. Participants were then asked to fill out a questionnaire asking their age and sex.

Positive control

Preliminary testing was performed to confirm a fear response was elicited from the horror clip. This positive control group consisted of participants experiencing the bimodal audiovisual stimulus. It was confirmed that there was an increase from baseline measurements to experimental measurements. This is demonstrated in Table 1.

Statistical analysis

The average maximum and the average mean of each physiological response collected from the three groups was determined and then analysed using a one-way ANOVA statistical test. For all one-way ANOVA tests, the null hypothesis was that all sample means were equal, and the alternative hypothesis was that at least one of the means was different. For all paired, two sample t-tests, the null hypothesis was that the two sample means were equal. P-values were

calculated and compared to a significance level of 0.05 to determine the statistical significance of the data.

Results:

Subjects consisted of 75% females and 25% males as shown in figure 5. Age demographics were 20-29, but the majority was aged 20-22 (Figure 4).

The maximum values were recorded from a single point in time with the highest value. The average values for respiration (mV), heart rate (bpm), and EDA (microsiemens) were calculated using the BIOPAC software.The average and standard error for baseline and experimental EDA (microsiemens), respiration rate (mV), and heart rate (bpm) were collected from all 8 participants from each group and then averages were calculated for each group as a whole.

The mean baseline EDA measurements for Group 1 (audiovisual) was 8.58 microsiemens with a standard error (SE) of 1.38. The baseline maximum was 8.52 microsiemens (SE 1.1546). The experimental EDA mean and maximum were 9.23 (SE 1.5009) and 10.98 (SE 1.925) microsiemens, respectively. Group 1 baseline respiration rate (mV) mean and maximum were 0.0143 (SE 0.3965) and 1.31 (SE 0.3965), respectively. Experimental mean and maximum respiration rates for Group 1 were 0.143 (SE 0.001245) and 1.31 (SE 0.3965). Baseline heart rate mean for Group 1 was 76.207 (SE 4.55) and increased by 4.923 bpm to an experimental mean of 81.13. The maximum heart rate for Group 1 increased by 6.776 bpm from baseline to experimental.

The Group 2 (audio only) average EDA baseline mean was 6.387 (SE 1.338) and the average EDA experimental mean was 6.35 (SE 1.496). Group 2 maximum EDA baseline was

7.1917 (SE 1.53) and experimental was 7.29 (SE 1.76) showing an increase of 0.0983 microsiemens from baseline to experimental. Baseline and experimental mean respiration rate for Group 2 were 0.010756 mV (SE 0.00493) and 0.0039025 mV (SE 0.0027), respectively. Respiration rate maximum for baseline and experimental were 1.62 mV (SE 0.59) and 1.532 mV (SE 0.4915). Group 2 showed an increase of 0.925 bpm from baseline to experimental heart rate mean and an increase of 1.8 bpm from baseline to experimental heart rate maximum.

Group 3 (visual only) mean EDA baseline and experimental data was 7.682 microsiemens (SE 1.493) and 8.19 microsiemens (SE 1.721). Respiration rate maximum for Group 3 increased by 1.488 mV from baseline to experimental. The baseline and experimental respiration rate mean values for Group 3 were 0.04029 mV (SE 0.02736) and 0.004178 mV (SE 0.00329), respectively. Mean heart rate baseline and experimental values were 71.839 bpm (SE 5.626) and 75.34 bpm (SE 5.29). Maximum heart rate baseline and experimental values for Group 3 were 90.484 bpm (SE 3.8978) and 110.455 bpm (SE 10.37).

The absolute change in average EDA in group 1 was higher than the other 2 groups as shown in Figure 6. As shown in Table 2, which also shows changes in EDA from baseline to experimental, the group with the most dramatic increase in EDA mean is Group 1 (audiovisual) with an increase in baseline to experimental by 7.04%. The group with the most drastic increase in heart rate was also Group 1 (audiovisual) with an increase in mean heart rate by 6.04%, as shown in Table 4. The absolute change in average respiration rate was comparable in Group 2 (audio only) and Group 1 (audiovisual) as shown in Figure 8. The respiration rate (mV) shows an overall decrease in all three group in mean respiration from baseline to experimental (Table 3).

The ANOVA p-value of 0.014 for absolute change of average heart rate (bpm) shows that there is at least one statistical difference between the means of the three groups (Table 8). The ANOVA p-value of 0.028 for Percent change of average heart rate (bpm) shows that there is at least one statistical difference between the means of the three groups (Table 9).

As shown in Table 6, the absolute change from baseline to experimental for mean heart rate was shown to be statistically significant between Group 1 (audiovisual) and Group 2 (audio only) and between Group 1 (audiovisual) and Group 3 (visual only) by using paired two sample t-tests. The t-test conducted between Group 1 and Group 2 yielded a p-value of .005, which concluded that the difference between the groups was not solely due to chance (Table 6). The t-test conducted between Group 1 and Group 3 yielded a p-value of .03, which also concluded that the difference between the groups was not solely due to chance (Table 6).

As shown in Table 7, the percent change from baseline to experimental for mean heart rate was also shown to be statistically significant between Group 1 (audiovisual) and Group 2 (audio only) and between Group 1 (audiovisual) and Group 3 (visual only) by using paired two sample t-tests. The t-test conducted between Group 1 and Group 2 yielded a p-value of 0.04, which concluded that the difference between the groups was not solely due to chance (Table 7). The t-test conducted between Group 1 and Group 3 yielded a p-value of 0.014, which also concluded that the difference between the groups was not solely due to chance (Table 7). All other collected data was analyzed but did not yield statistically significant results.

Discussion

The sympathetic nervous system's fight or flight response induces an increase in EDA, respiration, and heart rate during a fearful stimulus as supported by the results of this experiment.

The audiovisual group displayed the largest increase in both mean and maximum heart rate from baseline to experimental. These results indicate that bimodal stimuli activate the sympathetic nervous system to a greater extent than unimodal stimuli. This agrees with the results found in Collignon's study performed in 2008 (Collignon, 2008). This study also concluded that the bimodality of stimuli is important to fully activate the brain and in turn evoke a strong physiological response Activation of the sympathetic nervous system causes the release of norepinephrine (along with other chemicals), which binds to beta 1 adrenergic receptors located in heart to increase the heart rate (Yang *et.al* 2007). As shown in Figure 10, audiovisual bimodal stimuli induced the largest increase in heart rate. The one-way ANOVA test (Table 8) statistically shows that there is a difference between at least one of the groups that is not solely due to chance. Paired t-tests performed between each of the groups (Table 6 and 7) statistically showed that the difference between the group with bimodal stimuli and the groups with unimodal stimuli was not solely due to chance. The percent increase in average heart rate from baseline to experimental also yielded statistically significant results between the group with bimodal stimuli and the groups with unimodal stimuli, concluding that the differences between the groups were not solely due to chance (Table 9). Group 1 (audiovisual) had the largest percent increase from baseline to experimental mean heart rate, which further suggests that this combination of stimuli has the largest effect on the sympathetic nervous system and thus the most notable fear response. The results of this experiment are supported by the study "Audio-Visual Integration of Emotion Expression." (Collignon 2008).

Figure 9, which graphically depicts the absolute change from the participants' average baseline EDA to their experimental maximum EDA, shows that bimodal audiovisual stimuli

have a larger effect on the physiological response of EDA than unimodal visual or auditory stimuli. The absolute change in EDA from baseline to experimental is largest for audiovisual, moderate for visual, and smallest for auditory stimuli. Again, these results support the assumption that multisensory perception of emotions is important in provoking a complete fear response, however, in unimodal situations, participants demonstrated visual dominance in emotional processing.

There were many instances for possible errors throughout this experiment. For example, there were issues with electrodes peeling off and possibly altering heart rate measurements. Some participants laughed or tried to talk during the clip. It is possible that these movements caused changes in data. Additionally, the room where the experiment was performed had thin walls. Outside noises and stimuli could have distracted participants from the fearful stimulus (horror clip). Future studies can be designed to control for these possible errors. Perhaps the usage of headphones and stricter instructions encouraging complete silence while the participant is being monitored may assist in mitigating the effect these errors may have on future results.

This experiment also had a limited sample size and a limited amount of diversity within the population. The majority of the participants were female and aged 21 to 22. This young (and mainly female) group may not be a good representation of the physiological responses of larger and more diverse populations. Future experiments should have a larger population with wider ranges of ages and more balance between males and females. This will allow for a more accurate representation of physiological responses to fear for the general population. Different types of fear inducing stimuli should also be studied. Some individuals enjoy horror films and therefore

may not show as great of a response to this fear stimulus in comparison to other fear inducing stimuli.

An important application of this experiment is not only to induce a greater fear response, but also to limit the fear response in certain situations. For example, some individuals cannot tolerate a significant increase in heart rate as it is dangerous to their health. As supported by this experiment, one way to avoid this spike in heart rate when exposed to fear inducing stimuli would be to eliminate or minimize either the audio or visual components of the stimuli. In follow up experiment, stimuli can be tweaked by using only subtle changes in the relationship between the audio and visual and then seeing whether these changes either greatly enhance or greatly reduce a physiological response such as heart rate. This would be a good way to investigate the best methods to reduce fear responses in individuals.

Future studies should consider monitoring facial expressions or other emotional responses to fear. Emotional responses can be difficult to quantify and measure objectively but they are an important consideration for fear studies. Therefore, ocular movement or movement of facial muscles could be studied to eliminate some of the issues around emotional subjectivity between individual subjects and experimenters.

The results in this experiment support the hypothesis that the combination of both audio and visual stimuli will produce a greater physiological response to fear than visual or auditory stimuli individually. These findings are applicable to horror film producers and others marketing fear inducing products. The simultaneous use of both visual images and audio soundtrack in fear inducing products may better capture the audience's attention. In addition to researching short term fear responses, for example those elicited by horror films, it is also important to continue

studying the long term physiological effects of fear. For people living in fear inducing situations, like a war zone, it is important to understand what long term physiological changes may be taking place and how these changes will impact lifespan and life quality. By better understanding these physiological changes, measures can be taken to prevent or minimize these negative long term changes and thus improve the health outcomes for those experiencing chronic fear.

Figures and tables:

Table 1. Positive Control

	EDA Baseline Maximum	EDA Experimental Maximum	Respiration Rate Baseline Maximum	Respiration Rate Experimental Maximum	Heart Rate Baseline Maximum	Heart Rate Experimental Maximum
Group 1 Subject 1	5.85 microsiemens	6.87 microsiemens	3.73 mV	3.85 mV	67 bpm	72 bpm
Group 1 Subject 2	6.98 microsiemens	9.20 microsiemens	4.34 mV	3.86 mV	108 bpm	116 bpm

Table 1 shows preliminary data taken to serve as the positive control in the experiment. This data ensured that a physiological response will be yielded in our subjects. Both subjects in Group 1 (audiovisual stimulus) display an increase in physiological response from baseline to experimental. EDA increased by an average of 19.6% in the two subjects from baseline to experimental. Heart rate increased by an average of 0.069% in the two subjects from baseline to experimental.

Figure 1. Chronological outline of the experimental design

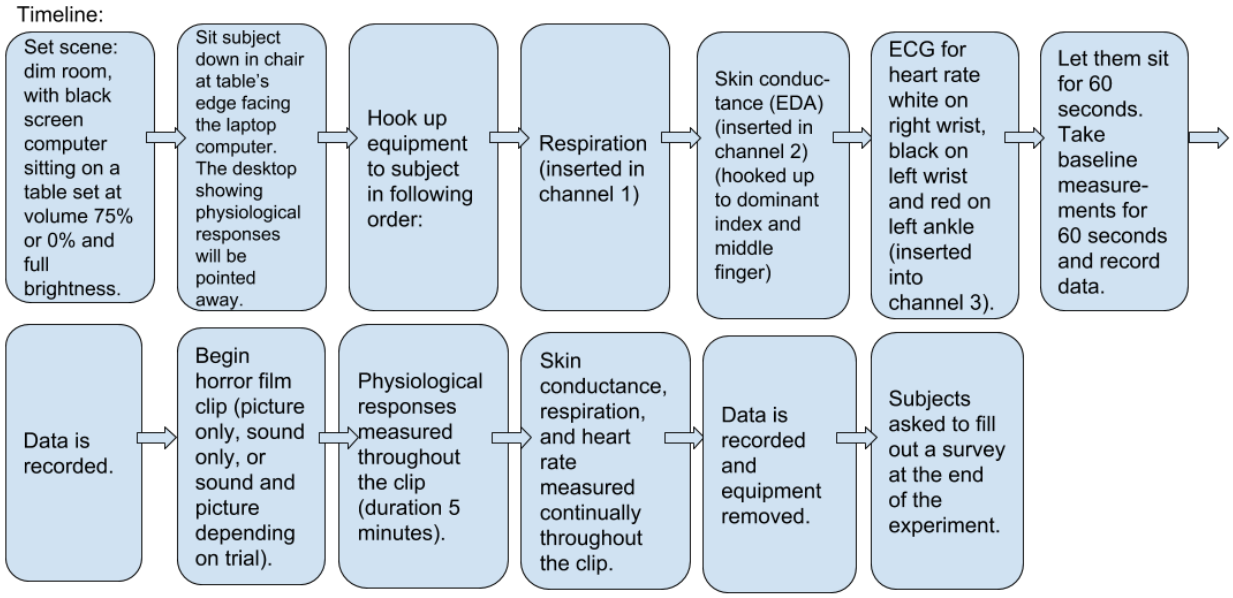

Figure 1: After completing the consent form, the participant was brought into a quiet dim room and sat at the edge of a table. The laptop computer was dark and set at full brightness or 0% brightness and 75% or 0% sound. The desktop computer used to record physiological data was angled away from the participant. The experiment attached the respiration monitor to the participant and connected it to channel 1 of the BIOPAC acquisition unit. Next,the experimenter then attached the Skin conductance (EDA) to the middle and index finger on the participant's dominant hand. Lastly ECG electrodes were attached to the right and left wrists and the left ankle. ECG was inserted into channel 3. Baseline measurements were taken for 60 seconds and data was recorded. Then the 5 minute clip was started. Skin conductance, heart rate and respiration were measured continually throughout the clip. After the clip finished, the experimenter helped remove the equipment. The subject then filled out a survey including their age and sex.

Figure 2.

Figure 2: This is an example of the BIOPAC data collected during a trial. The red circle marks the max respiration value recorded in mV. The vertical axis is in mV and the horizontal axis is time in seconds. The yellow circle marks the max EDA value measured in microsiemens. On this graph, the vertical axis is in microsiemens and the horizontal axis is time recorded in seconds. The maximum was recorded as a single point in time with the highest value. The average values for respiration and EDA were calculated by the BIOPAC software.

Figure 3.

Figure 3 shows how the the ECG graph was used to configure the graph for heart rate. The red circle marks the max heart rate measured in beats per minute (BPM). On this graph, the vertical axis is in BPM and the horizontal axis is time recorded in seconds. The maximum was recorded

as a single point in time with the highest value. The average value for heart rate was calculated by the BIOPAC software.

Figure 4. Age Demographics

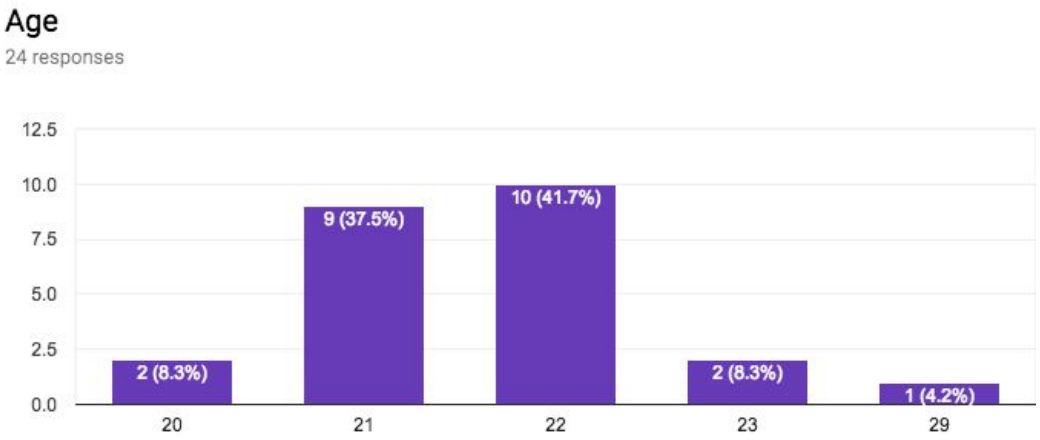

Figure 4 shows that the 24 participants ranged from ages 20 to 29. It also shows that the majority of the participants were 21 or 22 years old.

Figure 5. Gender Demographics

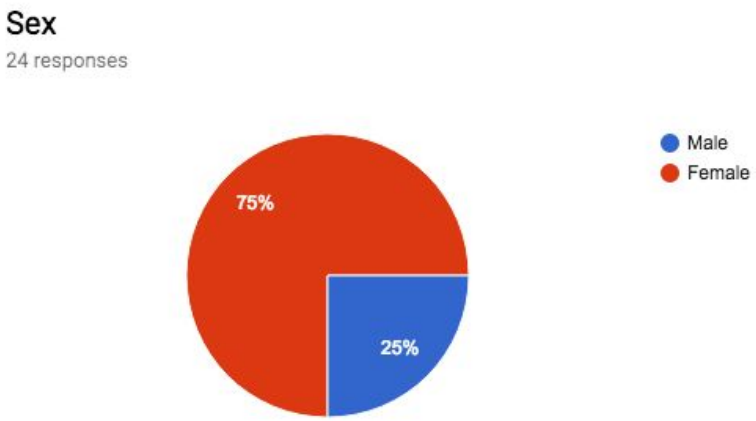

Figure 5 shows the participant population. The 18 of participants were female and 6 were male. Females were 75% of the participants and males were 25% of the participants.

Table 2. EDA Baseline and Experimental Results

	Group 1: Audiovisual	Group 2: Audio only	Group 3: Visual only
EDA baseline mean (microsiemens)	8.58 (Standard Error: 1.38)	6.39 (Standard Error: 1.338)	7.68 (Standard Error: 1.493)

EDA baseline max (microsiemens)	8.52 (Standard Error: 1.564)	7.19 (Standard Error: 1.53)	8.29 (Standard Error: 1.55)
EDA experimental mean (microsiemens)	9.23 (Standard Error: 1.5009)	6.35 (Standard Error: 1.496)	8.19 (Stand Error: 1.721)
EDA experimental max (microsiemens)	11.0 (Standard Error: 1.925)	7.29 (Standard Error: 1.76)	9.41 (Standard Error: 1.93)

Table 2 displays the average and standard error EDA data collected from all 8 participants in each group. The general pattern is an increase in maximum and mean from baseline to experimental. The one exception to this is Group 2 EDA maximum in which there is a decrease by 0.037 microsiemens. In general, this data shows an increased physiological change in EDA. The group with the most dramatic increase in EDA maximum is Group 1, audiovisual with an increase in baseline to experimental by 7.04%.

Table 3. Respiration Rate Baseline and Experimental Results

	Group 1: Audiovisual	Group 2: Audio only	Group 3: Visual only
Respiration Rate Baseline mean (mV)	.0143 (Standard Error: 0.01245)	.0108 (Standard Error: 0.00493)	.0403 (Standard Error: 0.02736)
Respiration Rate Baseline max (mV)	1.31 (Standard Error: 0.3965)	1.62 (Standard Error: 0.59)	.0273 (Standard Error: 0.352)
Respiration Rate Experimental mean (mV)	.0081 (Standard Error: 0.003310)	.00390 (Standard Error: 0.0027)	.000418 (Standard Error: 0.00329)
Respiration Rate Experimental max (mV)	1.67 (Standard Error: 0.577)	1.53 (Standard Error: 0.4915)	1.52 (Standard Error: 0.346)

Table 3 displays the average and standard error respiration rate data collected from all 8 participants in each group. This data shows an overall decrease in mean respiration rate in mV from baseline to experimental, and an overall increase in maximum respiration rate (mV) from baseline to experimental.

Table 4. Heart Rate Baseline and Experimental Results

	Group 1: Audiovisual	Group 2: Audio only	Group 3: Visual only
Heart Rate Baseline Mean (bpm)	76.2 (Standard error: 4.55)	70.8 (Standard error: 4.43)	71.8 (Standard error: 5.626)
Heart Rate Baseline Max (bpm)	93.8 (Standard Error: 6.977)	86.7 (Standard Error: 7.9987)	90.5 (Standard Error: 3.8978)
Heart Rate Experimental Mean (bpm)	81.1 (Standard Error: 5.409)	71.7 (Standard Error: 2.27)	75.3 (Standard Error: 5.29)
Heart Rate Experimental Max (bpm)	100 (Standard Error: 6.77)	88.4 (Standard Error: 3.25)	110.0 (Standard Error: 10.37)

Table 4 displays the average and standard error heart rate data collected from all 8 participants in each group. Each group showed an increase in heart rate mean and maximum (bpm) from baseline to experimental. The group with the most drastic increase in heart rate was Group 1, audiovisual with an increase in mean heart rate by 6.04% from baseline to experimental.

Figure 6. Absolute Change of Electrodermal Activity (EDA)

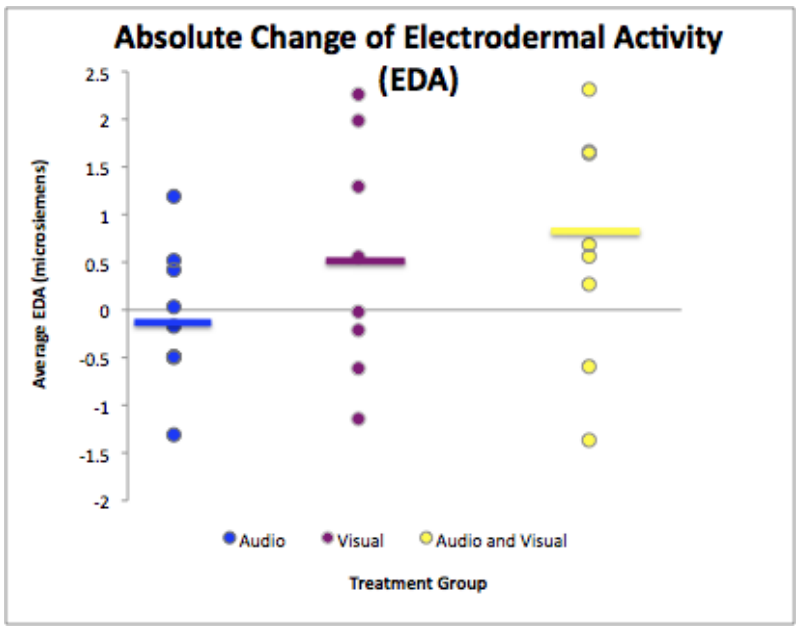

Figure 6 shows the absolute change of average EDA (microsiemens) between audio, visual, and audio and visual groups. The absolute change was calculated by subtracting the experimental average EDA from the baseline average EDA. Dots on the graph represent individual data points and the line represents the mean from the group.

Figure 7. Absolute Change of Heart Rate (BPM)

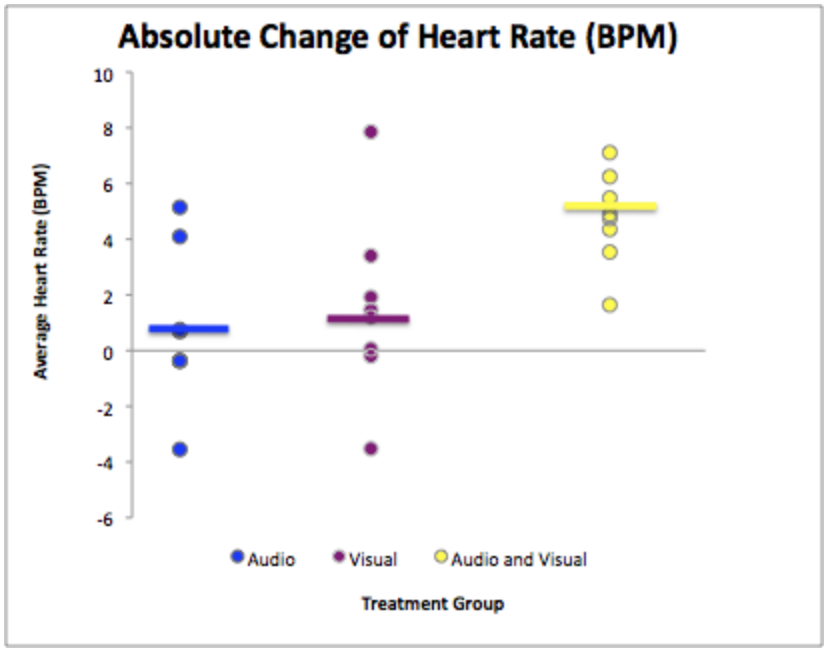

Figure 7 shows the absolute change of Average Heart Rate (bpm) between audio, visual, and audio and visual groups. The audio group (Group 2) had N=7 due to system error on one individual. The absolute change was calculated by subtracting the experimental average heart rate from the baseline average heart rate. Dots on the graph represent individual data points and the line represents the mean from the group.

Figure 8. Absolute Change of Respiration Rate (mV)

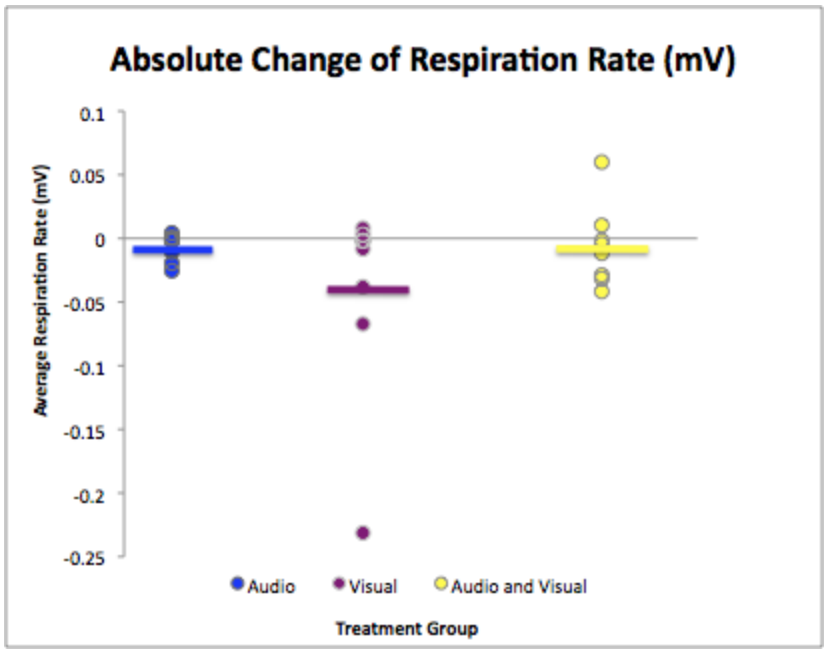

Figure 8 shows the absolute change of average respiration (in mV) between audio, visual, and audio and visual groups. The absolute change was calculated by subtracting the experimental

average respiration rate from the baseline average respiration rate. Dots on the graph represent individual data points and the line represents the mean from the group.

Figure 9. Average Baseline EDA vs. Experimental Max EDA (microsiemens)

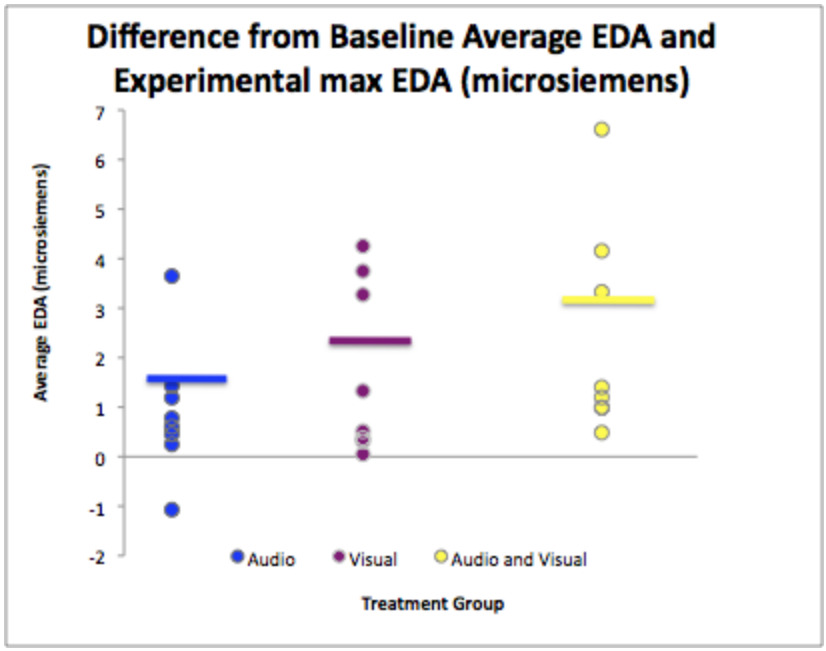

Figure 9 shows the absolute change from the participants' average baseline EDA (in microsiemens) to their experimental maximum EDA. Dots on the graph represent individual data points and the line represents the mean from the group.

Figure 10. Percent Change of Absolute Change of Average. Heart Rate (BPM)

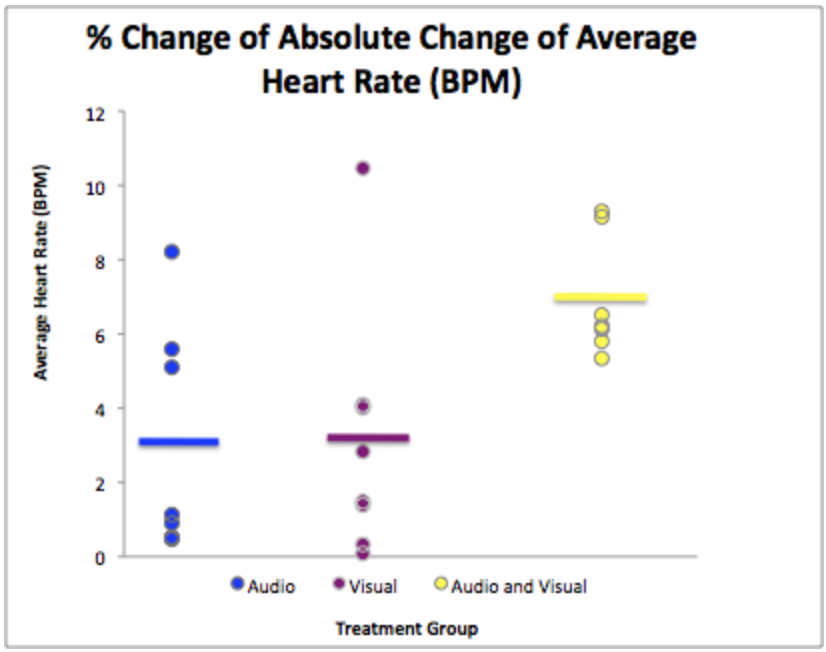

Figure 10 depicts the percent change of baseline average heart rate (bpm) and experimental average heart rate for individuals in each group. Dots on the graph represent individual data points and the line represents the mean from the group.

Table 5. t-Test 1

	t-Test: Paired Two Sample for Means (Absolute Change [Baseline Average-Experimental Max][BPM])		
	Audio vs Audio&Visual	**Audio&Visual vs Visual**	**Audio vs Visual**
t-score	-1.21	-1.07	-1.87
dF	6	6	6
p-value	0.14	0.16	0.06

Table 5 shows data from a paired t-test of the difference between baseline average and experimental max heart rate. P values less than 0.1 but greater than 0.05 ($0.5<P<0.1$) are not considered statistically significant; however, they are trending towards significance and show that there is likely a difference between the two groups that is not solely due to chance. Further testing with an increased sample size could be considered in future experiments.

Table 6. t-Test 2

	t-Test: Paired Two Sample for Means (Absolute Change of Averages [BPM])		
	Audio vs Audio&Visual	**Audio&Visual vs Visual**	**Audio vs Visual**
t-score	3.74	-2.29	-0.54
dF	6	6	6
p-value	0.005	0.03	0.3

Table 6 depicts the paired t-test data for the absolute change of the baseline average heart rate and experimental average heart rate. P-values less than 0.05 are considered statistically significant and prove that the difference between the two groups is not solely due to chance.

Table 7. t-Test 3

	t-Test: Paired Two Sample for Means (% Change of Averages [BPM])		
	Audio vs Audio&Visual	**Audio&Visual vs Visual**	**Audio vs Visual**
t-score	2.08	-2.86	-0.33
dF	6	6	6
p-value	0.04	0.014	0.38

Table 7 shows the paired t-test results for the percent change between the experimental heart rate and the average heart rate. P-values less than 0.05 are considered statistically significant and prove that the difference between the two groups is not solely due to chance.

Table 8. ANOVA Test 1

ANOVA: Single Factor						
Absolute Change of Average Heart Rate (BPM)						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Audio (Absolute Change)	7	6.39752	0.913931429	8.544682766		
Audio & Visual (Absolute Change)	7	36.34128	5.191611429	1.432955318		
Visual (Absolute Change)	8	12.18758	1.5234475	10.62177365		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	75.95169109	2	37.97584555	5.375879193	0.014118519	3.521893261
Within Groups	134.218244	19	7.064118107			
Total	210.1699351	21				

Table 8 shows the one-way ANOVA test performed for the absolute change of average heart rate. As shown here, the p-value of 0.014 is of statistical significance and proves that there is a difference between at least one of the groups that is not solely due to chance.

Table 9. ANOVA Test 2

ANOVA: Single Factor						
% Change of Average Heart Rate (BPM)						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Audio (%Change)	7	21.92867094	3.132667277	9.756725651		
Audio & Visual (% Change)	7	48.45115778	6.921593969	2.610006748		
Visual (% Change)	8	24.68342796	3.085428495	11.20191148		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	69.43966103	2	34.71983052	4.322524497	0.028365749	3.521893261
Within Groups	152.6137747	19	8.032303933			
Total	222.0534358	21				

Table 9 shows the one-way ANOVA test performed for the percent change of average heart rate. As shown here, the p-value of 0.028 is of statistical significance and proves that there is a difference between at least one of the groups that is not solely due to chance.

Table 10. ANOVA Test 3

ANOVA: Single Factor						
Absolute Change from Baseline Average Heart Rate & Experimental Max Heart Rate (BPM)						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Audio (Absolute Change)	7	123.67295	17.66756429	29.98377198		
Audio & Visual (Absolute Change)	7	172.39727	24.62818143	99.6049316		
Visual (Absolute Change)	7	256.08798	36.58399714	496.5270893		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1281.520689	2	640.7603445	3.070168578	0.071246341	3.554557146
Within Groups	3756.694758	18	208.7052643			
Total	5038.215447	20				

Table 10 shows the one-way ANOVA test performed for the absolute change from baseline average heart rate and experimental maximum heart rate. As shown here, the p-value of 0.071 did not meet the significance level cut-off value of 0.05 However, this value trended towards significance ($0.05<p<0.1$) and shows that there is likely a difference between at least one of the groups that is not solely due to chance. Further testing with an increased sample size could be considered in future experiments.

Figure 11. Post Trial Form

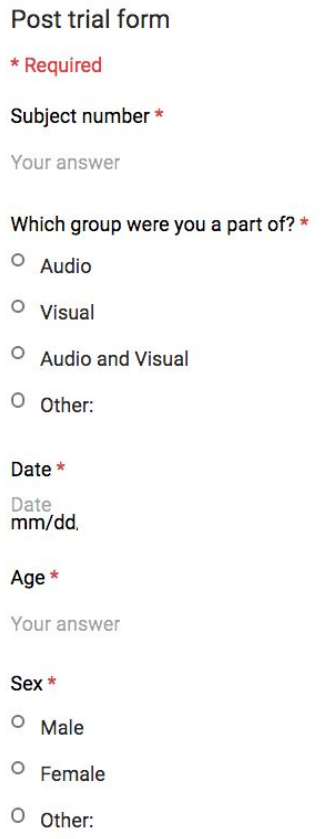

Figure 11 shows the from that participants completed after baseline and experimental data were collected.

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Appendix:

UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Physiological Responses to Isolated Visual Stimuli versus the Combination of Auditory and Visual Stimuli

Principal Investigators: Claire Conner, Sarah Nyberg, Rashea Minor, Nolan Moran, Yanika Davis

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study about physiological responses to visual and auditory stimuli. .

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

The purpose of the research is to measure how both auditory and visual stimuli evoke shifts in variables away from baseline physiological values.

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 exposed to visual and auditory stimuli. Your pulse, respiration depth and rate, and electrodermal activity will be recorded. Afterwards, you will be asked to complete a short survey.

If you believe that visual and/or auditory stimuli would cause harm to you, please do not participate in this study. If you do not wish to participate, simply return this blank consent form.

Your participation will last approximately 10 minutes

After the semester is completed, data may be published in the Journal of Advanced Student Science .

No credit will be assigned for your complete and voluntary participation. We also ask that you do not share the details of the study with any other students.

ARE THERE ANY RISKS TO ME?

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 for said injury or death that occurs while I am engaged in this activity. 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?

A feeling of pride from volunteering your time to assist with this study.

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?

Sarah Nyberg, sanyberg@wisc.edu or Yanika Davis ykdavis@wisc.edu

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_____