An Analysis of Physiological Arousal in Response to Sad and Fearful Video Stimuli

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Abstract:

Sadness and fear are two emotions that play an important role in acclimating to our environment. Sadness has often been associated with a decrease in response to one's environment, while fear is thought to activate the fight-or-flight response. However, emotions are perceived differently and at variable intensities according to an individual's past experiences. To measure the effects of these emotions, we examined the physiological variables of heart rate, blood pressure and skin conductance on 20 participants after watching both fearful and sad video stimuli. We also had each participant complete a survey about the emotion they experienced while watching each video, as well as the intensity of that emotion. We hypothesized that the fearful stimuli would result in a greater increase in all three physiological measurements when compared to the sad stimuli. The results support a significant increase in heart rate following the fearful stimuli compared to the sad stimuli, suggesting an evolutionary relationship between the autonomic nervous system and fear. Our results did not indicate a significant relationship between the fearful or sad stimuli and blood pressure or skin conductance. A video screening tool similar to the equipment used in our study could have future implications as a diagnostic tool for disorders encompassing emotion recognition deficits or inappropriate physiological responses to emotional stimuli.

Introduction:

Previously, Sadness, anger, happiness, and fear have been identified as universal emotions (Russell, 1994). Emotions often impact one's behaviors and psychological health. For example, emotional experiences can provoke direct physical changes in the human body, as well as have profound influences on one's ability to communicate with others. Therefore, how emotions affect one's physiology is critical to understanding how emotions influence one's behaviors and overall well-being. Schwartz et al. (1981) looked at the effects of happiness, sadness, anger, and fear on cardiovascular health and found sadness to decrease one's heart rate and blood pressure and fear to have no significant effect on one's heart rate and blood pressure. This study looked at how reflecting on past sad or fearful memories impacted one's physiological variables, but it does not address if emotions such as sadness and fear have significantly different effects on an individual's physiology when caused by an external stimulus. According Salas et al. (2012), internal stimuli (i.e. recalling memories) and external stimuli showed no significant difference in regards to emotion intensity of target emotions, with the exception of joy, which is an emotion that will not be used in our study. Thus, external stimuli are a sufficient means for eliciting emotions.

Sadness and fear are two emotions that play an important role in acclimating to our environment. For example, sadness occurs when an individual is unable to reach a goal or when one is separated from a valued person or object. This leads to feelings of discouragement, isolation and lack of motivation, and is consequently thought to be associated with a decrease in response to one's environment. Therefore, individuals who experience sadness more frequently may be considered less adaptable because it could hinder the drive to survive, but this idea needs to be further examined. Fear, on the other hand, is perceived as a threat to an individual and leads to activation of the autonomic nervous system and to a possible flight-or-fight response. These distinctions suggest that sadness and fear will also elicit different changes in physiological processes (Kreibig 2007).

To determine the effects of sadness and fear on short-term physiological arousal, we will be looking at how heart rate, blood pressure, and skin conductance change in response to sad- and fear-inducing external stimuli. The stimuli are short video clips found on YouTube that have gained popularity in eliciting sad and fearful responses. Our hypothesis is that stimuli eliciting fear and sadness will generate significantly different responses in heart rate, blood pressure, and skin conductance. The positive control group in our study will undergo prolonged stimuli provoking sadness and fear to determine if a physiological change is observed in the three measures. These will be conducted among our lab group members, thus it will not be blind. The negative control group will simply include the participants' baseline measurements, which will be recorded before any of the video stimuli are presented, as well as during the rest periods, during which a neutral "fireplace" video will be playing as the participant's physiological measurements return to baseline. The experimental group will undergo four trials of sad or fearful stimuli separated by two minutes of rest with a neutral “fireplace” stimulus, while their physiological measurements return to baseline (See Figure 1). These groups will be blind to the experimental purpose and those who analyze the data will not be informed of the order of the stimuli presented to the participant. Each trial will be followed with a short survey in which the participant will state any emotions they felt and rate the intensity of those emotions on a scale from 1-5. Unlike previous studies, this survey will allow us to analyze the influence of the perceived emotion on physiological variables, rather than assuming a specific emotion is experienced during each stimulus.

After conducting a pilot experiment with our positive control, we preliminarily found that the fear stimuli induced a greater increase in heart rate, blood pressure, and skin conductance in comparison to the sad stimuli. The sad stimuli also increased each of these measures, but to a lesser extent. Blood pressure, heart rate, and skin conductance will be measured before and after each stimulus. We predict that fear will produce a greater increase in all three physiological measures.

Methods:

Participation:

In total, 20 participants completed this study (8 males, 12 females). All participants were college students enrolled in Physiology 435 at the University of Wisconsin-Madison and ranged from 18 to 22 years of age. All participants provided consent before participating in the study and were allowed to stop participating at any point during the study. Each participant was assigned an identification number to ensure that his or her identity was kept confidential. All participants were additionally asked to keep what they did in the study confidential.

Materials:

The three variables measured during this study were blood pressure, heart rate, and skin conductance. An Omron 10 series + Blood Pressure Monitor was used to measure blood pressure in millimeters of Mercury (mm Hg) (Model: BP791IT, Part: SN 20121004275LG), a pulse oximeter to measure heart rate in beats per minute (BPM) (Model: 9843 (Nonin), Part: SN 118103120), and a BSL EDA Finger Electrode Xdcr (Model: SS3LA, Part: 13013862 , BIOPAC Systems, Inc. M36) and Isotonic Recording Electric Gel 101 to measure skin conductance in microsiemens. Skin conductance measurements were recorded using the computer software BIOPAC Systems, Inc. M36. Heart rate was the measure used to determine when the participant returned to baseline. The participant was considered back to baseline when their heart rate was within five percent of their recorded baseline heart rate.

To ensure that these physiological variables were measurable, a series of positive control trials were performed among the lab group members. The videos chosen for the trials had been known to elicit sad and fear responses in the lab members previously, and were therefore chosen to elicit the same emotional changes in the positive control trial. Before each stimulus, a baseline measure was conducted for blood pressure, heart rate, and skin conductance to detect if any changes occur due to the video stimulus. After viewing the sad- and fear-inducing videos, changes in all three physiological measures in each of the positive control participants were observed. For one of the positive control trials involving a fearful stimulus, there was an observed change in blood pressure from 106/78 to 120/88, a change in heart rate from 68 bpm to 136 bpm, and a net change of +0.80261 microsiemens in skin conductance. Changes in these three variables were also observed in our positive controls when given a sad stimulus, but to a lesser extent. These data were evidence that blood pressure, heart rate, and skin conductance were measures that could detect emotional arousal induced by an external stimulus.

Experimental Stimuli:

Four videos were chosen as the external stimuli to elicit the emotions of sadness and fear. The specific videos chosen to evoke sadness were 4 minutes and 14 seconds of the opening scene from Pixar's movie, "Up", (Link 1) and a Budweiser commercial lasting 50 seconds (Link 3). To trigger fear, two videos were chosen that have an unexpected figure jump out at the viewer (Links 2 and 4), lasting 7 seconds and 14 seconds respectively. These four clips were chosen due to their widespread circulation and hypothesized ability to induce a measurable change in blood pressure, heart rate, and skin conductance during the positive control trials. While these videos have been found to induce sadness and fear respectively, a survey was created to confirm each participant's emotional perception of the four videos (Figure 8). This survey allowed participants to choose any of the six universal emotions (fear, disgust, surprise, sadness, happiness and anger) when recording their response. The survey results indicated that viewing the videos usually elicited sadness and fear, and not other emotions. This information helped us confirm when changes in the three measured physiological variables were due to an emotional response of the emotions of interest (sadness and fear), and allowed us to explore the relationship between individual perception of emotions and the observed physiological response.

Experimental Design:

The time frame for one participant performing the experiment is shown in Figure 2. While seated in front of a laptop, a blood pressure cuff was placed on the participant's dominant arm, the pulse oximeter was placed on the participant's index finger of their non-dominant hand (the pulse oximeter was positioned sideways if the participant was wearing nail polish to ensure a clear reading), and the skin conductance electrode was always placed on the participant's middle finger of their non-dominant hand. This ensured that no measuring device interfered with one another. For all subsequent blood pressure measurements, the blood pressure cuff was placed on alternating arms to avoid interference from previous measurements. Participants were then asked to record their sex and age on the survey and then instructed to record their emotional responses on the survey after each video stimulus shown. Baseline measurements were recorded before the start of the video. Participants were then instructed to place headphones over their ears and to notify the administrator when they were ready for the experiment to start.

The video organization is outlined in Figure 1. The participant watched a video containing four different emotional stimuli with 2 minutes of a neutral, “fireplace” stimulus separating each video to decrease expectancy of the next stimulus and to allow the participant’s heart rate to return to baseline (Figure 1). If the participant’s heart rate did not return to baseline within this two-minute time frame, the neutral stimulus was extended until the heart rate was within five percent of baseline measurement. The lights in the room were turned off in the testing room to eliminate distractions during the video stimulus. During the last 10 seconds of each stimuli, heart rate and blood pressures were immediately taken. Following this, lights in the room were turned on and the participant was allowed to fill out the survey. Skin conductance measurements were ongoing throughout the entire experiment and analyzed after the trial was done. At this point, the experimenter reminded the participant to fill out the survey regarding their emotional arousal. The survey, as pictured in Figure 8, included four response forms with one for each video stimulus. Each form asked the participant to choose which of the six basic emotions (happy, sad, angry, disgust, fear, and surprise) the video elicited the most and to rate the intensity of that emotion on a scale from 1 to 5 (1=low intensity; 5=high intensity). Once the 2 minutes had elapsed or the participant’s heart rate was within five percent of baseline, the lights were turned off and the next video was presented. This procedure was repeated for each of the four video stimuli. After the last video was presented and the survey form was completed, the equipment was removed from the participant and the experiment was concluded.

Data Analysis:

Blood pressure and heart rate measurements were directly recorded in a master spreadsheet in Excel, and formulas were inserted to calculate the total change from baseline during each video. Skin conductance changes were calculated from the BIOPAC Systems, Inc. M36. The researcher highlighted the time period from the end of the neutral stimulus to the end of each emotional stimulus and used the “Delta” feature to obtain the total change in skin conductance during the emotional stimulus (See Figure 3). This procedure was repeated for each of the four emotional stimuli and total change was recorded in the master spreadsheet. Final figures for heart rate change, skin conductance, and blood pressure include averaged data from all the subjects tested.

To organize the data and analyze the results, R Studio and Microsoft Excel were used. The means and standard deviations of the measured variables were calculated using R Studio. Linear Regressions were used to examine the change in heart rate, blood pressure (systolic [SP], diastolic [DP]), and skin conductance, as well as the final mean arterial pressure (MAP). These were done to determine if there was a significant relationship between changes in these measured variables, the type of emotional stimulus, and the participant's perceived level of emotion in response to each video stimulus as recorded on the survey. Excel was used to calculate the mean arterial pressure (MAP) from the measured initial systolic and diastolic pressures and final systolic and diastolic pressures (MAP = DP + [⅓ SP-DP]). Graphs were also created to indicate how the measured variables changed in relation to the four video stimuli.

Results:

Heart Rate:

There was a significant difference between the change in heart rate during the sad stimuli and the change in heart rate during the fear stimuli (p = 5.83e^{-5}). Average values for the change in heart rate for all participants during each stimulus are plotted in Figure 4. Fear typically elicited a positive change in heart rate, whereas sadness often elicited a decrease or no change in heart rate as depicted in Figure 5. There was no significant relationship between heart rate and blood pressure or skin conductance. The means and standard deviations of initial heart rate and change in heart rate can be seen in Table 1.

Blood Pressure:

There was no significant difference between the change in systolic, diastolic, or mean arterial blood pressure seen during the sad stimuli and that seen during the fear stimuli (p = 0.578; p = 0.321; p = 0.6934). Average values for the change in each of these measures throughout the duration of the study are displayed in Figure 6. The means and standard deviations of systolic, diastolic, and mean arterial blood pressure can be seen in Table 1.

Skin Conductance:

There was no significant difference in skin conductance during the sad and fear stimuli (p = 0.4463). Average values for the change in skin conductance during each stimulus are plotted in Figure 7. The means and standard deviations of skin conductance can be found in Table 1.

Perception of Emotions:

There was no significant relationship between the level of perceived emotion and either of the measured variables. The linear regressions for perceived emotion and heart rate, blood pressure, and skin conductance can be found in Table 2.

Discussion:

The hypothesis of this study was that the fear stimuli would produce a significantly greater increase in all three physiological measures, heart rate, blood pressure, and skin conductance, when compared to the sad stimuli. Our data supports this hypothesis in regards to heart rate. However, there appear to be no significant differences in the change in blood pressure or skin conductance during each set of stimuli.

Heart Rate:

Our results indicated a significant difference between the change in heart rate during the sad stimuli and the change in heart rate during the fear stimuli. The significant difference in heart rate between the sad and fear stimuli indicates that fearful stimuli elicit an autonomic sympathetic response. According to Robinson et. al (2009), sadness was characterized as involving a low physiological arousal state, while the emotions anxious and angry shared several distinguishing symptoms, most notably cardiac excitation and general restlessness. These findings support the significant difference in heart rate we found between sadness and fear.

Blood Pressure:

Our results indicated no significant differences between the change in blood pressure observed during the sad stimuli and that during the fear stimuli. It is assumed that the autonomic nervous system is activated during a fearful response, and thus the blood pressure would increase along with the increasing heart rate. However, during our experiment, blood pressure measurements were taken with an automatic digital monitor that occasionally malfunctioned. This resulted in blood pressure measurements taken well after the stimulus of emotion had subsided, allowing the response or pressure to begin returning to baseline, which may have influenced our results. In Schwartz et. al (1981), the researchers palpated and marked the brachial artery on the non-dominant arm of each participant to get a more consistent reading of blood pressure. This may be useful in allowing us to observe more accurate changes in blood pressure in future studies.

Skin Conductance:

A few subjects showed promising results in regards to skin conductance including a significant increase during the fear stimuli, but generally it was a difficult measurement to obtain. The electrode often failed to pick up a signal from the participant, ultimately altering the results. This caused several missing data points and inaccurate readings. We followed through with analyzing the skin conductance data, but it produced insignificant results. In Zaitsu (2016), skin conductance was used as a measure during a memory task and utilized Ag/AgCl disposable electrodes (PPS-EDA, TEAC, Japan) on the first and second finger distal phalanges. This technique increased the surface area of the readings and, because of its disposability, it was ensured that the equipment was clean and in optimal condition for each participant. Therefore, this technique may be useful to implement in a replication of our study.

Emotion Survey:

Previous studies have examined physiological changes due to emotional stimuli, but these studies have failed to address individuals' perceptions of the stimuli. Our inclusion of a survey of perception of the emotional stimuli made our study different than previous research because it accounted for independent variability in how the stimulus is perceived. The data showed a general trend of higher ratings of emotional intensity with increased physiological responses, but there was no significant relationship between the perceived level of emotion and the measured variables. This may have been due to familiarity with the video stimuli themselves or self-report bias. For example, the participant may not have wanted to admit to experiencing high levels of fear during the fearful video clips in an attempt to appear strong or stoic.

Limitations

There are several aspects of our experimental design that limit the application of our results. Due to the limited availability of subjects, our results do not reflect population as a whole. The subjects in this study consisted of similarly aged, college-educated students and do not properly represent the general population. The videos selected as our stimuli are popularly known, which was intentional to avoid the possibility of an emotional breakdown during testing. However, this could cause there to be anticipatory effects for the fear videos, as several participants mentioned that they had seen the fear clips before and knew what was coming. In addition, there could be interference from other memories or emotions associated with the sad stimuli such as a happy occasion of watching the movie “Up” with their friends. A similar association may have been the case for the three participants who selected “Happy” as the emotion they felt while watching the sad stimuli. Lastly, due to the limited space in lab, distractions in the external environment may have inadvertently affected physiological variables among some of the participants.

Future Studies

Expansion of our study could have implications in regards to the innate and evolutionary physiological consequences of experiencing the basic emotions and the influence an individual’s perception of the stimuli has on these physiological variables. To accomplish this, it would be useful to select a larger and more representative sample of the general population. It would also be valuable to use a larger collection of stimuli, including videos for each of the six basic emotions. It would be interesting to see if there are specific emotions that are commonly labeled incorrectly or interchanged. Additionally, longer duration videos may produce more accurate results, as it may take longer than a few minutes for an individual to fully comprehend a stimulus and subsequently experience an associated emotion. The order of presentation of the video stimuli should also be explored for any undesirable outcomes, including anticipatory effects. Lastly, it would be beneficial to use videos that are not popularly known, to eliminate the potential influences of associated memories or emotions.

Implications

Implications of the results from our emotion survey suggest that participants perceive videos differently based on previous experiences. For example, a subject who watched the movie “Up” and had a positive experience may perceive the clip differently than someone with no previous memory associated with the movie. In addition, people who mask or suppress their emotions may not have as much of a physiological response as others, and individuals with disorders that often inhibit social cognition, such as autism and traumatic brain injury, may have a decreased physiological response. Therefore, a video viewing task involving emotions and social situations could have future implications as a screening tool for such disorders.

Overall, our results indicated that the fear stimuli elicited a similar response across our sample of healthy individuals, including fear-like perceptions and an increase in heart rate. This suggests that fear, potentially due to evolutionary reasons, elicits a more pronounced autonomic sympathetic response than sadness. In conclusion, the results suggests that fear is universally recognized by healthy, college-aged individuals in accordance with an increased heart rate. Characterizing a “normal” physiological response for all of the basic emotions would be useful for generating a screening tool for individuals with mental conditions that inhibit them from correctly identifying emotions.

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Appendix:

Heart Rate	Mean (bpm)	Standard Deviations (bpm)
Heart Rate Initial	72.3	10.86
Heart Rate Change (S)	0.325	8.82
Heart Rate Change (F)	7.4	8.33

Blood Pressure	Mean (mmHg)	Standard Deviations (mmHg)
BP Systolic Initial	113.15	9.03
BP Diastolic Initial	75.05	8.64
MAP Initial	87.75	8.23
BP Systolic Change (S)	-5.96	10.404
BP Diastolic Change (S)	-2.99	6.11

BP Systolic Change (F)	-4.55	8.33
BP Diastolic Change (F)	-1.9	5.87
MAP Final (S)	83.2	7.72
MAP Final (F)	84.97	7.13

Skin Conductance	Mean (microsiemens)	Standard Deviations (microsiemens)
Skin Conductance Change (S)	0.15	0.92
Skin Conductance Change (F)	0.07	0.7

Table 1. The means and standard deviations of heart rate, blood pressure (BP) and skin conductance during the sad (S) and fear (F) stimuli. The initial measurements were recorded for heart rate and blood pressure once at the beginning of the trial and used as a reference for both the sad and fear stimuli measurement changes. Heart rate includes the average initial and change in heart rate measured in beats per minute (bpm). Blood pressure includes the average initial and change for both systolic and diastolic blood pressure as well as the mean arterial pressure (MAP) average initial and final measures. These were measured in millimeters of mercury (mmHg). Skin conductance was measured in microsiemens and includes the average change as calculated using the BIOPAC Systems, Inc. MP36 delta software. The initial measurements of heart rate and blood pressure were used as a baseline to determine if the individual's measured variables changed in response to the emotional stimuli.

Heart Rate	Type of Emotional Stimulus	Level of Perceived Emotion
Change in heart rate	$5.83\ e^{-5}$ ***	0.2452

Skin Conductance	Type of Emotional Stimulus	Level of Perceived Emotion
Change in skin conductance	0.4463	0.6636

Blood Pressure	Type of Emotional Stimulus	Level of Perceived Emotion
Change in systolic BP	0.5784	0.2738
Change in diastolic BP	0.3210	0.6930
Final MAP	0.6934	0.1517

Table 2. Summary of the *p*-values of each measured variable (heart rate [bpm], skin conductance [microsiemens], and blood pressure [mmhg]) in relation to the type of emotional stimulus (sad or fear) and the level of perceived emotion as recorded by the participant after each emotional stimulus. Heart rate was the only measured variable found to be significantly related to the type of emotional stimulus (*p*-value = $5.83\ e^{-5}$). No measured variable was found to be significantly related to the level of perceived emotion. *** indicates a *p*-value of less than 0.01.

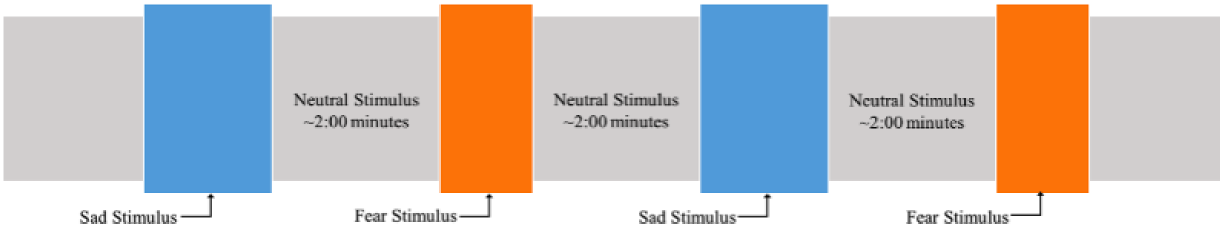

Figure 1: Video Timeline

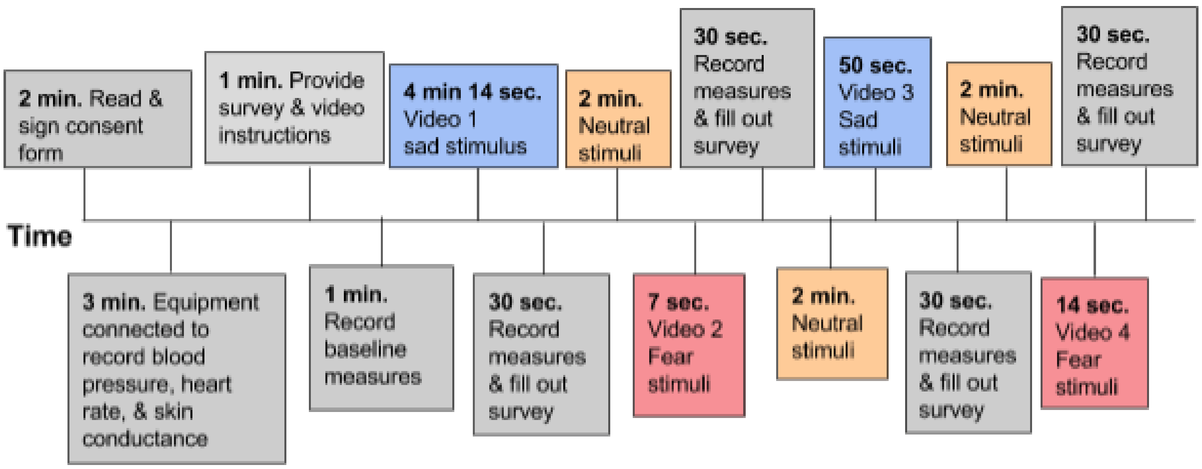

Figure 2: Time frame for one participant doing the study

Link 1: https://www.youtube.com/watch?v=F2bk_9T482g

Link 2: https://www.youtube.com/watch?v=avh5ziZqalQ

Link 3: https://youtu.be/eubWYPhcEEo

Link 4: https://www.youtube.com/watch?v=tCn1LzOk6Hs

Video Links: These four video links correspond to the four different emotional stimuli used during each trial. Links 1 and 3 are the video stimuli used to elicit sadness and links 2 and 4 were used to elicit fear. After each stimuli, the participant recorded their perceived emotion and the intensity of that emotion and their heart rate, blood pressure, and skin conductance were recorded.

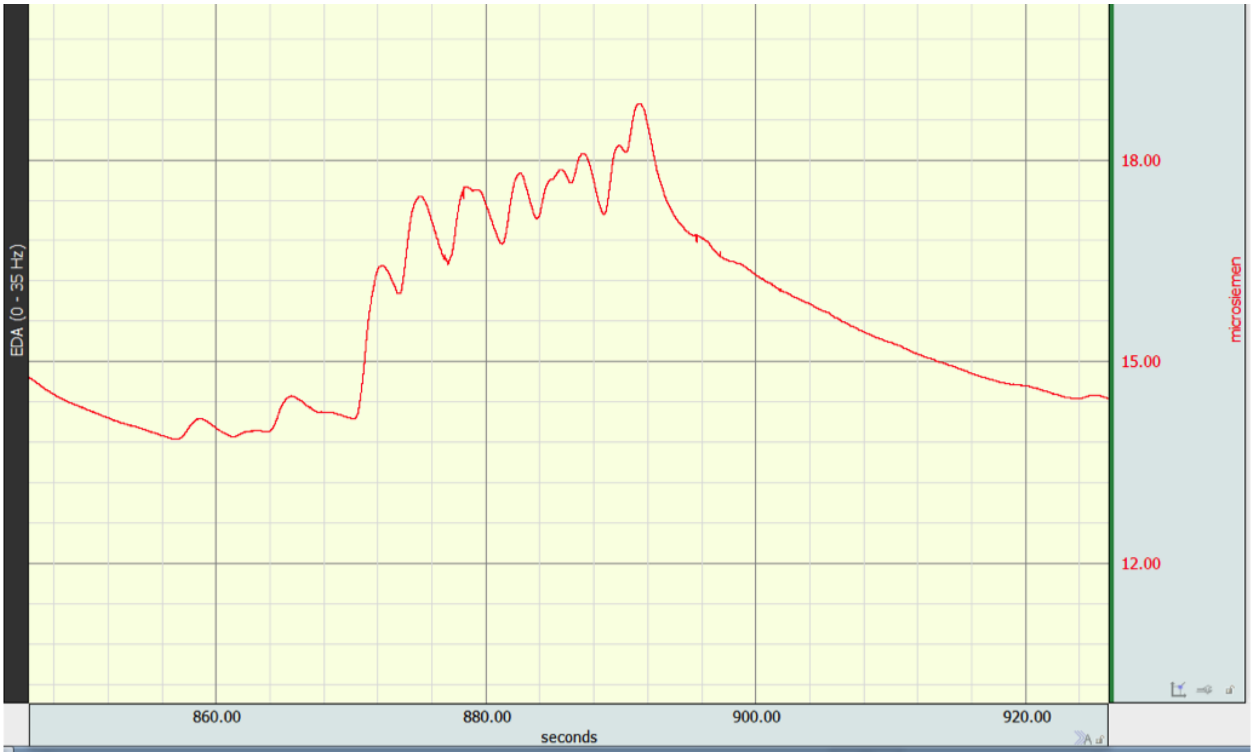

Figure 3: Represented changes in skin conductance obtained after viewing a 4th stimulus (fear). Using tools in Biopac, appropriate data was selected and the "Delta" function was used to calculate the change in skin conductance (microsiemens) over time (seconds).

Figure 4: Heart Rate values, recorded at rest and after every stimulus, were averaged for every individual to see the gradual change in heart rate in relation to the stimuli. Higher average heart rates were observed for the fear stimuli.

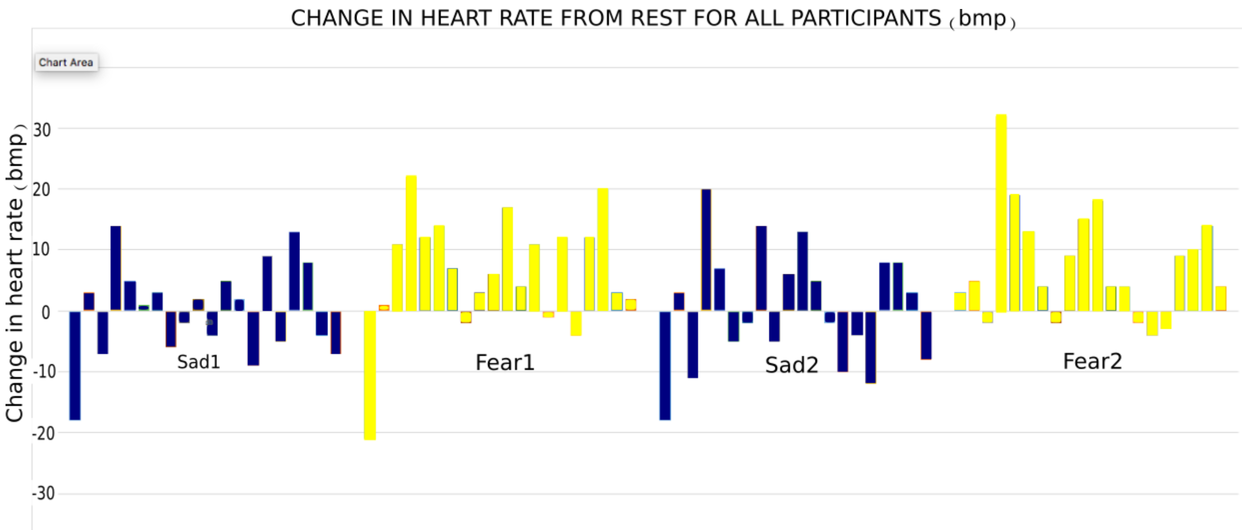

Figure 5: Heart rate was measured at the end of each stimulus and compared to the initial resting heart rate. Each participant's change in heart rate per stimuli was plotted. Fear typically elicited a positive change in heart rate, which is expected in relation to the sympathetic nervous system. Heart rate change for the sad stimuli was variable.

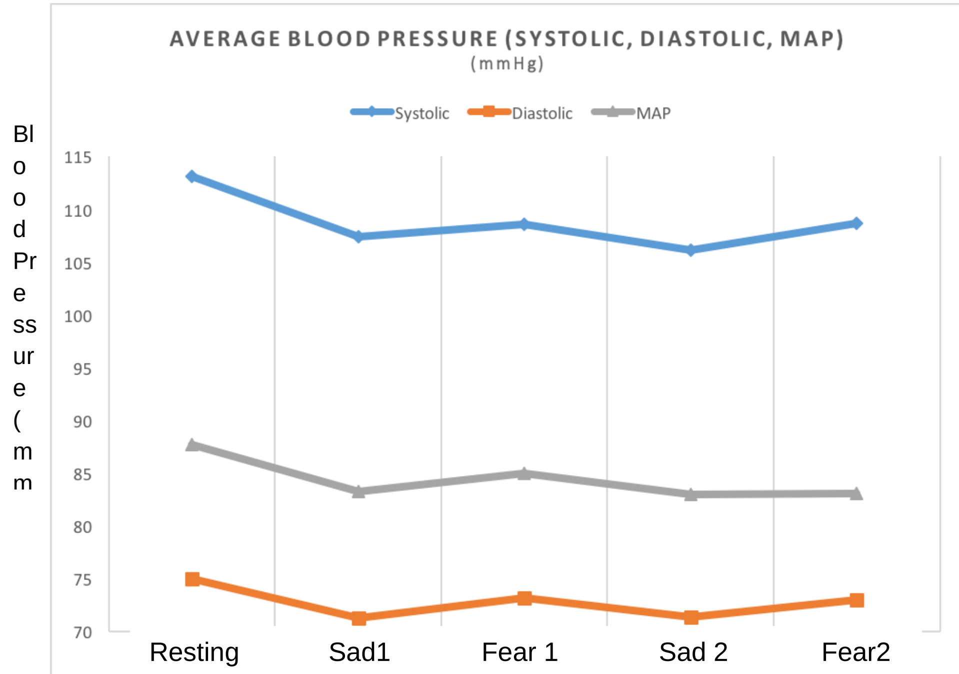

Figure 6: Blood pressure was measured at rest and after each stimulus. Systolic (SP) and Diastolic pressure (DP) was recorded and averaged for each individual. Mean Arterial Pressure (MAP) was calculated at each point using the formula DP + ⅓(SP - DP). The average of each MAP value was then averaged.

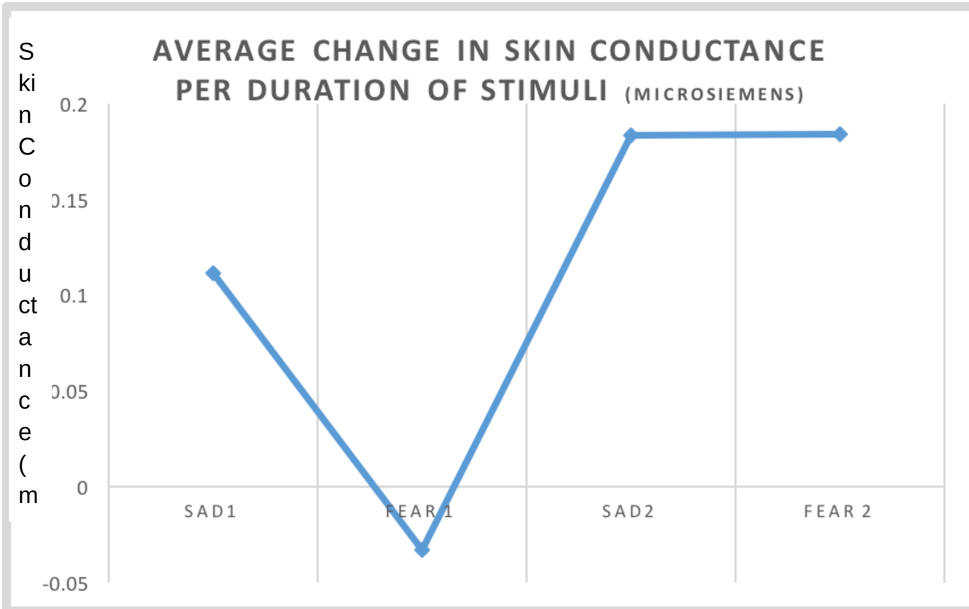

Figure 7: Skin conductance was the most variable measure of the three that were used in the study. Values for the change in skin conductance were collected over the duration of each stimulus for each participant and these values were averaged for each video stimulus.

Participant ID_________ Date_____________

Response Form:

Video 1: Select ONE emotion that best describes how this video made you feel

Happy Sad Angry Disgust Fear Surprise

Emotion Intensity

Low Intensity High Intensity

0 1 2 3 4 5

Video 2: Select ONE emotion that best describes how this video made you feel.

Happy Sad Angry Disgust Fear Surprise

Emotion Intensity

Low Intensity High Intensity

0 1 2 3 4 5

Video 3: Select ONE emotion that best describes how this video made you feel.

Happy Sad Angry Disgust Fear Surprise

Emotion Intensity

Low Intensity High Intensity

0 1 2 3 4 5

Video 4: Select ONE emotion that best describes how this video made you feel.

Happy Sad Angry Disgust Fear Surprise

Emotion Intensity

Low Intensity High Intensity

0 1 2 3 4 5

Figure 8: Emotion Perception Survey. The participant was asked to indicate which emotion they experienced and the intensity of that emotion after each video stimulus.