Stress responses due to application of audio or visual stimuli

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Abstract

Stressful events promote activation of the sympathetic nervous system which causes measurable physiological changes in the body. Visual and auditory inputs often aid in this “fight or flight” stress response if potential harm is detected. In this study, seemingly stressful visual or auditory stimuli were presented to participants. The physiological stress response was assessed by measuring heart rate, skin conductance, and breathing rate before and after exposure to the stimuli. The data was analyzed in order to determine whether audio or visual stimuli elicit a stronger stress response. Our results showed that audio and visual stimuli elicit similar stress responses.

Introduction

A stressful situation can trigger the release of stress hormones that produce many physiological changes. Stressful events may make heart rate increase, breath quicken, and skin sweat. These reactions are part of the “fight-or-flight” response. This response evolved as a survival mechanism, allowing mammals to react quickly to life-threatening situations. When faced with a stressful situation, hormonal and physiological changes occur almost instantaneously to allow one to respond to the threat (Harvard, 2011). Physiological systems that are needed to deal with threats are activated and systems that are not are suppressed (Kemeny, 2003). The body may also overreact and respond to stressors which are non-life-threatening (Harvard, 2011).

In the presence of a stressor, visual and auditory input is detected by sensory organs and immediately travels to the thalamus. From the thalamus, sensory information is sent along two separate pathways. One pathway goes from the thalamus to higher level visual and auditory association areas of the brain and then to the prefrontal cortex for further processing and integration. The other pathway is quicker and takes information from the amygdala to the hypothalamus, releasing a stress response before the information is completely processed. The hypothalamus communicates with the body through the autonomic nervous system (Cosic, 2010). The autonomic nervous system controls involuntary functions such as breathing, blood pressure, heart rate, and the dilation or constriction of blood vessels (Harvard, 2011). The autonomic nervous system consists of two components: the sympathetic nervous system, which increases involuntary processes in threatening situations, and the parasympathetic nervous system, which controls involuntary resting functions (Kemeny, 2003). The hypothalamus activates the sympathetic nervous system, and also sends signals to the adrenal glands, which release epinephrine to the bloodstream. The release of norepinephrine by the nervous system and epinephrine by the adrenal glands causes the physiological changes associated with the “fight or flight” stress response including increased heart rate, breathing rate, and perspiration (Harvard, 2011). A person under stress will display sympathetically-mediated responses.

The purpose of our study is to compare the sympathetic stress response between visual stimulation and audio stimulation. Noxious or stressful stimulation dilates the pupils in humans, which is primarily mediated by the sympathetic nervous system (Reeves, 1969). Many recent studies have utilized visual inputs in order to observe a change in the sympathetic variable because of an increased stress level. One experiment linking vision and sympathetic response demonstrates that viewing stressful images increases the skin sympathetic nerve activity (Henderson, 2012). There have not been many studies that link emotional auditory stimuli with the sympathetic stress response. The pathways of the stress response in the auditory system involve the sympathetic stimulation within the cochlea (Bielefeld and Henderson, 2007). The generation of a comparative analysis of auditory and visual responses to a stressful stimulus will be the main focus of the present study.

Noxious visual stimuli elicit a greater increase in the galvanic skin response, heart rate, and respiration rate than noxious auditory stimuli. We generated this hypothesis due to the knowledge that the autonomic nervous system's sympathetic branch controls involuntary functions such as heart rate, perspiration, and inhalations during the stress response. This direct link between bodily stress and the visual integration led us to the hypothesis that a noxious visual stimulus will elicit a larger deviation from the baseline than a noxious auditory stimulus.

Our experimental design defined a stress response as a statistically significant increase from baseline in the galvanic stress response, heart rate measured by ECG, and respiration rate measured by a spirometer. We took measurements of the galvanic skin response (perspiration), ECG (heart rate), and spirometer (respirations) in order to show that the sympathetic stress response was being triggered by our audio and visual stimuli. We expected the individual undergoing the visual stimulus, a video clip of a crying baby without audio, to demonstrate a greater increase in perspiration, heart beats per minute, and breaths per minute than the audio stimulus, an audio clip of a crying baby without video.

Previous experiments exposing both parents and non-parents to the sounds of babies crying have demonstrated an increase in sympathetic nervous system activity, namely increases in heart rate and skin conductance. In a study comparing the difference in the stress response between a violent audio stimulus and a crying baby audio stimulus, no significant difference was found, highlighting the potency of the sounds elicited by a crying baby. (Tkaczyszyn et al. 2013). Our video utilized an uncontrollable stressor where participants were unable to assist the unhappy baby. Breier et al. (1987) showed that subjects under conditions of an uncontrollable stress have greater sympathetic nervous system activation and higher skin conductance than subjects who have control over their stressors. Experiments (Frodi et al. 1978) have also shown that there is no difference in change in psychophysiological responses in men and women. They are both affected equally by a crying baby stimulus.

Acting as a negative control, participants sat stationary with their eyes closed and a measurement of their sweat production, heart rate, and respirations was taken to establish their baseline. Acting as our positive control, participants exercised vigorously by doing jumping jacks for one minute and their perspiration, heart rate, and respirations were recorded.

We predicted that visual stimuli contribute to a significantly higher stress reaction than auditory stimuli. There is scientific evidence in the literature to corroborate our hypothesis; one such study has to do with television. It has been shown that as the pace and arousal level of a television message is increased, auditory recognition declines while visual recognition remains constant. Visual processing appears to be an automatic process regardless of the intensity, whereas auditory processing seems to me more of a controlled process that is resource-limited (Lang, 1999). Due to the high pace and high intensity of the experimental stimuli, we thought that participants in the audio-only group would not have the psychological resources to fully process the input, and would have a lower stress reaction than individuals in the video-only group.

Materials and Methods

Consent forms outlining the purpose, benefits, and risks of the experiment were given to participants to sign. Subjects were randomly assigned to either an audio-only or visual-only experimental group. Each participant was required to participate in the experiment which occurred on two separate days. The first day of experimentation consisted of subjects participating in a positive control while hooked up to a Biopac system which measured respiratory rate and sweat output. A separate hand-held pulse oximeter was used to measure baseline heart rate. This monitor was only capable of measuring instantaneous heart rate. We chose to use the handheld pulse oximeter instead of the ECG option within the Biopac system because the Biopac ECG took far longer to set-up and would fall off easily during aerobic positive controls. We sought to attract the highest number of participants possible by having a quick and comfortable experimental experience. Participants sat idly in a chair for one minute to achieve baseline data to demonstrate that there was a change once the positive control was being taken. Positive controls simulated a stress response and consisted of participants doing jumping jacks for one minute, mimicking the amount of time that the visual/audio stimulus was applied. Measurements of heart rate were taken before and after the one minute time intervals, while the breathing rate and skin conductance were monitored continuously.

On day two of experimentation, the participant was again hooked up to the Biopac system and the handheld pulse oximeter, and baseline data concerning breathing rate, heart rate, and sweat output were taken. This baseline data was used to compare against the changes observed during and after the stimulus in the results section. This data was considered the negative control. Heart rate was taken at the end of the minute of baseline data, while the breathing rate and skin conductance were taken continuously. The participant was then exposed to the audio-only or visual-only stimulus that was randomly assigned on the first day of experimenting. Data on breathing rate and skin conductance were taken throughout the course of the stimulus, and heart rate was also monitored, while only the heart rate at the end of the minute was recorded. The subject that listened to the audio stimulus listened to it with headphones and was wearing a blindfold to prevent any type of visual stimuli from affecting the results. The video stimulus group wore earplugs and headphones, with no sound input, to prevent any audio from affecting the results.

The video used was a video found off of YouTube. It was a baby lying in a crib and crying. The original video was longer than a minute, but the video was trimmed down to one minute for the experiment.

Subjects were asked to fill out a survey following the experiment that denoted their subjective level of stress to the stimulus, whether they had ever witnessed the same stimulus before, whether they had had personal experiences that may have either reduced or increased their stress response to the stimulus, and the level by which these personal experiences may have impacted their stress response.

Results

The mean difference of heart rate after exposure to the stimuli compared to the negative control showed a decrease of 2 ± 6.23 beats per minute for the visual stimulus and a decrease of .727 ± 5.29 beats per minute for the audio stimulus. p=.54 (Table 1). Skin conductance showed an average increase after exposure to the stimuli compared to the negative control of .018 +/- .022 microSiemens for the visual stimulus and .022 ±

.045 microSiemens for the audio stimulus. p=1 (Table 2). Breathing rate showed an average increase of 1 ± 2.83 breaths per minute for the visual stimulus and 3.54 ± 6.30 breaths per minute for the audio stimulus when compared to the negative control. p=.35 (Table 3).

Self-report data demonstrated an average stress level (on a scale of 1 to 10; 10= highest level of stress) for the audio condition of 3.91 ± 1.70 and for the visual condition of 2.64 ± 1.50. No participants reported ever seeing the video before. 8 of the 22 participants (4 from each condition) reported exaggerated responses due to previous personal experiences.

Discussion

Our results suggest that there is no significant difference between audio or visual when our stress stimuli were applied to each group. A possibility behind this outcome could be the strength of the stress stimuli. The video clip of the baby crying could have not been a potent stressor to trigger an extreme response out of the participants. This is in contrast to what we have previously read in articles before conducting our experiment. (Tkaczyszyn et al. 2013). In an experiment that looked at the effects of stress and shock anticipation on pre-pulse inhibition of the startle reflex, the participants were exposed to sudden large bursts of noises to trigger a response extreme enough to elicit stress and shock. Prior to the participants undergoing the study they were required to answer a questionnaire asking about mental illnesses, neurological and psychological disorders, PTS (post traumatic stress), or using illegal drugs or alcohol. This way they could screen properly to ensure that no participants had conflicting situations that would cause them to be overly sensitive to the stimulus. (Grillon et al. 1997). Future researchers should follow a similar methodology by screening participants properly, allowing them to use a more extreme stimulus and possibly achieve a higher stress response.

Due to time constraints and our unfamiliarity with the Biopac system, we potentially made errors in the data collection process. A factor that could have affected our results was that the majority of our skin conductance values were negative, which suggests incorrect calibrations and/or machine malfunctions. When measuring breaths per minute there were often irregularities and overlaps between breaths, which made it difficult to measure individual breaths. Heart rate values often constantly changed throughout the one-minute of baseline or experimental data measurement; hence, the single heart rate value we measured at the end of the one minute time frame was frequently not a reflection of the overall heart rate of that entire time period. To future researchers we would advise taking more instantaneous heart rate measurements via the handheld pulse oximeter within each minute interval and then calculating an average heart rate value to offset these fluctuations. Another potential option would be using the ECG option within the Biopac system which would give a complete picture of the heart rate throughout the whole minute interval. There was commonly a spike in skin conductance and breathing rate at the onset of experimental stimuli due to the initial shock of a new stimulus. This appears to have influenced the audio group more as they were given less forewarning of when the stimulus was going to begin. However, our results showed that neither audio nor visual stimuli elicited a larger stress response than the other.

In order to acquire an adequate amount of data to analyze under time constraints, we chose to have each participant exposed to either the visual or audio stimulus. To increase the accuracy of the experimental results, participants should be exposed to both the visual and audio stimuli if further experimentation is conducted.

To reinforce the findings of our study, further experimentation using alternative methodologies should be conducted.

Figures and Tables

Table 1.

Heart Rate			
Visual Stimulus		Audio Stimulus	
Mean Difference ± *sd*	-2 ± 6.23 Beats per Minute	Mean Difference ± *sd*	-.727 ± 5.29 Beats per Minute
Variance	38.8	Variance	28.0

This table shows the heart rate data from participants exposed to the visual or audio stimuli. The mean differences of heart rate after exposure to the stimulus compared to the negative control, standard deviations, and variances are provided.

Table 2.

Skin Conductance			
Visual Stimulus		Audio Stimulus	
Mean Difference ± *sd*	.018 ± .022 microSiemens	Mean Difference ± *sd*	.023 ± .045 microSiemens
Variance	.00048	Variance	.002

This table shows the skin conductance data from participants exposed to the visual or audio stimuli. The mean differences of skin conductance after exposure to the stimulus compared to the negative control, standard deviations, and variances are provided.

Table 3.

Breathing Rate			
Visual Stimulus		Audio Stimulus	
Mean Difference ± *sd*	1 ± 2.83 Breaths Per Minute	Mean Difference ± *sd*	3.54 ± 6.30 Breaths Per Minute
Variance	8	Variance	39.7

This table shows the breathing rate data from participants exposed to the visual or audio stimuli. The mean differences of breathing rate after exposure to the stimulus compared to the negative control, standard deviations, and variances are provided.

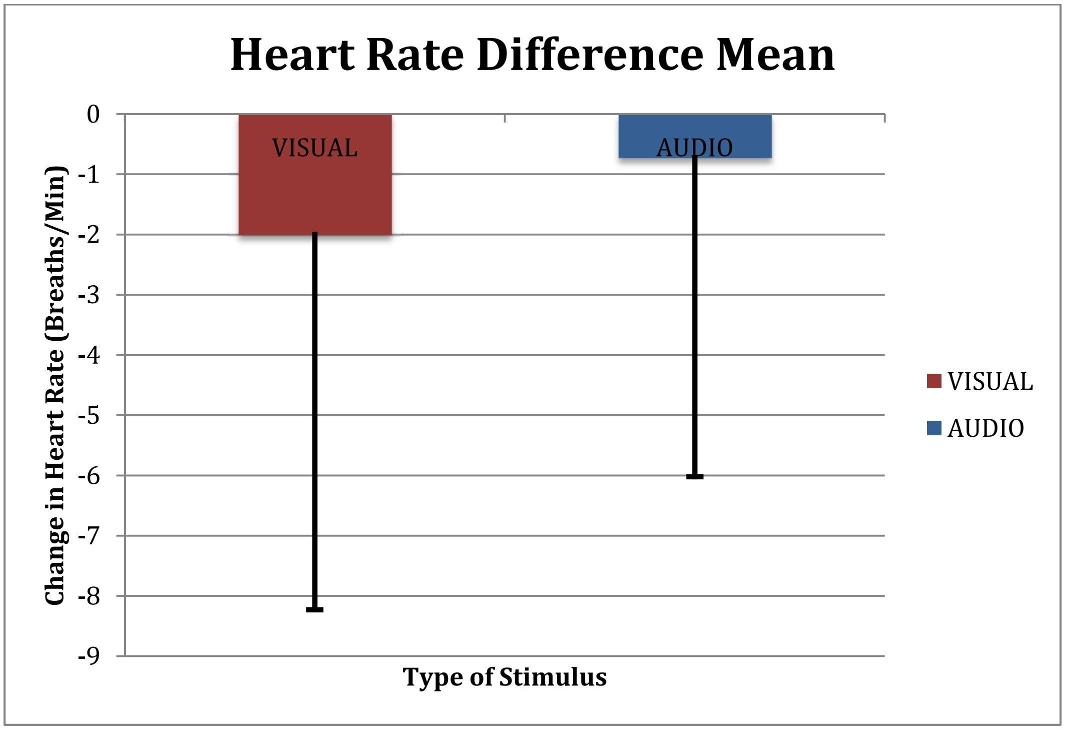

Figure 1. This figure shows the average difference in heart rate observed in the visual and audio stimulus groups.

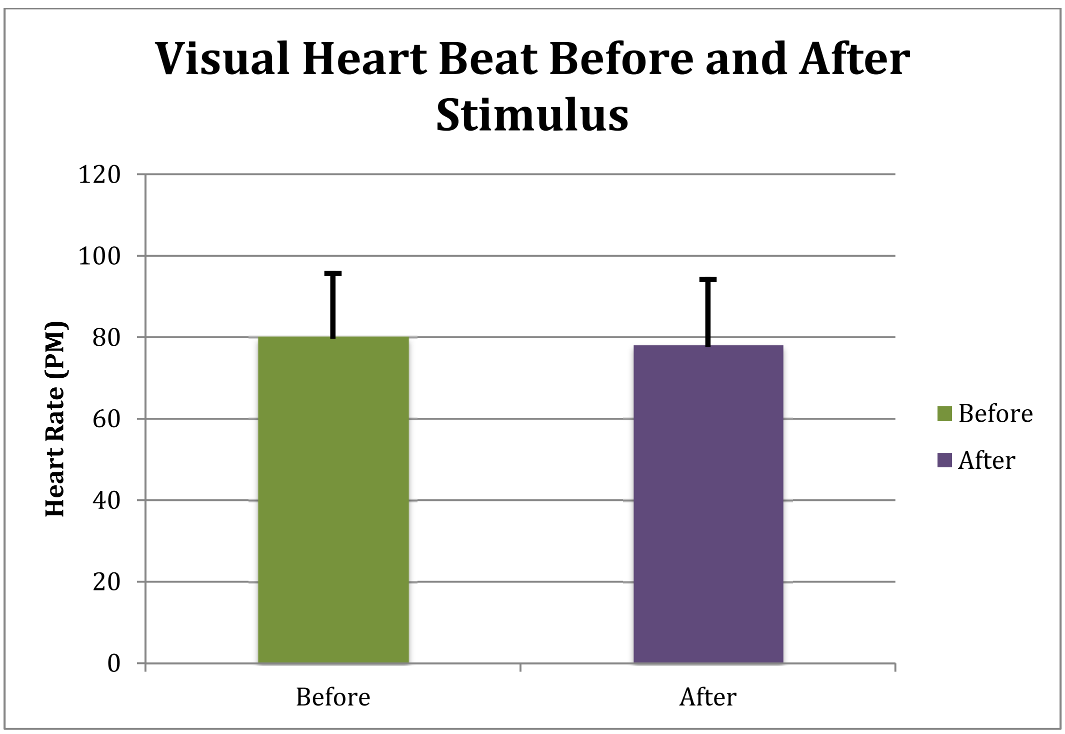

Figure 2. This figure shows the average heartbeat observed before and after exposure to the visual stimulus.

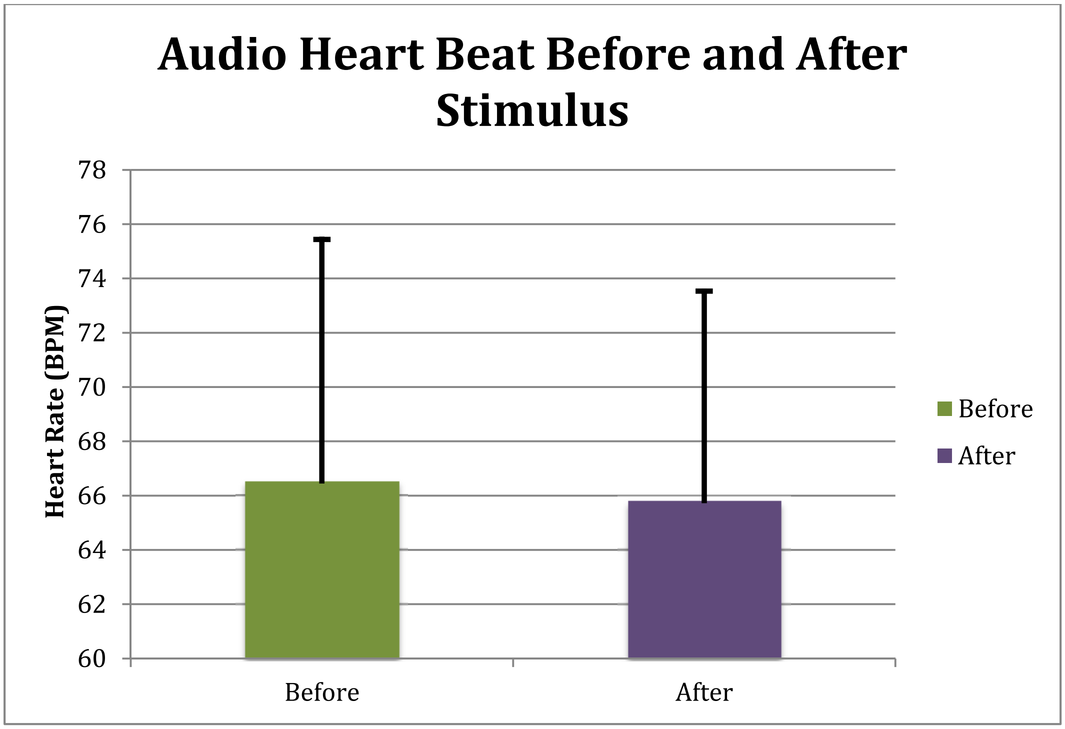

Figure 3. This figure shows the average heartbeat observed before and after exposure to the audio stimulus.

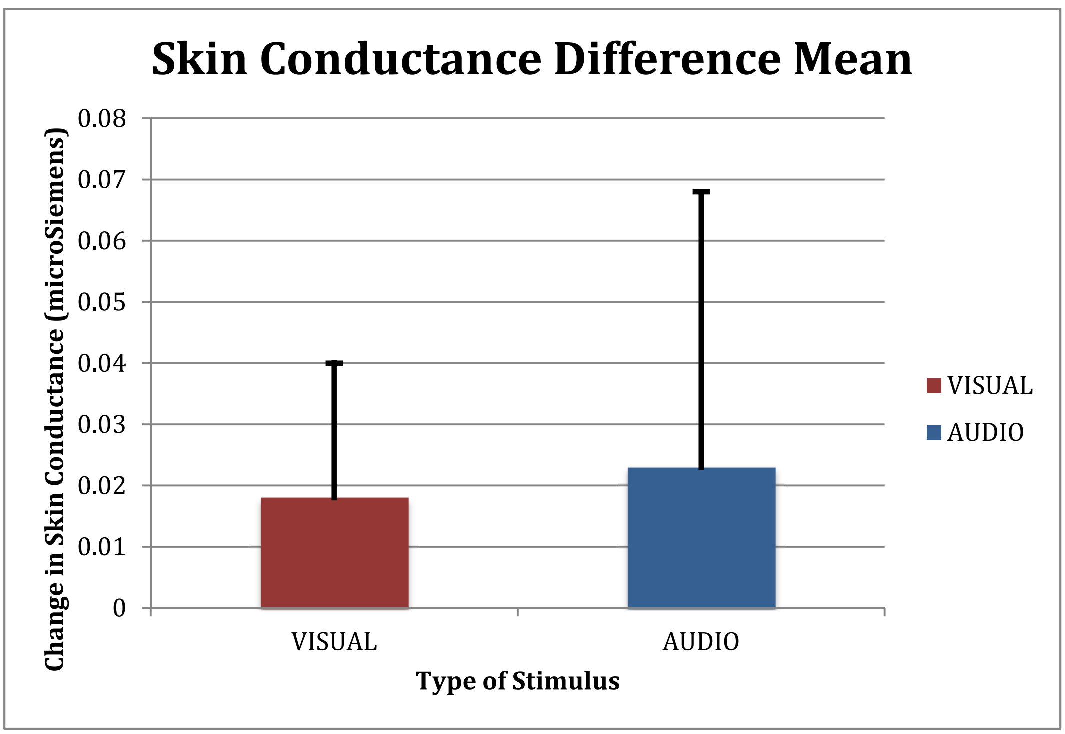

Figure 4. This figure shows the average difference in skin conductance observed in the visual and audio stimulus groups.

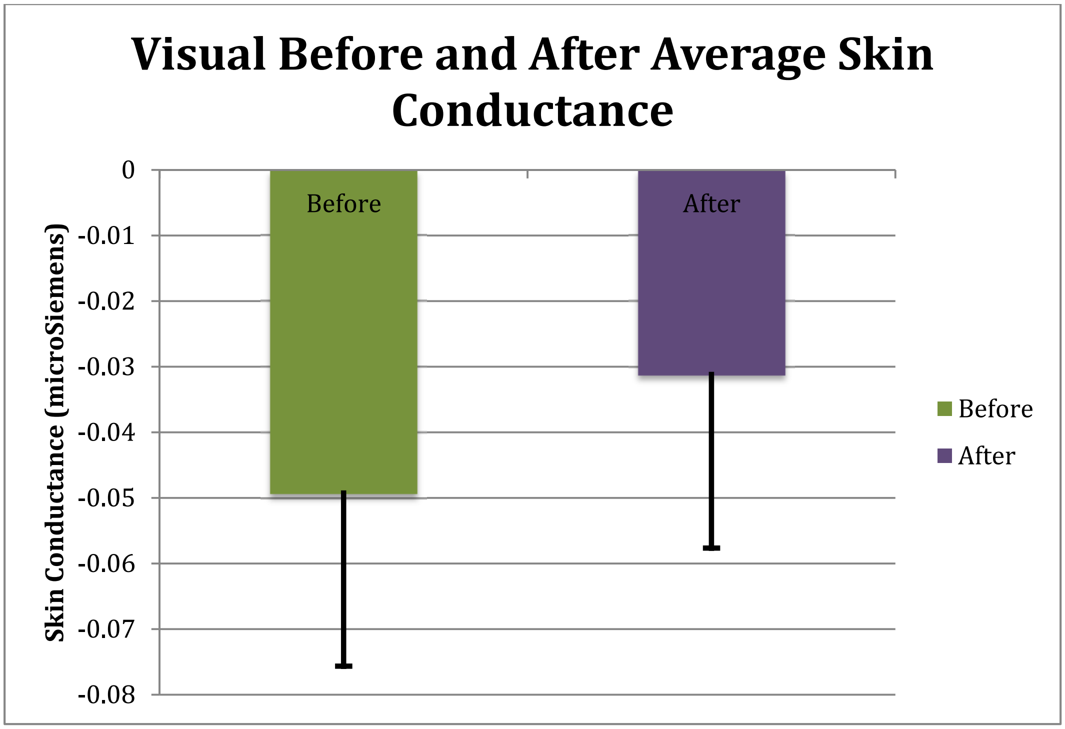

Figure 5. This figure shows the average skin conductance observed before and after exposure to the visual stimulus.

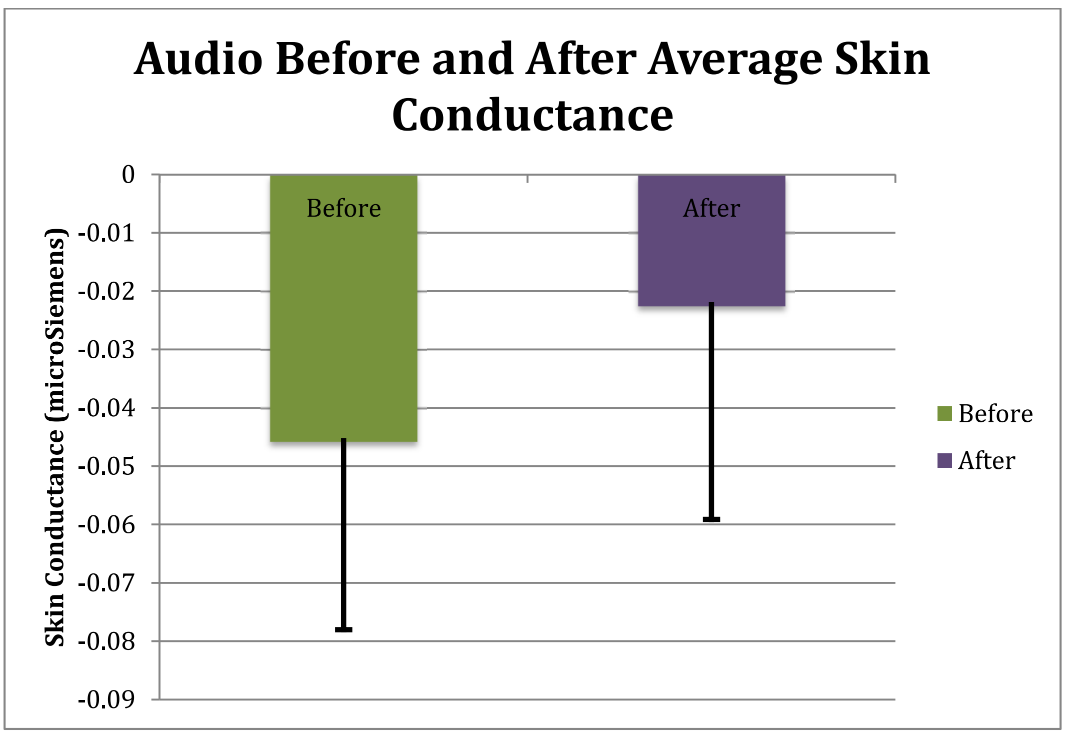

Figure 6. This figure shows the average skin conductance observed before and after exposure to the audio stimulus.

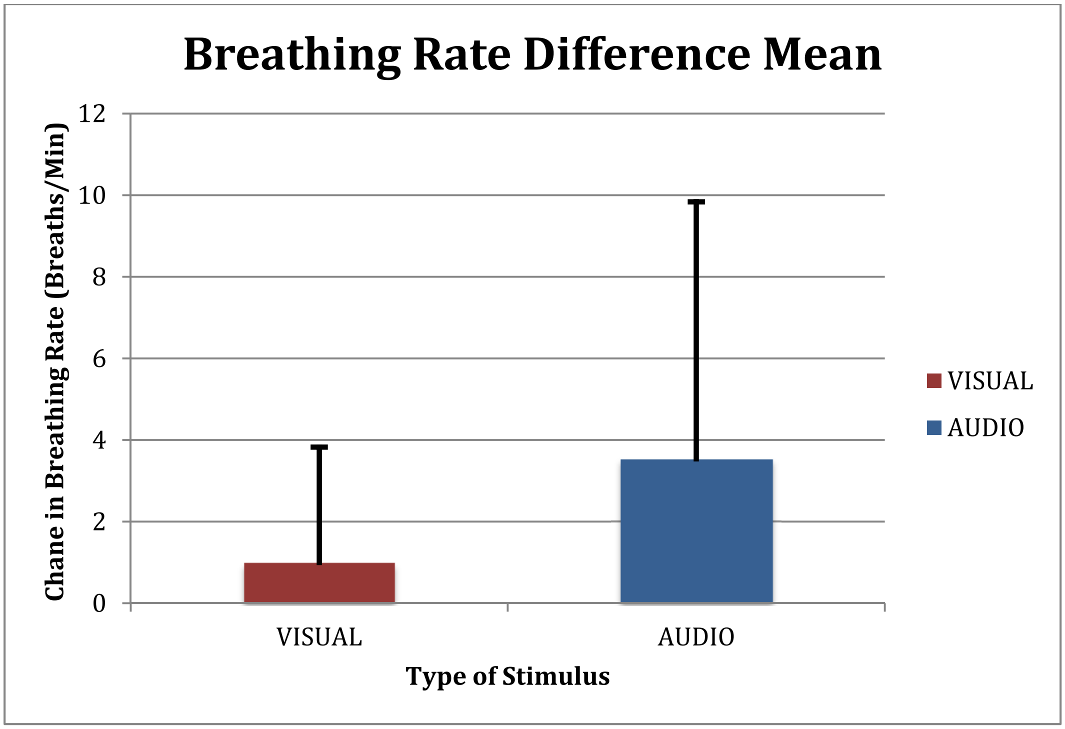

Figure 7. This figure shows the average difference in breathing rates observed in the visual and audio stimulus groups.

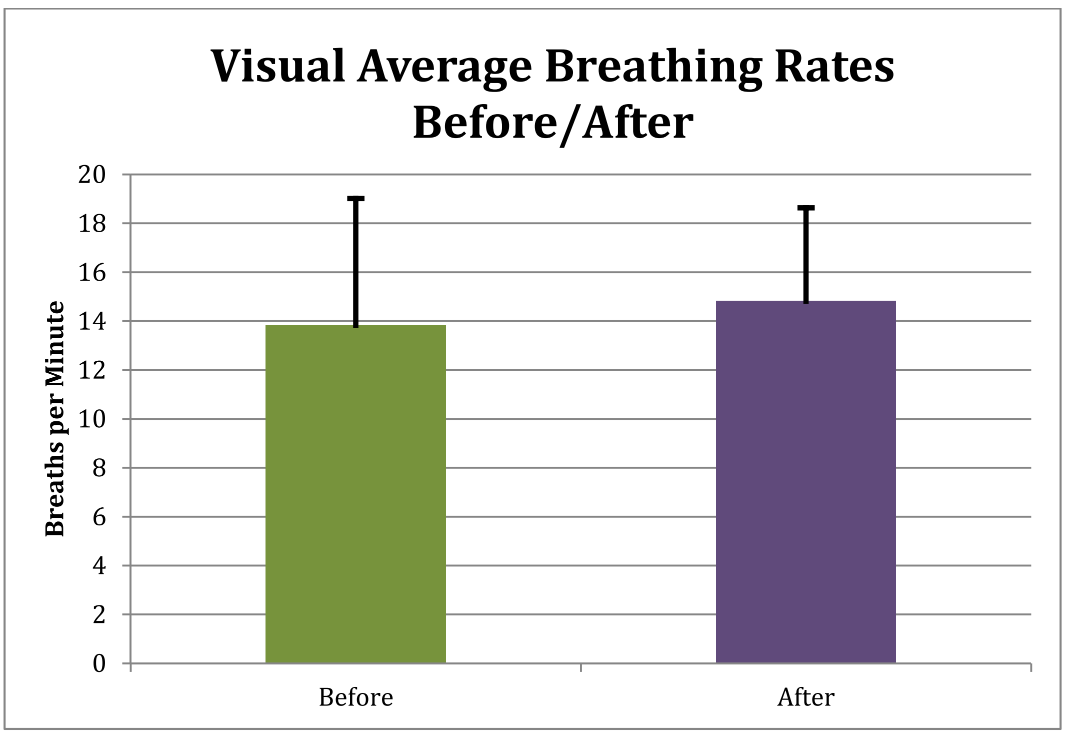

Figure 8. This figure shows the average breathing rates observed before and after exposure to the visual stimulus.

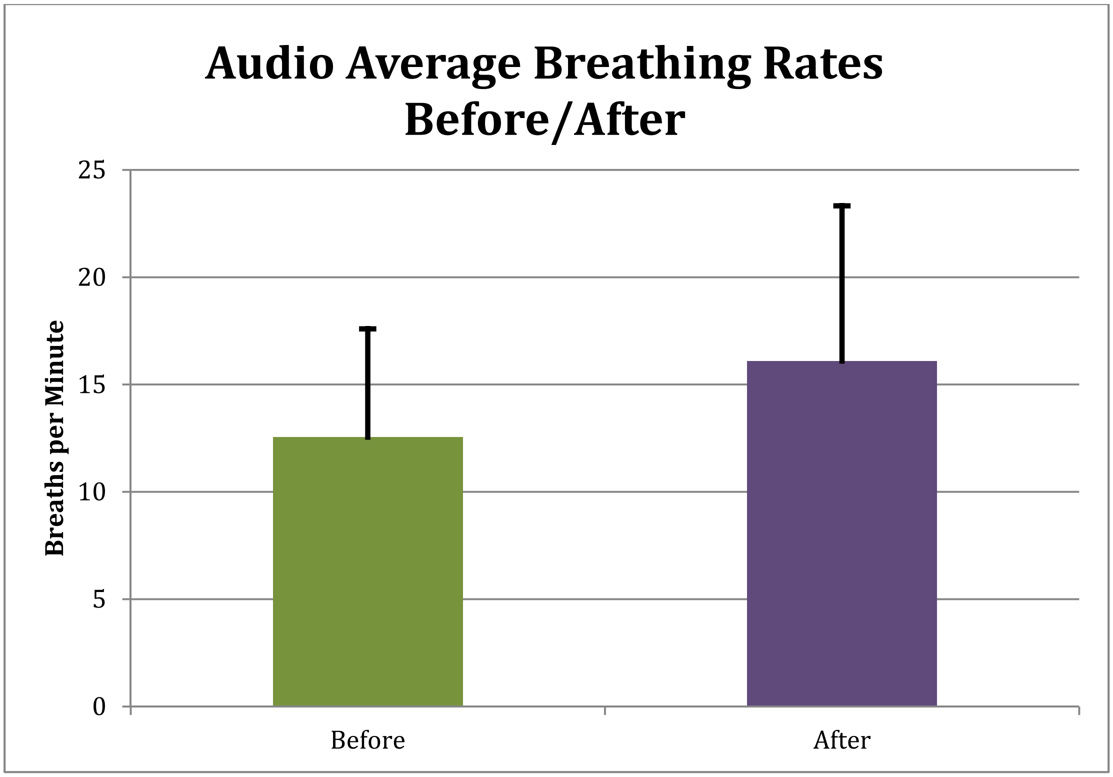

Figure 9. This figure shows the average breathing rate observed before and after exposure to the audio stimulus.

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