

# **Effects of Auditory Stimuli on Blood Pressure, Respiration Rate, and Heart Rate Changes While Watching a Suspenseful Video**

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## Abstract

The purpose of this study was to test the effect of auditory and visual stimuli on subjects' physiological response. The auditory stimuli included white noise, calming music, and music anticipated to induce stress, which were divided among three groups. The physiological response was measured by the following parameters: diastolic and systolic blood pressure, respiration rate, and heart rate. These values were compared to baselines taken while participants received no auditory stimuli and values taken while participants listened to unique stimuli based on their group assignment. We hypothesized that calming music would result in similar values to those taken as baselines while watching the horror movie scene, while the scary music would result in elevated heart rate, blood pressure, and respiration rate compared to the control. Our results displayed a reduction in heart rate with calming music and an increase in heart rate with stressful music alone, however the results were not significant enough to conclude a definitive relationship between the auditory stimuli and heart rate. Values for blood pressure and heartbeats per minute were also not significant enough to support our hypothesis.

## Introduction

Fear is a universal emotion experienced by people of all walks of life. Small children fear monsters under their bed when the lights go out. Adults fear harm to themselves or a loved one or the uncertainty that these things might take place. The human body responds to fear and anxiety in measurable physiological ways. The emotional experiences of fear and anxiety act to alert the body to danger or threat. This elicits adaptive responses in the physiological functioning of the body through a complex coordination of the brain, hormones, and the cardiovascular system (Steimer, 2002). As an active coping method, the sympathetic nervous system is engaged through the release of epinephrine and norepinephrine from the adrenal glands as the brain perceives a threat to the body. The release of these hormones results in many physiological actions; "respiration deepens; the heart beats more rapidly; the arterial pressure rises; the blood is shifted away from the stomach and intestines to the heart and central nervous system and the muscles" (Funkenstein, 1955). These are preparatory mechanisms that allow the body to be equipped for a rapid "fight or flight" response to danger.

Sinha et al. (1992) performed a study to measure the response of the cardiovascular system to perception of different emotions. Through a series of imagery experiments that allowed participants to experience different emotions within a safe setting, the team measured heart rate and blood pressure. The study concluded that there was an increase of the systolic blood pressure and the heart rate of the participants that experienced fear in their imagery session. However, there was little change in the diastolic pressure mediated by a low peripheral vascular resistance in these same participants. Sinha et al. (1992) attributed this to a sympathetic response of the nervous system and a release of epinephrine.

Extensive research has been done on the effects of music on pain and anxiety. Timothy Onosahwo Iyendo (2016) performed a meta-analysis on research related to sounds in hospitals, including research on music intervention in the treatment of patients. He found that, across multiple studies, patients listening to relaxing music within the hospital experienced a decrease in stress and anxiety levels, including a decrease in blood pressure and heart rate across all age

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levels. Relaxing music has been shown to partially reduce the body's physiological response to stress during an extended hospital stay. When music is received by auditory sensors in the inner ear, it is relayed to the auditory cortex in the brain. The brain then perceives this stimuli as pleasant and the patient has a positive emotional response. Neuroimaging has shown that experiencing a pleasant auditory stimulus recruits parts of the brain such as the amygdala, the hypothalamus, and the frontal cortex, as well as controlling the release of immune-boosting hormones and decreasing stress hormones, like cortisol (Iyeno, 2016). One study done by le Roux et al. (2007) tested the effects of Bach's Magnificat on the cortisol levels of patients suffering from infectious lung conditions. The three-day experiment compared the cortisol levels in patients that were given physiotherapy with the music to a control group that did not hear the music. The study showed a significant decrease in the stress hormone in the patient group that listened to the classical music compared to the group that did not listen to the music, who experienced a significant increase in plasma cortisol levels. This finding indicates that the patients who received music therapy as part of their treatment experienced lower stress levels and decreased negative emotions in comparison to their counterparts.

A caveat to this type of research is that the emotional responses that people have to different types of sound vary widely. What is perceived as stressful or peaceful to one person may not elicit the same emotional response in another individual. However, the data of the previously mentioned studies suggests that a patient under stress can be rescued from some of that anxiety and experience health benefits by listening to a stimulus that they deem pleasant.

We are interested in exploring the link between auditory and visual stimuli in their relationship to emotional physiological responses. In order to determine the relationship between the physiological response to fear and music in conjunction, we will observe the change in systolic blood pressure, heart rate, and respiration rate as a response to auditory and visual stimuli. These three physiological measurements have been observed to be significantly altered by the sympathetic response to fear. Blood pressure, respiration rate, and heart rate will be measured and compared across participants. Participants will be exposed to a fear-inducing video while listening to either calming music, meant to reduce anxiety, or stressful music, meant to enhance the feelings of fear. Our negative control participants will listen to ambient white noise that is not meant to change the participants' emotions when viewing the video. By comparing the data among auditory stimuli, we hope to be able to see how music mitigates or enhances the physiological effects of fear and anxiety. We predict that the calming music will decrease heart rate, blood pressure, and respiration rate, while the stressful music will increase these physiological responses, both in comparison to the negative control of the ambient sound.

## Methods

### *Participants*

Participants for this study were recruited from Physiology 435. Participants were randomly assigned to one of three groups. Group 1 participants watched a short video clip from the ending of the movie "Insidious" while listening to white noise through headphones. Group 2 participants watched the same clip accompanied by calming music. Group 3 listened to suspenseful music while watching the video. Twenty-three participants completed this study, sixteen female and

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seven male. Participants were between twenty and twenty-two years of age. All participants were volunteers and received no financial compensation or direct benefit from this study. All students signed a consent form prior to completing the study.

### *Materials*

The following is a list of materials to be used in this experiment:

- Omron Automated Blood Pressure Monitor, Model BP791IT (HEM7222ITZ), Serial Number: 20141004275LG, Manufactured by Omron Healthcare Inc. (Lake Forrest, IL)
- Biopac Respiration Belt, Model SS5LB, Serial Number: 1602007558, Manufactured by Biopac Systems (Goleta, CA)
- Monin Pulse Oximeter, Model 9843, Serial Number: 118103098, Manufactured by Monin Medical Inc. (Minneapolis, MN)
- Biopac Student Labs 4.0 Software, Model MP36, Serial Number: MP36E1204002784, Manufactured by Biopac System (Goleta, CA)
- Laptop computer
- Over-ear headphones
- White noise, “White Noise Fan for Babies”, The White Noise
- Calm music, “Dalur” by Ólafur Arnalds, Brasstrío Mosfellsdals
- Suspenseful music, “Monsters Under the Bed” by Charlie Mac, Kevin Darnell Barnes
- “Insidious the Ending” on YouTube
  - <https://www.youtube.com/watch?v=dVWdqC6jzJQ>
  - Start at 1:36

### *Procedure*

A timeline for our experiment is shown in Figure 1. Participants were first outfitted with blood pressure monitor (Omron Automated Blood Pressure Monitor), respiration belt (Biopac Respiration Belt), and pulse oximeter (Monin Pulse Oximeter) while sitting with relaxed posture in a chair. They were also asked to wear a pair of noise-canceling headphones. The participant’s resting vitals were measured, including respiration rate, blood pressure, and heart rate.

Respiration rate were collected continuously with the Biopac software, and the baseline value were collected by analyzing the data with Biopac software (Figure 2). The Biopac software was used to find the mean respiration rate, in breaths per minute, over the 1 minute control period. Blood pressure were taken once to establish a control value. Heart rate was monitored continuously and the values from consecutive 10 second intervals were collected and averaged over the 1 minute control period. After all three vital measurements were made, participants began to listen to their assigned audio. After 2 minutes of audio with no added visual stimuli, the video clip was started. Participants watched the video while continuing to listen to their assigned audio. Average respiration rate and heart rate were collected over the 2 minute audio period and over the 1 minute video and audio period in the same way as described for the control period. Single blood pressure measurements were taken at the 2 minute mark (1 minute into the audio only section) and at the end of the video. Based on previous studies, measurements of systolic blood pressure were analyzed, while diastolic measurements were not used for analysis.

Researchers then assisted the participant with removing the monitoring equipment and the

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participants were asked to complete a short survey assessing their emotions after watching the video. The survey also collected demographic data, including gender identity and age, and inquire about participant's interest in suspenseful movies and whether they have seen the video clip prior to the experiment. Data from participants who had seen and had not seen the clip prior to the experiment were pooled (statistical analysis of data did not show significant differences between these two groups for all physiological variables tested).

### **Positive Controls**

#### *Procedure*

Three group members were outfitted with the same pulse oximeter, respiration belt, and blood pressure monitor. Each member's control values were recorded for one minute. They then removed the pulse oximeter and blood pressure cuff and performed ten jumping jacks. Respiration rate was recorded throughout the exercise. After, each member's blood pressure and heart rate were recorded by replacing the equipment. The following figure outlines the data points collected, following the procedure outline above.

	Blood Pressure, mmHg (systolic/diastolic)	Pulse, beats per minute	Respiration Rate, breath per minute
<b>Control</b>			
Besma	105/66	69	21.1
Emily	120/81	106	15.0
Rachel	120/75	87	13.2
<b>Post Exercise</b>			
Besma	114/77	98	65.3
Emily	125/91	125	80.2
Rachel	125/91	125	157.3

#### *Statistical Analysis*

Statistical Analysis was done by running t-Tests on systolic blood pressure, heart rate, and respiration rate before and after exercise. For the purpose of this study, significance was assumed if the p-values obtained were less than 0.15. For systolic blood pressure, the p-value obtained was 0.097. This value was accepted as statistically significant for the purposes of confirming our positive control. The p-value for heart rate was 0.14, and the p-value for respiration rate was

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0.049. These values were also accepted as statistically significant. This significant increase in blood pressure, heart rate, and respiration rate after exercise confirms that the equipment used was functioning properly and that changes in these variables can be detected using the methods outlined above.

## Results

### *Systolic Blood Pressure*

Average systolic blood pressure values over time are shown in Figure 3A to 3C. Results from the baseline are shown in Figure 3A, for the music period in Figure 3B, and for the video-music period in Figure 3C. For Group 1, the averages for the baseline, music, and video periods were 108.9 mmHg (SD=10.4), 106.9 mmHg (SD=15.0), and 108.3 mmHg (SD=12.3), respectively. For Group 2, the averages were 108.1 mmHg (SD=14.1) during the baseline, 107.8 mmHg (SD=15.0) during the audio only period, and 103.4 mmHg (SD=10.0) during the audio-video paired period. For Group 3, the baseline, audio, and audio-video averages were 102 mmHg (SD=11.6), 103.6 mmHg (SD=9.5), and 103.6 mmHg (SD=8.2), respectively.

No significant changes in systolic blood pressure were detected between the control group and either experimental group during the audio-only period of the experiment based on a two-tailed T-test run assuming equal variances (p-values Group 2 0.45, Group 3 0.32), or during the audio and video paired period (p-values Group 2 0.18, Group 3 0.19). Additionally, there were no significant difference in systolic blood pressure between the two experimental groups either during the audio period (p=0.26) or during the paired period (p=0.49).

### *Heart Rate*

Average heart rates for each group over time are shown in Figure 4. Group 1 heart rate averages for baseline (Figure 4A), audio period (Figure 4B), and audio-video (Figure 4C) period were 69.4 (SD=7.6), 69 (SD=6.7), and 69.7 (SD=7.4) heart beats per minute (HBPM), respectively. For Group 2, values (in HBPM) were 74.7 (SD=14.9) for baseline, 73.5 (SD=14.8) for audio only, and 74.0 (SD=13.9) for audio-video paired. For Group 3, the baseline average was 70.69 HBPM (SD=13.4), the audio average was 68.2 HBPM (SD=12.3), and the audio-video paired rate was 71.2 HBPM (SD=11.4).

No significant changes in heart rate were detected between the control group and either experimental group. This lack of significance was reflected in both the audio only period and the audio-video paired period for Group 2 (p=0.23 and p=0.24) for Group 2 (p=0.44 and p=0.39). Additionally, differences in heart rates between Group 2 and Group 3 were not significantly different for the audio only (p=0.23) or paired period (p=0.34).

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### *Respiration Rate*

Average respiration rates for each group from throughout the experiment are shown in Figure 5. Rates in breaths per minute (BPM) for Group 1 during the baseline (Figure 5A), audio only (Figure 5B), and audio-video paired (Figure 5C) periods were 15.1 (SD=3.6), 18.1 (SD=7.8), and 16.5 (SD=4.9), respectively. Group 2 rates in BPM were 13.7 (SD=4.7) for the baseline, 14.9 (SD=7.2) for the audio period, and 13.4 (SD=6.0) for the audio-video period. Group 3 rates in BPM were 12.6 (SD=3.6) for baseline, 12.8 (SD=4.0) for audio only, and 13.8 (SD=6.5) for audio-video paired.

Respiration rates for experimental groups compared to the control group were not significant. This was seen for the audio only period in Group 2 ( $p=0.21$ ) and Group 3 ( $p=0.07$ ) and during the audio-video period in Group 2 ( $p=0.14$ ) and Group 3 ( $p=0.19$ ). The differences between Group 2 and Group 3 were also not significant for audio only ( $p=0.24$ ) or audio-video paired periods ( $p=0.46$ ).

### Discussion

The results of the experiment did not prove statistically significant for any of the three physiological variables tested. Therefore, we are unable to prove that changes in blood pressure, respiration rate, and heart rate were due to the different auditory stimuli experienced by participants. We can not conclude that there are different physical reactions to a fear-inducing video when listening to calm music or suspenseful music. However, the results did show that the suspenseful music was close to significantly changing the respiratory rate in the subjects of Group 3 when compared to the control group ( $p=0.07$ ) (Fig 5A and 5C).

The purpose of this study was to understand the relationship between auditory and visual stimuli and their relationship to emotional physiological responses. Our hypothesis was that calming music would cause no change in heart rate, blood pressure, and respiration rate compared to the control group while suspenseful music would increase these variables, as compared to the control. Although the data showed trends similar to our predictions, after conducting two-tailed T-tests, we found that the trends were not statistically significant ( $p>0.05$ ). As discussed in the introduction, Timothy Onosahwo Iyendo (2016) found a positive correlation between relaxing music and a decrease in stress; however, on average the experimental designs examined in this meta-analysis involved subjects listening to the music for longer and more regular periods of time. This point introduces a possible error in our study design. In order to use our allotted time period efficiently and maximum the number of participants, each subject was tested for an average of 4 minutes, including only 3 minutes of auditory stimuli. The short duration of this experiment is a potential cause of the insignificant findings. For blood pressure especially, testing at 2 minutes and 4 minutes into the experiment may not have been the optimal timepoints to reflect any potential changes in the variable that could have taken place if more time had

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elapsed. The same may be true for heart rate and respiration rate, indicating a possible direction for future studies similar to procedure outlined above.

The post-testing questionnaire survey completed by participants revealed that 10 of the 23 participants had seen the video clip prior to the experiment. However, when comparing measurements of all three variables for the subjects who had seen the clip and the subjects who had not, there were no significant changes in values for any group. These findings led us conclude that previous exposure to the video clip had no confirmed effect on our data.

The hypothesis of this experiment that different forms of music can influence physiological responses to suspenseful videos in the form of increased blood pressure, heart rate, and respiration rate was unable to be proven in this study. However, there is a strong argument to be made for repeating the design of this study with longer periods of auditory-only stimuli and a longer video clip that is unknown to more participants. We hypothesize that with a longer duration of scary music stimulus, a positive correlation between increases in physiological response and exposure to scary music could be shown.

### Acknowledgements

Our group would like to thank Dr. Andrew Lokuta, Dr. Beth Altschaf, and the Physiology 435 Teaching Assistants and Peer Learning Volunteers for their lending their expertise and guidance to us during the completion of this project.

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References

Funkenstein, Daniel H. (1955) "15. The Physiology Of Fear And Anger." *Psychopathology*.

Iyendo, Timothy Onosahwo. (2016)"Exploring the effect of sound and music on health in hospital settings: A narrative review." *International Journal of Nursing Studies* 63: 82-100.

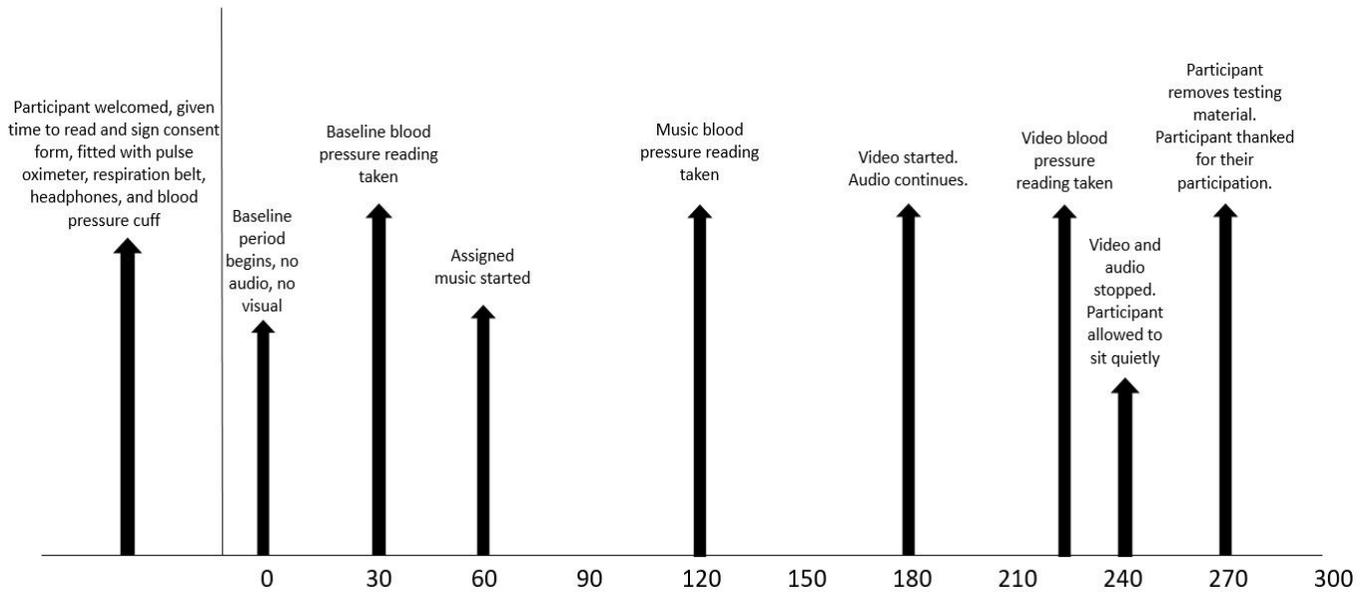
Roux, F. H. Le, P. J. D. Bouic, and M. M. Bester. "The Effect of Bach's Magnificat on Emotions, Immune, and Endocrine Parameters During Physiotherapy Treatment of Patients with Infectious Lung Conditions." *Journal of Music Therapy* 44.2 (2007): 156-68.

Sinha, R., W. R. Lovallo, and O. A. Parsons. "Cardiovascular differentiation of emotions." *Psychosomatic Medicine* 54.4 (1992): 422-35.

Steimer, Thierry. (2002) "The Biology of Fear- and Anxiety-Related Behaviors." *Dialogues in Clinical Neuroscience* 4.3: 231–249.

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## Figures

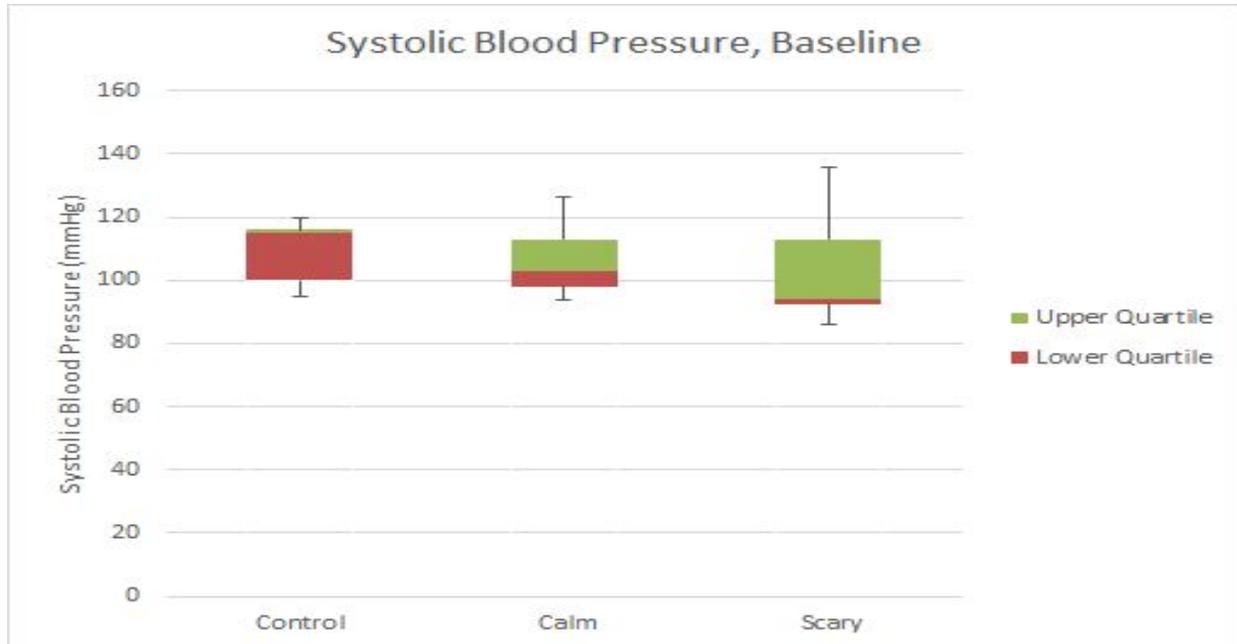


**Figure 1.** Timeline for the experiment.

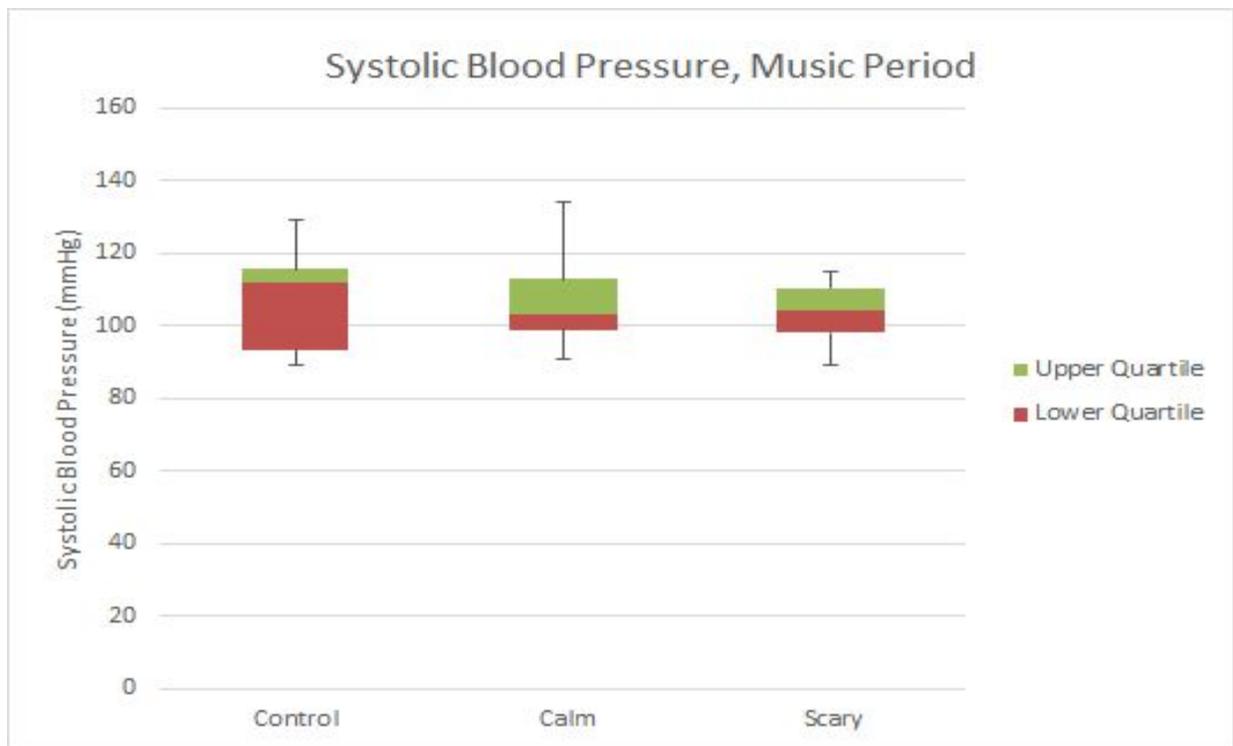


**Figure 2.** Enlargement of Biopac respiration data demonstrating how peak to peak data was obtained by software to determine average breaths per minute for each period--baseline, audio only, and audio-video paired--of the experiment.

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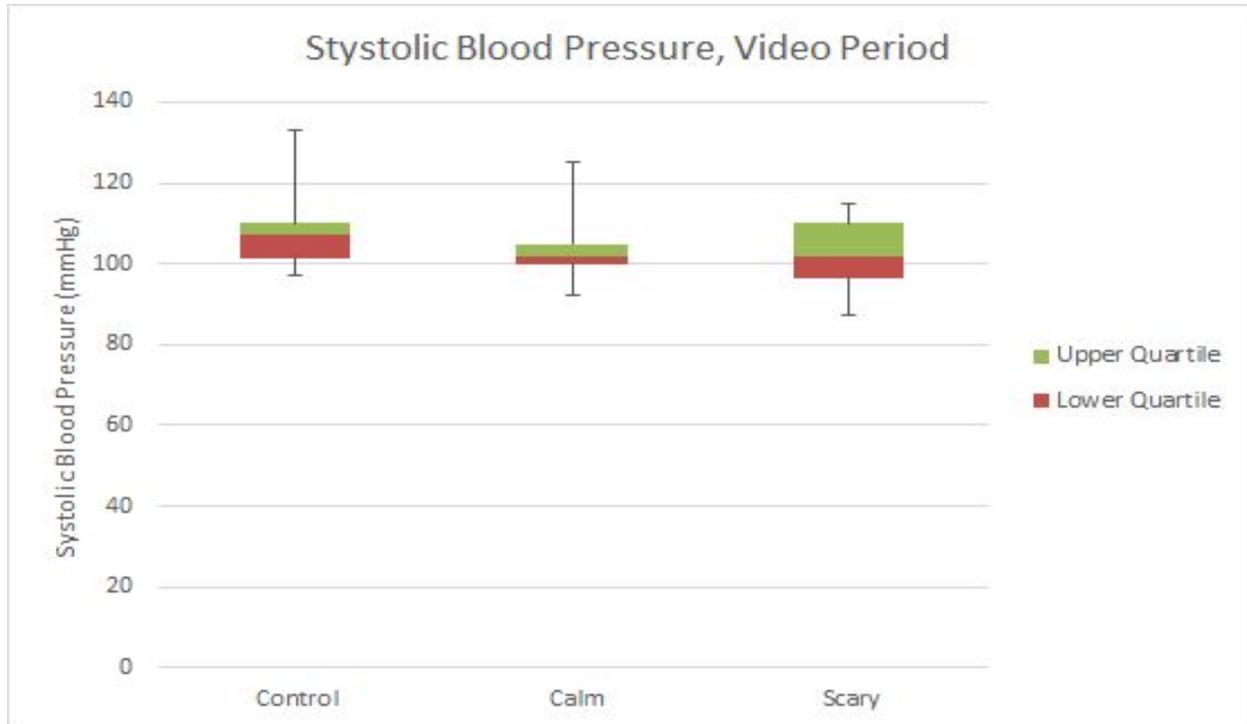


**Figure 3A.** Systolic blood pressure during the baseline period. Measurements taken while participant sat quietly without added auditory or visual stimuli. The division between the upper quartile and lower quartile represents the mean of the data.

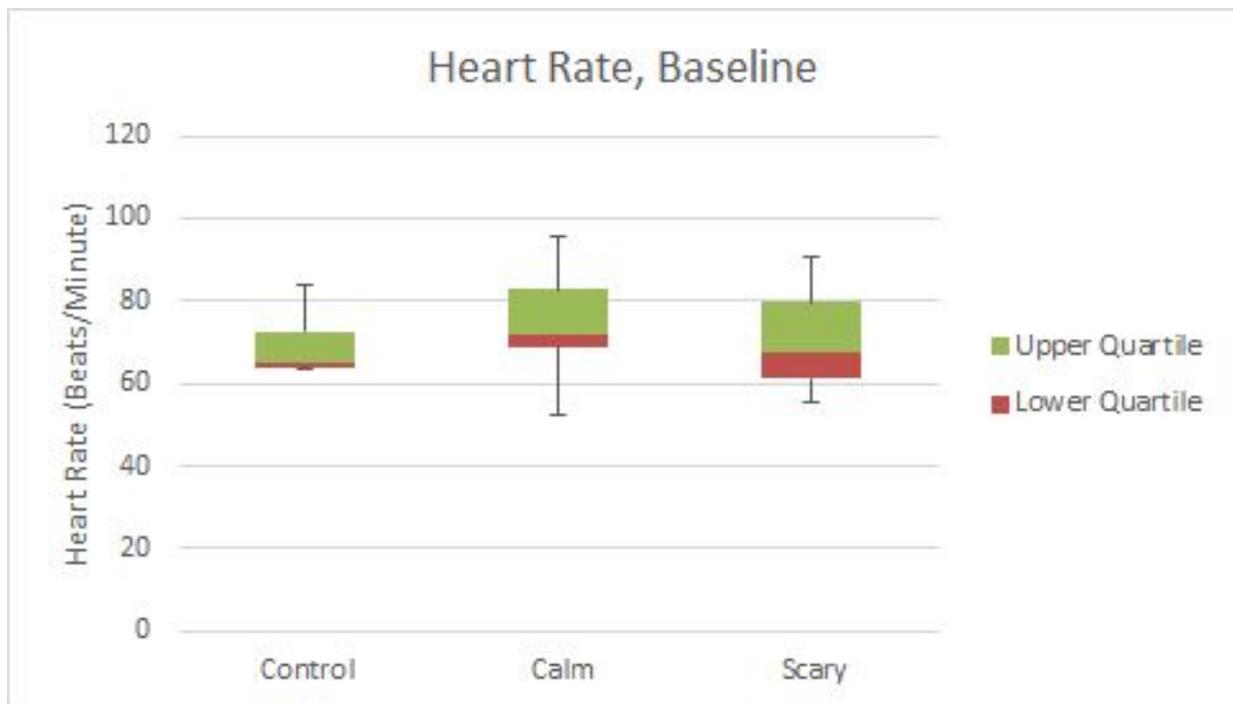


**Figure 3B.** Systolic blood pressure over time during the music period.

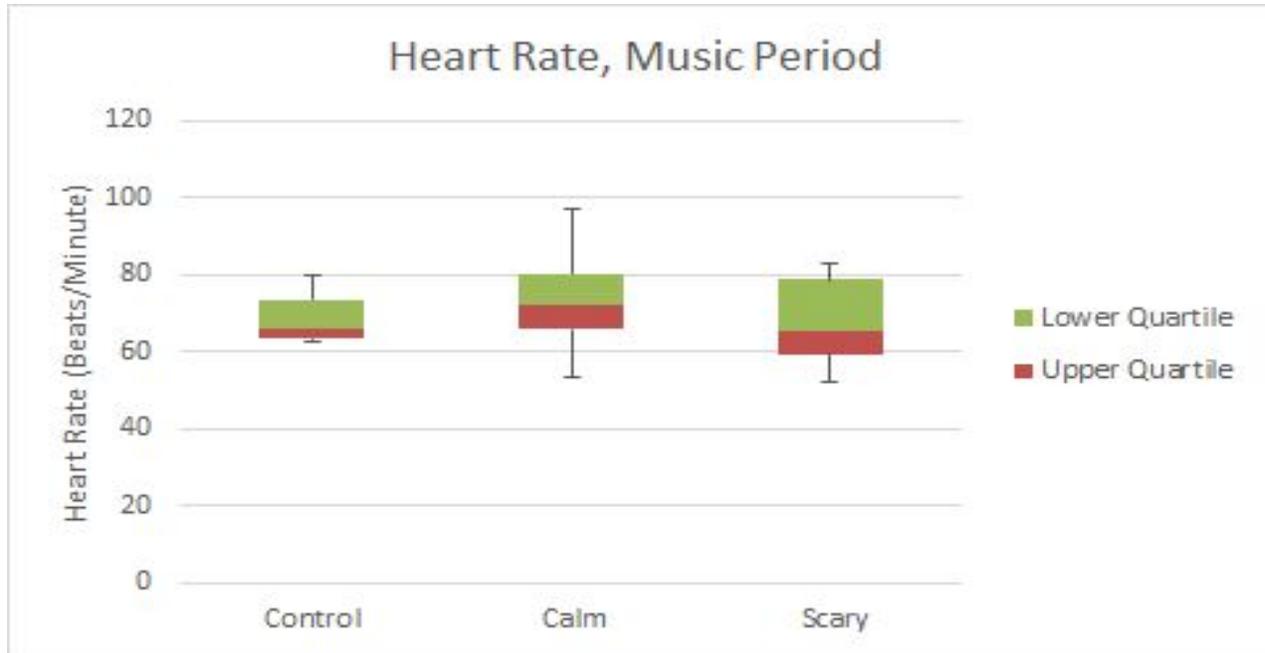
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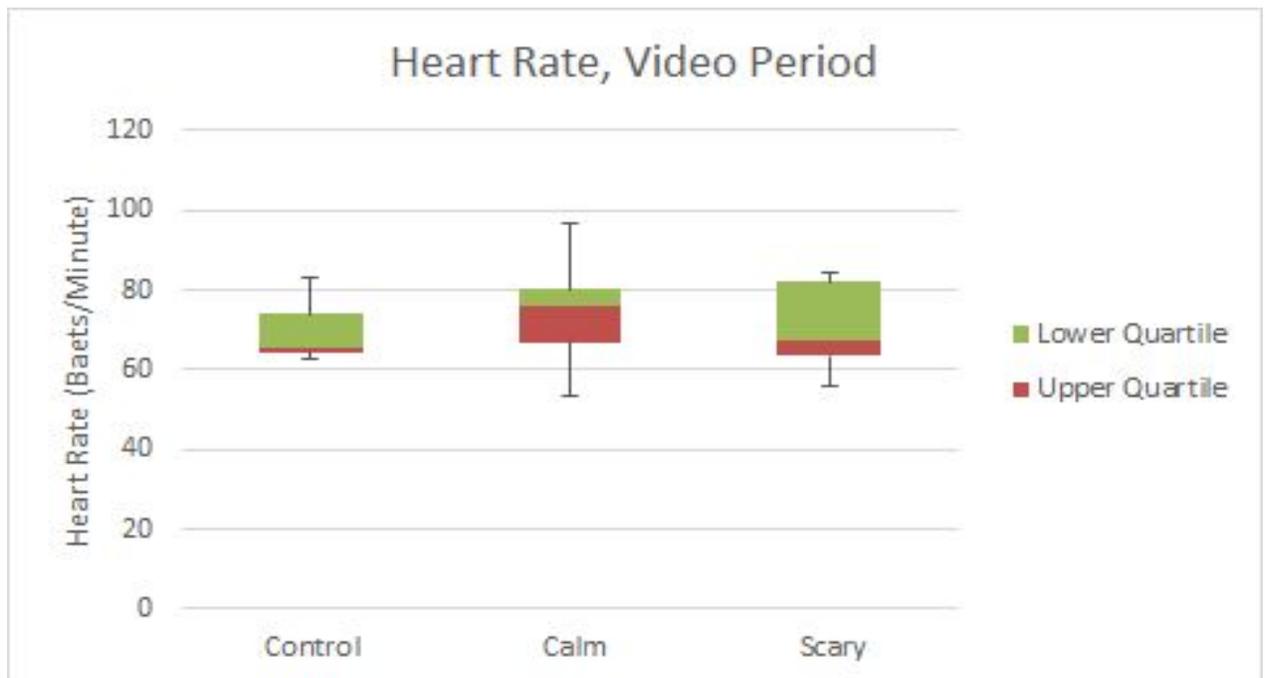
**Figure 3C.** Systolic blood pressure over time during the video and music paired period.



**Figure 4A.** Heart rate over time during the baseline period.

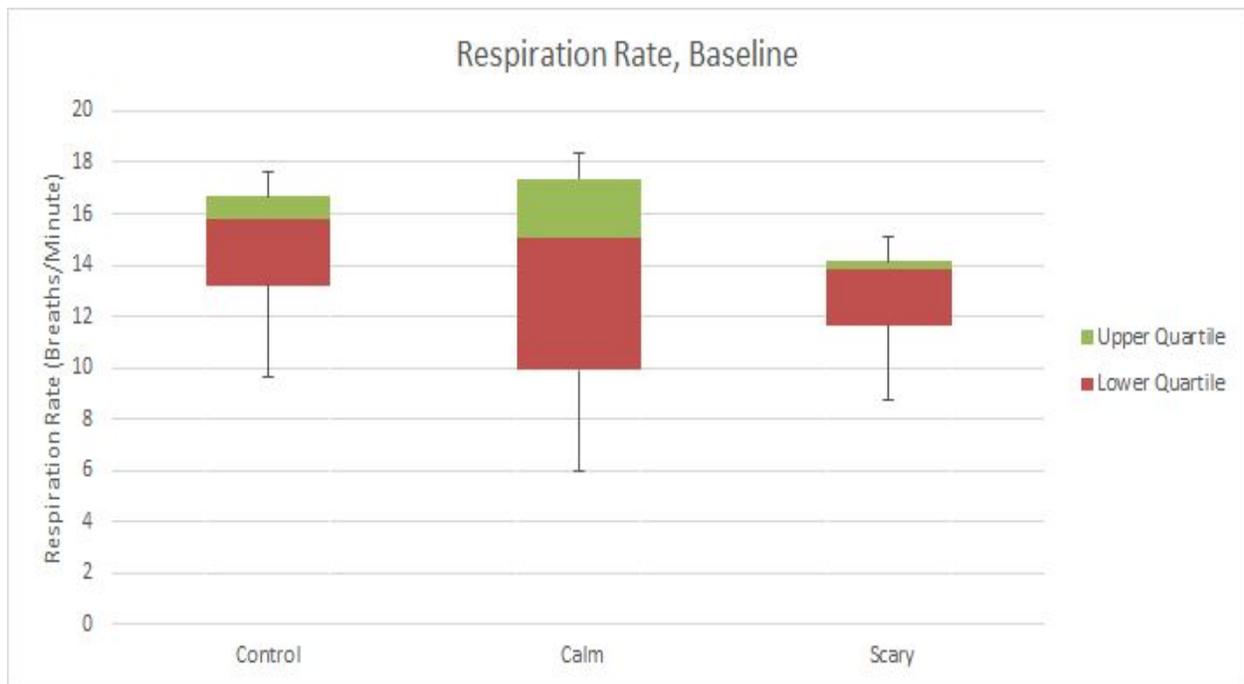


**Figure 4A.** Heart rate over time during the music period.

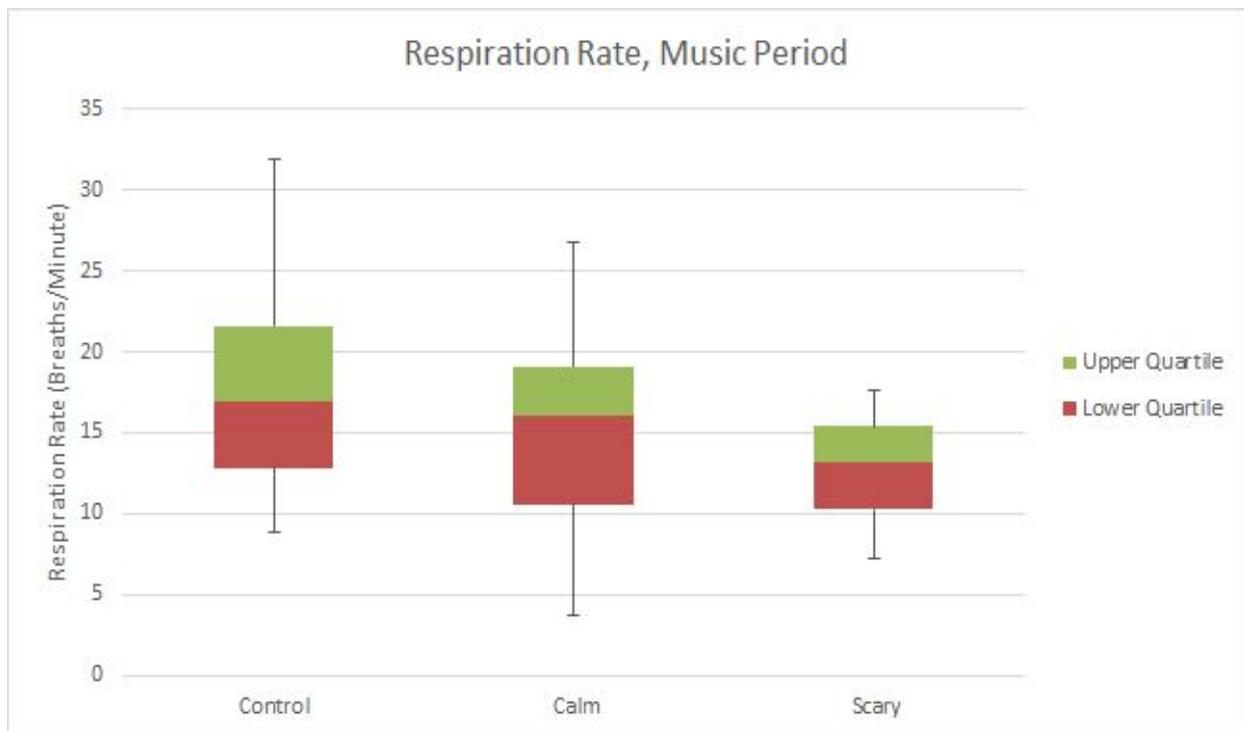


**Figure 4C.** Heart rate over time during the video and music paired period.

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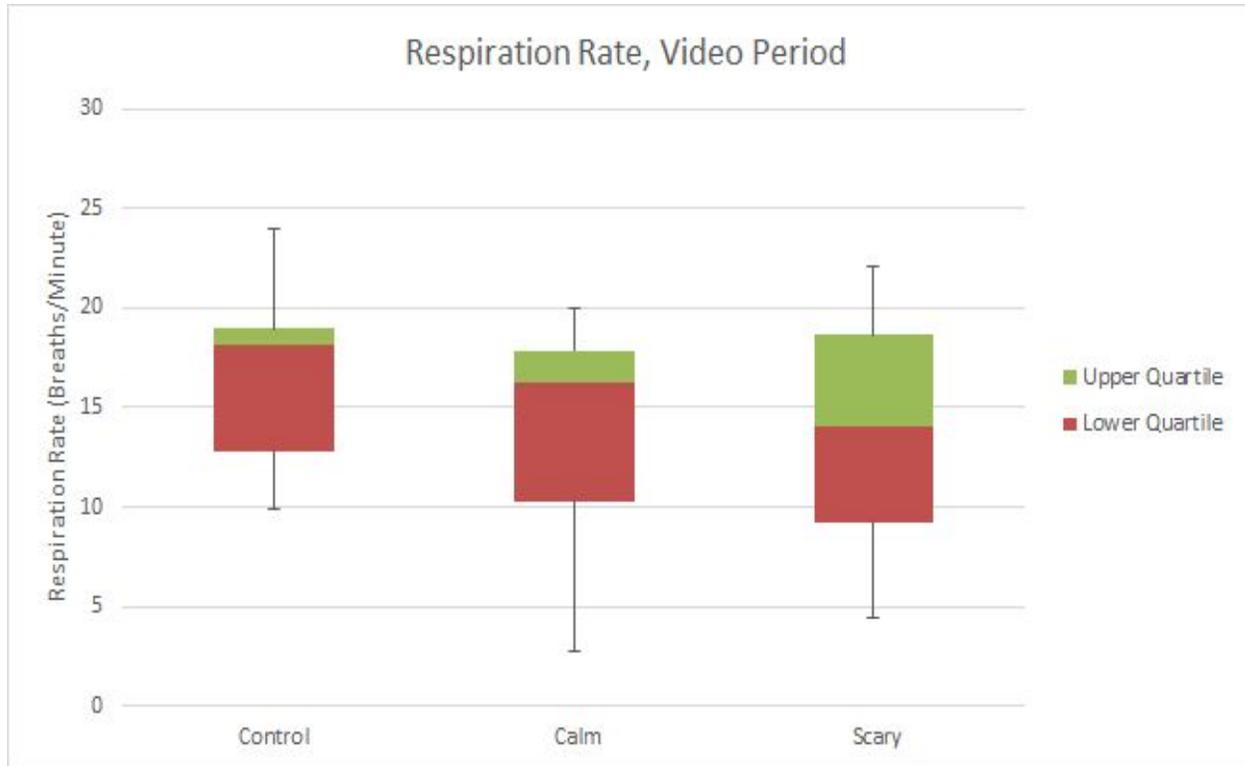


**Figure 5A.** Respiration rate over time during the baseline period.



**Figure 5B.** Respiration rate over time during the music period.

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**Figure 5.** Respiration rate over time during the music and video paired period.