The Effect Of a Minor Stressor with Varying Auditory Stimuli on Physiological Response

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Abstract

College students experience high levels of stress relating to classes, exams, and personal conflicts. Persistent high levels of stress can lead to adverse health outcomes such as mental illness or digestive system complications. Many students use music as a method to cope with stressful situations and anxiety levels, but also as a supplementary studying device. Past research studies have established that high tempoed music, such as that heard in pop music, resulted in increased physiological response and slow tempos heard in classical music, resulted in a decreased physiological response. The purpose of the present study was to determine whether varying genres of music affected the the physiological response of experimental participants after the induction of a minor stressor. All participants were asked to perform a three minute word search in four different experimental groups. Two groups received classical or pop music as the auditory stimulus and a minor stressor, another group received no auditory stimulus, but a minor stressor, and the last group received no auditory stimulus and no stressor. We hypothesized that individuals who listened to pop music would experience a larger positive increase in heart rate, diastolic blood pressure, systolic blood pressure, and respiration rate compared to classical music. Our results showed that exposure to pop music lead to a heightened physiological stress response based on higher systolic and diastolic blood pressures in reference to baseline. Classical auditory stimulus had little effect in response to the stressor. Despite the statistically significant physiological response in participants, music played no noticeable role on task performance between treatment groups.

Introduction

A stressful stimulus is categorized as any perceived threat to the body or overall welfare and includes major life events, trauma, and abuse. The physiological response to stress varies between individuals and is largely determined by two factors: the way a person identifies a potentially stressful event and a person's state of physical health (McEwen, 1998). Upon the induction of a stressor, the autonomic nervous system is activated, as well as the hypothalamo-pituitary-adrenal axis, which releases hormones that produce a distinct physiological response (McEwen, 2007). During a stressful event, the brain acts as a command center to interpret the stimulus and produce an appropriate response. In this way, the mechanisms of response produced by the brain are similar regardless of the stressful stimulus, but the

magnitude of response may vary (Selye, 1950). Although the magnitude of response fluctuates, the actions of the endocrine system are always required to elicit a physiological response.

The endocrine system responds to a stressful event by increasing the amount of plasma cortisol through activation of the pituitary-adrenal axis. Cortisol is a hormone that is critical to maintaining homeostasis during a stressor and does so by causing global changes to the body including increased blood glucose, decreased intestinal activity, reduced immune response, and increased brain function (Cacioppo et. al, 1998). In addition to cortisol, vasopressin and catecholamines, such as epinephrine and norepinephrine are also released in response to stressful stimuli. Vasopressin acts to increase the release of adrenocorticotropic hormone (ACTH) from the anterior pituitary gland, which increases the release of cortisol into the blood, but also causes vasoconstriction, increasing blood pressure. The activation of corticotropes work in conjunction with cortisol to increase the release of catecholamines, leading to increased cardiac output, skeletal muscle blood flow, and glucose release (Ranabir & Reetu, 2011).

These physiological responses are common in college students experiencing high levels of stress relating to exams, grades, and future plans. This stress can manifest in one or more of the following: emotional distress such as depression or anxiety; digestive system problems; elevated blood pressure, rapid heartbeat, and respiration. Persistent high levels of stress can cause chronic elevations in any of these variables, causing detrimental effects to an individual's physical and emotional health (Brawner, 2016). This leads to a need for constructive strategies to manage daily stress levels for students. Many methods for stress management require time or money, such as meditation or yoga. A short-term method that has been proposed to decrease

levels of stress in students is musical therapy, or the act of listening to music (Linnemann et. al, 2015).

Music is often used as a method to control emotions and reduce the arousal of individuals in stressful situations (Standley, 1986). Many students use music as a method of relaxation, especially while studying for classes and exams. Although students often use music as a way to relax, many do not understand the physiological response that music can induce. Music has the capacity to initiate many cognitive processes within the brain, causing varying emotions (Thoma et. al, 2013). Individuals have varying conscious reactions or preferences to different genres of music, but evidence suggests that physiological responses such as heart rate and respiratory rates increase with faster tempo music, no matter how the individual feels about the music genre (Bernardi, 2006). A specific study found that music with lower tempos produced lower heart rate, systolic and diastolic blood pressure, and respiration rate compared to more upbeat, excitative music (Iwanaga, 1999). These findings suggest that lower tempo music, such as classical music may have a stress-reducing effect in relation to task performance.

It has been found in experimental conditions that do not pertain to stressful events, that lower tempo music can decrease physiological variables such as heart rate, blood pressure, and respiration rate. Nonetheless, it is unclear how varying genres of music can affect these variables in stressful conditions. Previous investigations have found a reduction in perceived levels of stress, increases in the ability to cope, and altered levels of relaxation after listening to music in a stressful context (Thoma et. al, 2013). A study conducted by Linnemann and coauthors (2015) emphasized the ability for music to lower subjective stress levels, but not necessarily

physiological stress variables. These varying results have caused inconsistencies in whether music has stress-reducing functions or not.

The goal of this study is to determine the effect that different genres of music have on the physiological responses of participants while subject to a stressful stimulus during a word-search task. In this study, the two different genres of music are classical music or top 40's hits pop music, both listened to for three minutes. The physiological response experienced by subjects may have implications in the effects of listening to certain types of music while doing thought-intensive tasks, such as studying. We expect to find that those listening to pop music will experience a greater increase in physiological responses such as heart rate, blood pressure, and respiration rate compared to subjects listening to classical music. Therefore, we hypothesize that participants who listen to pop music will experience a larger positive change from baseline measurements compared to participants who listen to classical music.

Materials and Methods

Participants

The study tested thirty-six participants who were enrolled in Physiology 435 at the University of Wisconsin-Madison during the spring 2017 semester. Of the thirty-six participants, 17 were male and 19 were female. After signing a consent form, each subject was randomly assigned an identification letter (A-D) to ensure confidentiality.

Procedure

Individuals were randomly assigned to treatment groups A, B, C, or D through a website entitled *Random Number Generator* (2017). Participants in group A and B were instructed to sit

calmly and quietly in a chair and then complete an elementary animal word search (**Figure 7**) from *Livewire Puzzle* (2006). Prior to administration of the word search, a minor stressor was induced in which the subject was informed that they would be ranked among other participants based on how many words were found, and that most subjects found the majority of words. The participants were allotted three minutes to complete the word search while heart rate, blood pressure, and respiration rate were measured. Participants in group A listened to the pop song, "Can't Stop the Feeling" by Justin Timberlake (2016), while participants in group B listened to the classical song, "River Flows in You" by Yiruma (2001). Individuals were not informed beforehand which musical genre they would be hearing. Musical stimulus was played for the full three minute duration while respiratory rate, heart rate, and blood pressure were measured once every sixty seconds. Changes in these physiological variables over time would be an indicator that the given musical genre might have an impact on the subjects' performance.

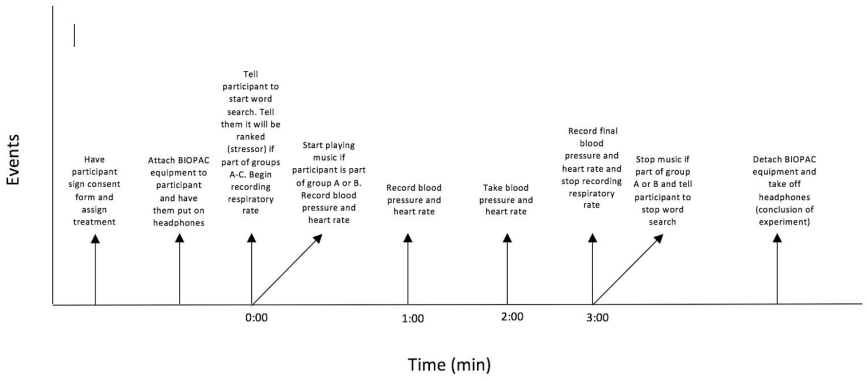

Fig 1. Timeline and procedure for recording data. Respiratory rate is measured continuously, with blood pressure and heart rate being recorded every 60 seconds.

A positive control was established by assigning five subjects to determine a reference physiological response to the minor stressor. Participants in group C were instructed to sit calmly

and quietly in a chair and then complete the elementary animal word search **(Figure 7)**, similar to groups A and B. Group C received a verbal stressor explaining that they would be ranked among their peers for the their performance in the word search, but completed the word search in the absence of the musical stimulus. These subjects were expected to have lower measurements for heart rate, blood pressure, and respiratory rate compared to experimental group A, and higher physiological measurements compared to experimental group B and the negative control measurements.

A negative control was established by assigning five subjects to a subgroup to determine baseline values of the physiological variables without the verbal stressor or the musical stimulus. Participants in group D were instructed to sit calmly and quietly in a chair and then complete the elementary-level animal word search **(Figure 7)**. Unlike groups A, B, and C, group D did not receive the minor stressor or the musical stimulus. Because of this, the negative control group was not expected to show any noticeable changes in heart rate, blood pressure, or respiratory rate. This data was used as a baseline measurement to compare results from experimental groups A, B, and C. Due to time constraints, it was not possible to test another control group that received a musical stimulus, but no verbal stressor. This group would be important to have in future research relating to the physiological responses relating to music to fully understand the stimuli's ability to diminish a stressful response.

Equipment

The music was played on wireless Beats Solo 2 headphones (FL6S58V3GH84) at a volume of 11 bars on an iPhone 7 (C77SKH0RHG7K) for three minutes while physiological variables were measured. To measure respiratory rate, the study used a BIOPAC Respiratory

Transducer (SS5LB), manufactured in Goleta, CA by BIOPAC Systems Inc. Participants placed the device around the chest at sternum level. Breaths per minute were used as a unit for respiratory rate; this was measured by analyzing peak to peak on the BIOPAC program's respiratory graph, which represented one full breath. Using this data for one breath, the average value for breaths per minute was taken from the BIOPAC Student Lab 4.0 Program. The participant had the device attached throughout the study in order to obtain continuous data.

A Nonin Pulse Oximeter (model 9843), manufactured in Plymouth, MN by Nonin Medical Inc. was used to measure heart rate. The device clipped onto the non-dominant finger of the participant and remained attached throughout the duration of the study. This provided continuous data of heart rate. The study used beats per minute as the unit of measurement for heart rate.

The last device used was a BIOPAC Blood Pressure Cuff (SS19L/LA), manufactured in Goleta, CA by BIOPAC Systems Inc. This device was used to measure blood pressure in mmHg throughout the study. Each physiological variable was recorded four times throughout the study, once before the minor stressor was induced and musical stimulus administered, then three times during the study at sixty second intervals.

Data Analysis

The study used a within-subject design to compare data in reference to each individual's baseline. To analyze the data each measurement was subtracted from the individual's first reading to get a value that showed how far away the participant was from baseline. Averages were then compiled from this data for each physiological variable at the three time frames (one

minute, two minutes, and three minutes). After the average change in heart rate, systolic blood pressure, diastolic blood pressure, and respiratory rate was calculated at each time frame, four linear figures were created to compare the physiological response results between the genres of music and control groups. These graphs were created for both the classical music study and the pop music study. Another figure analyzed the effects of gender, musical genre, and control group on words found in the word search. To produce these figures, the average amount of words found in the word search were taken between these three different groups, the participants being separated by gender and experimental manipulation.

To compare changes in the physiological variables between the four different groups of participants, ANOVA tests were used as statistical analysis. Each of the four physiological variables underwent separate two-way ANOVA analysis because heart rate, blood pressure, and respiratory rate represent three different dependent variables. Within a specific two-way ANOVA test, the two independent variables or factors that were analyzed in relation to the three dependent variables were the genre of music the participant received (or no music) and whether the participant received a minor stressor or not. This statistical method was used because it allowed for the analysis of each independent variable's effect on the dependent variable, but also analyzed the interaction of the two independent variables in relation to the particular dependent variable. To determine whether the results of the experiment were significant or not, the p-value was evaluated; a low p-value (≤ 0.05) suggested that different music genres do provoke varying physiological responses. A two sample t-test was used to analyze the performance of the experimental treatment groups A and B to determine if a specific music genre altered task performance.

Results

Data was analyzed using the program *R*. A two-population t-test between the classical music and pop music assuming unequal variance was performed at an alpha-level of 0.05. To compare the amount of words found, an ANOVA test, alpha level .05, was run between groups to see if the physiological changes had any effects on working memory.

Heart Rate Variations

Each participant had their heart rate measured four times throughout the experimental study: once for a baseline measurement, one minute into the study, two minutes into the study, and finally three minutes into the study. As seen in **Figure 2**, participants who listened to pop music throughout the experiment experienced a decrease in heart rate while those who listened to classical music did not experience a change in heart rate. Both the negative and positive control groups experienced an increase followed by a decrease in heart rate throughout the experiment. For all of these experimental groups, the average heart rate at the three experimental points (all those excluding baseline measurements) were taken and placed into a graphical representation. Although there was a deviance in heart rate depending on the type of music the participant was listening to, there was a slight noticeable change, but no statistical significance was detected ($p=0.1286$).

Diastolic Blood Pressure Variations

The changes in diastolic blood pressure were most noticeable in participants in the pop music experimental group: there was an initial gradual decline in blood pressure followed by a drastic drop midway through the experiment (at 1.5 minutes). **Figure 3** shows that the participants who were listening to classical music experienced no significant changes in diastolic blood pressure throughout the experiment, visible in the decreased slope of the line. The positive and negative control groups experienced an initial slight decrease followed by a large increase in diastolic blood pressure. Data collected for diastolic blood pressure variation was determined to be significant ($p=0.03136$). This suggests that pop music may cause elevated diastolic blood pressure under stressful situations, compared to other genres of music or no music at all.

Systolic Blood Pressure Variations

Changes in systolic blood pressure followed similar patterns as those seen in the diastolic blood pressure results. However, more drastic fluctuations were seen in the classical music group in this measurement than in the diastolic blood pressure measurements. The participants in the classical music experimental group stimulation experienced, on average, a large decrease followed by a gradual but steady increase in systolic blood pressure throughout the study. **Figure 4** depicts that both the positive and negative control groups had an initial decline followed by a rise in systolic blood pressure. The pop music experimental group showed a relatively constant reading of systolic blood pressure until halfway through the experiment (two minutes into the study) where there was a drastic decline in systolic blood pressure experienced by the participants on average. The results supported this trend in the changes of systolic blood pressure and was determined to be statistically significant ($p=0.0348$). This suggests that pop music is

acting to increase systolic blood pressure while classical music lowers systolic blood pressure in reference to baseline physiological measures under stressful situations.

Respiratory Rate Variations

All experimental groups measured, including both the negative and positive control groups showed elevated respiration rate throughout the duration of the study. Although all treatments showed elevated respiration, over time respiration decreased towards baseline for each of the treatment excluding pop music (**Figure 5**). It appears that pop music showed elevated respiration rate, however this data was determined to not be statistically significant ($p=0.3774$), preventing the conclusion that it was from a different population than the other experimental manipulations.

Word Search Test Results

As seen, **figure 6** depicts the average number of words that each participant was able to find in the word search, separated by gender, music genre, or no music. On average, the participants in the positive control group found 9.6 words, while those in the negative control group found 10 words. Participants who listened to classical music while completing the word search found an average of 9.15 words while those who listened to pop music identified 9.8 words on average. The data was further split by the gender of the participants to account for any performance differences between the two genders. On average, males found 9.29 words and female participants found 9.84 words. The data differentiating the performance of participants in regard to the genre of music they listened to showed a p-value greater than 0.99 for an ANOVA test at 95% confidence, therefore, this data fails to reject the null and is considered insignificant.

Discussion

This study provided insight into our understanding of stress and music. From the results, there is varying evidence to support the initial hypothesis that popular music leads to elevation of physiological conditions while classical will lead to lower blood pressure, respiration rate, and heart rate.

Analysis of the Stressors Influence on Physiological State

The negative and positive controls were used to analyze the extent of the stressors influence on participants, as well as observe the effects the word seach alone had on physiological response. It appears the results paralleled what was expected, with the stressor causing a induced elevated physiological response without music present. Respiration rate and heart rate were both higher within the positive control group than the negative. This shows us that our stressor acted to induce a physiologically stressed state as described previously. With that in mind, the study can then correlate any further elevation, or depression of these unit towards the stimulus. Curiously, the stressor seemed to have little effect on blood pressure. Both systolic and diastolic blood pressure throughout the study remained consistently close between negative and positive control groups. This would suggest that our induced stressor did not physiologically alter blood pressure (McEwen, 2007). However, it seems that the act of performing a timed word search test induced a stress response on its own. The final blood pressure readings in both positive and negative controls groups were elevated, which could have been from a heightened state from the participant attempting to find words before the timer ended.

Elevated Respiration Rate Cross-Treatments

To begin, respiration rate measurements showed a collective elevation between all treatment groups throughout the study. Pop music in particular had higher measurements relative to baseline than the the other treatment groups. The cross-treatment elevation of respiratory rate cannot be attributed to either the initial stressor or music type since both the negative and positive control groups exhibited elevations. Therefore, it is challenging to assess the degree to which pop music influences respiratory rate elevation. The elevated respiration could be attributed to either systematic effects or inaccurate device readings (Linnemann, 2015). Since the actual application of the respiration belt causes discomfort the participants may become aware of their breathing which would induce increased respiration. Further studies could look into the effects of using respiration equipment to see if there are significant changes in breathing.

Pop Music and its Physiological Responses

After analysis of the data, the results show that pop music does lead to a prolonged, slight elevation in physiological response post-stressor. All four of the units observed showed noticeable elevation for pop music compared to the three other treatment. Two of those, systolic and diastolic blood pressure, are statistically significant with p-values of 0.0348 and 0.03136, respectively. Thus it is believed that pop music might prevent adaption to a stressor, and may prolong physiological responses to stress. This finding could help those with anxiety or those who respond negatively to stress. If popular, fast tempoed music propagates elevated physiological conditions, than those who suffer from stress could avoid such music.

Popular music at fast tempos could be acting biologically to influence participants response to stress. Under classical or no stimulus the body is able to focus on the stressor in order to “cope” and adapt. The data suggests that popular music acts uniquely by an unknown mechanism that

hinders the brain's ability to send sympathetic signals throughout the body (Bernardi, 2009). In particular it seems to limit the bodies ability to respond to blood pressure. Further studies could look into the biological systems behind this blood pressure elevation in correlation with pop music post-stressor to gain a better understanding of stress mechanisms.

Classical Music and its Physiological Responses

The results show that classical music does not lead to a clear decreased physiological response after exposure to a stressor. Systolic blood pressure was the only physiological unit tested that showed a significant decrease in response to classical music in comparison to baseline, with a p-value of 0.038. It was believed that participants exposed to classical music would express a lessened physiological response compared to participants in the positive control that were not exposed to music; however, the results show that there is no significant physiological difference in length of stress response between participants exposed to classical music and participants exposed to no music, except for systolic blood pressure. Based on this conclusion, it is believed that classical music can be used as a better alternative to pop music in stressful situations because classical music does not lead to the prolonged stress response that pop music did.

The Influence of Music on Word Search Performance

The effects of music seemed to influence individual physiological characteristics, however, those changes elicited no significant influence on performance during the word search. The ANOVA test concluded that there was no statistical significance between treatment groups, with a p-value >.99. Even when comparing the data separated by gender, there was no indication that any of the treatment groups would be from a different population. Ultimately, this would

suggest that music in no way influences performance on sustained attention tasks under stressful conditions. Further studies should look at the influence of stress on memory and performance tasks. A greater understanding of stressful actions on higher cognitive abilities can be used to maximize performance whether in a classroom or workroom environment. Further studies could use higher cognitive processing tests such as a challenging math tests to better understand if music alters cognition (Palmer, 2007).

Analysis of Time Allocation

As previously reported, the study was projected to analyze each participant over the course of three minutes. The analysis of data ended up being much longer than anticipated. In particular respiration rate was difficult to calculate given the amount of data manipulation that had to be done in Biopack Student Lab. This in turn lead to each participant's data collection to take approximately 10 minutes. This should be kept in mind for future studies when using respiration belts in conjunction with Biopac Student Lab.

Conclusion

In conclusion, music does seem to have a statistically significant influence on physiological states, however, the change is not large enough to affect performance during a word search. Pop music stimulus in particular showed a noticeable increased physiological state, especially for systolic and diastolic blood pressure. Classical music stimulus post-stressor showed systolic and diastolic blood pressure decrease in respect to baseline; although not significant, this noticeable trend could be looked at in further studies. Ultimately the physiological effects of music didn't influence word search performance. In particular, the increased physiological effects caused by pop music after a stressor was not strong enough to alter sustained attention and cognition used

in a word search. Further studies could potentially use a stronger stressor to assess the influence of music on lowering physiological effects post stressor.

Figures and Charts

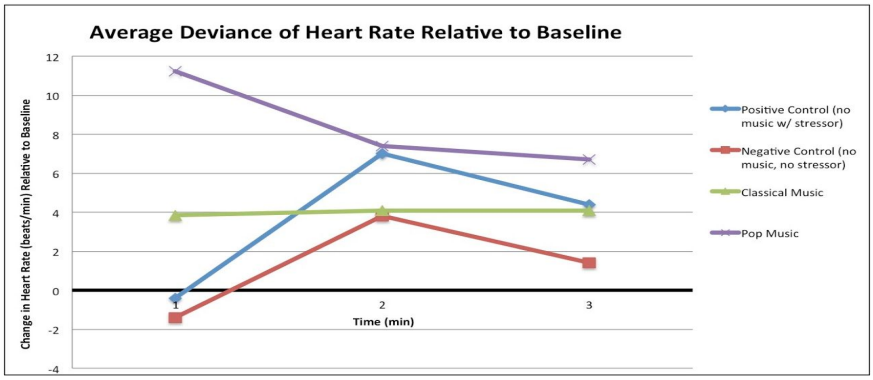

Figure 2 This graph shows the average deviance of heart rate relative to baseline. Each line represents a treatment as labelled. The x-axis measures time in minutes with data collected each minute. The y-axis is average change in heart rate relative to baseline

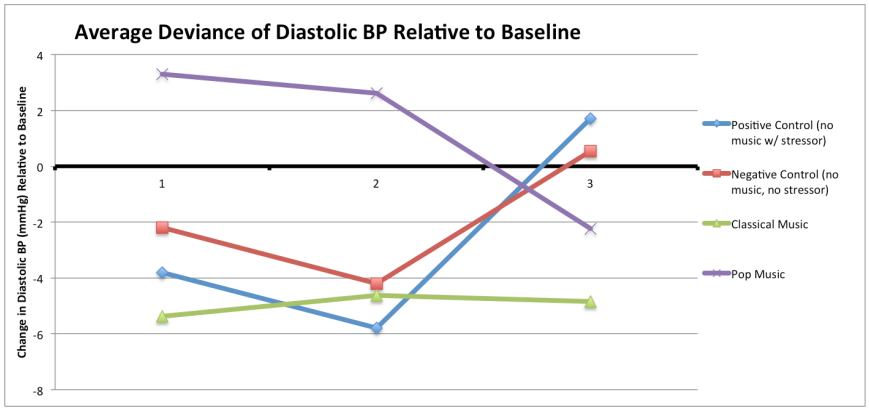

Figure 3 This graph depicts the changes in diastolic blood pressure experienced by each experimental group. Each line is a treatment as labelled with the x-axis as time and the y-axis the change in BP over time relative to baseline.

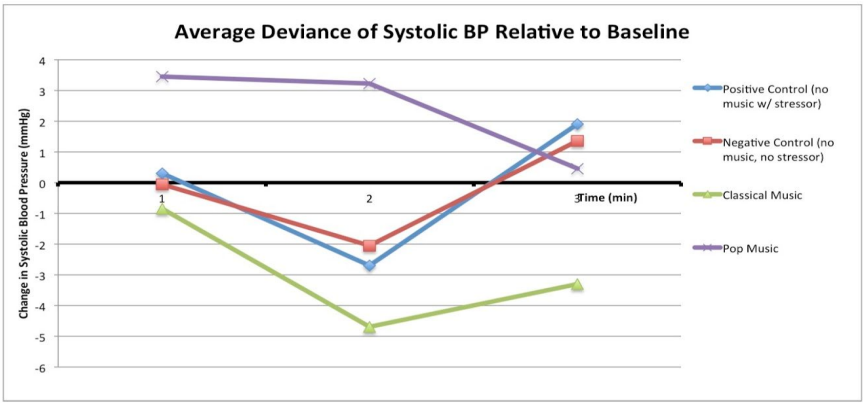

Figure 4 This graph shows the average deviance of systolic blood pressure experienced by each group throughout the duration of the experiment. Each line represents a group while with the x-axis showing time in minutes and the y-axis depicting change BP relative to baseline.

Figure 5 Image depicts the the average change in respiration rate relative to baseline of each treatment group over the 3 minute span of the study.

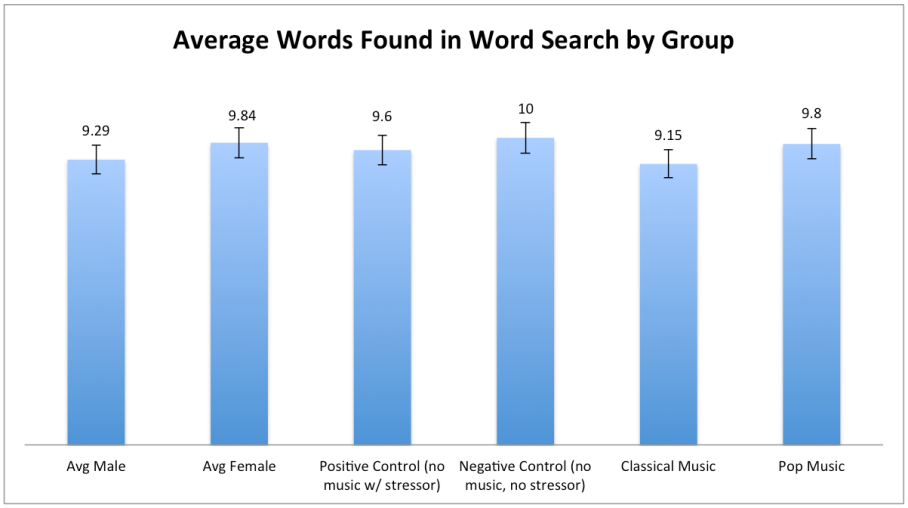

Figure 6 Average words found between treatment groups and between genders. The numbers represent words found within the word search.

Free Printable Word Search Puzzles

Animals 1

Find and circle all of the animals that are hidden in the grid.
The remaining letters spell the name of an additional animal.

A K Y E K N O D P M B I S O N E F O X
T E W I P R B E A R O T A G I L L A T
O S W A I A L V U L T U R E N A W S U
R I U C H I N C H I L L A M A G G P O
T H C M C T W T B B N R E E D N I E R
O S A A A N O O H A A E L K T I P A T
I I N R M T E R O E R B V A C T O C R
S F E W E O O N R D R R O A W H T O N
E Y A C A T O P I A P G A O R G T C E
V L G O D C S S O R P E R C N I E K R
O L L B O C A M E P E C C H U N R O W
D E E R W A O M A Z P V S K R D A L J
N J S A L M O N N H D I L E E D A I A
O O L G A E C A F R F O H O R R D O C
O K I U R L P E A D H P T U W M I N K
C C A O K M R P R T O I N N O R E H A
C E U C I R O O O G G N Y E K R U T L
A G Q H E E W L I E E K R A V D R A A
R L C T L S S E R R P O R C U P I N E

AARDVARK	DONKEY	HIPPOPOTAMUS	OTTER	SALMON
ALLIGATOR	DOVE	JACKAL	PANTHER	SLOTH
BABOON	EAGLE	JELLYFISH	PARROT	SWAN
BARRACUDA	ELK	KIWI	PEACOCK	SWORDFISH
BEAR	FERRET	LEOPARD	PELICAN	TIGER
BISON	FOX	LION	PIG	TORTOISE
CAMEL	GECKO	LLAMA	PORCUPINE	TROUT
CHIMPANZEE	GOAT	MACAW	QUAIL	TURKEY
CHINCHILLA	GOPHER	MEADOWLARK	RACCOON	VULTURE
COBRA	HAMSTER	MINK	RAVEN	WOLVERINE
COUGAR	HAWK	MOOSE	REINDEER	WOODPECKER
CROW	HERON	NIGHTINGALE	ROADRUNNER	WREN

Did you enjoy this puzzle? Visit: http://www.puzzles.ca/wordsearch.html

Fig 6 The word search used within the study.

Data Collection of Music Analysis							# of crosswords found
			Pre Music/Post Stressor	Music			
Participant	Treatment	Timestamp	0:00	1:00	2:00	3:00	
Example	Classical/Pop	Heart Rate (Beats/Min)	x	x	x	x	
		Blood Pressure (mmHg)	x	x		x	
		Respiratory Rate (Breaths/min)	x	x	x	x	
1M	Classical	Heart Rate (Beats/Min)	96	98	97	96	20
		Blood Pressure (mmHg)	126/80	123/69	120/70	121/73	
		Respiratory Rate (Breaths/min)	10.3	16.2	17.1	11.9	
2M	Pop	Heart Rate (Beats/Min)	76	77	72	70	25
		Blood Pressure (mmHg)	110/75	119/77	117/76	123/73	
		Respiratory Rate (Breaths/min)	10.5	16.1	16.1	13.9	
3F	Classical	Heart Rate (Beats/Min)	85	83	85	85	8
		Blood Pressure (mmHg)	109/82	114/67	112/70	112/75	
		Respiratory Rate (Breaths/min)	14.4	17.6	12.3	12.4	

Chart 1 Visual representation of how data was collect during our study.

Works Cited

Bernardi, L, et. al. (2009). Dynamic Interactions Between Musical, Cardiovascular, and Cerebral Rhythms in Humans. *Circulation* 119: 3171-3180. Retrieved from: http://circ.ahajournals.org/content/119/25/3171.short

Bernardi L, Porta C & Sleight P (2006). Cardiovascular, Cerebrovascular, and Respiratory Changes Induced by Different Types of Music in Musicians and Nonmusicians: The Importance of Silence. *Heart* 92: 445-452. Retrieved from: http://heart.bmj.com/content/92/4/445.short

Brawner J.W. (2016). Does Listening to Music Reduce Stress? *The Science and Practice of Stress*. Retrieved from: https://sites.utexas.edu/stressmanagment2016/expressive/progressive-expressiveness/musical-expressions/

Cacioppo JT, et. al. (1998). Autonomic, Neuroendocrine, and Immune Responses to Psychological Stress: The Reactivity Hypothesis. *Annals of the New York Academy of Sciences* 840: 664–673. Retrieved from: http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1998.tb09605.x/full

Collier R (2011). Stress and Heart Rate Variability. SweetWater Health. *Beat Healthy Journal*. Retrieved from: http://www.sweetwaterhrv.com/documentation/stressandhrv.pdf

Iwanaga M & Moroki Y (1999). Subjective and Physiological Responses to Music Stimuli Controlled Over Activity and Preference. *Journal of Musical Therapy*, 36(1): 26-38. Retrieved from: http://www.chinamusictherapy.org/file/file/doc/Subjective%20and%20Physiological%20

Responses%20to%20Music%20Stimuli%20Controlled%20Over%20Activity%20and%20Preference.pdf

Jeffrey S (1998). Protective and Damaging Effects of Stress Mediators. *The New England Journal of Medicine,* 338: 171-179. Retrieved from: http://www.nejm.org/doi/full/10.1056/NEJM199801153380307

Linnemann A (2015. Music Listening as a Means of Stress Reduction in Daily Life. *Psychoneuroendocrinology,* 60: 82-90. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0306453015002127

Livewire Puzzles (2006). Animals 1. Retrieved from: http://www.puzzles.ca/wordsearch/animals_1.html

McEwen B (2007). Physiology and Neurobiology of Stress and Adaptation: Central Role of the Brain. *American Physiological Society,* 87(3): 873-904. Retrieved from: http://physrev.physiology.org/content/87/3/873.full-text.pdf+html

Myriam V (2013). The Effect of Music on the Human Stress Response. *Public Library of Science,* 8(8): 1-12. Retrieved from: http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0070156&type=printable

Palmer E (2007). Assessment of higher order cognitive skills in undergraduate education. BioMed Central. *BMC Medical Education* 7:29. Retrieved from: http://bmcmededuc.biomedcentral.com/articles/10.1186/1472-6920-7-49

Ranabir S & Reetu K (2011). Stress and Hormones. *Indian Journal of Endocrinology and*

Metabolism, 15(1): 18-22. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3079864/

RandomNumberGenerator.com (2017). Random Number Generator. Retrieved from: http://www.randomnumbergenerator.com

Selye H (1950). Stress and the General Adaptation Syndrome. *The British Medical Journal* 1(4667): 1410–1411. Retrieved form: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2038162/?page=1

Standley J (1986). Music Research in Medical/Dental Treatment: Meta-Analysis and Clinical Applications. *Journal of Musical Therapy*, 23(2): 56-122. Retrieved from: https://academic.oup.com/jmt/article/23/2/56/918708/Music-Research-in-Medical-Dental-Treatment-Meta