The Effect of Language Recognition in Music on Short-Term Memory Recall and Physiological Stress Response

Rebecca Novak, Meghan Moroni, Jacob Des Jardins, XiongMee Vang, Thomas Matoska, Maura Keenan

University of Wisconsin-Madison, Department of Physiology

Physiology 435

Section 301, Group 1

May 8th, 2019

Word Count: 4986

Keywords: English, language, memory, music, retention, short-term, South African

Abstract

Adolescent and young adult students frequently listen to music while studying. While there is extensive research on the effects of music on memory, there is little evidence regarding whether style of music or language recognition is associated with the physiological mechanisms driving memory recall tasks. The objective of this study was to investigate the effects of language recognition in music on short-term memory performance and physiological variables. Participants in the study completed a word search while listening to a song in English, a song performed in native South African dialects, or no music at all. During the word search, heart rate, respiration rate, and skin conductance were recorded in order to assess the physiological response of the participant and their stress response. Immediately after, the participants was asked to recall as many words as they could from the word search as a way to measure short-term memory. Results showed that listening to music in a non-native language has no effect on short-term memory performance or the physiological stress response of the participants when compared to the other two conditions. This suggests that foreign music may not act as a physiological stressor and distraction during a cognitive task. Instead, foreign music may function more as white noise.

Introduction

In preparation for exams, students typically engage with material while listening to music for a variety of reasons, such as aiding in focus, blocking out distractions, or for enjoyment, while building the information into their short-term memory (STM). However, it is likely that they have never considered whether listening to music, as well as the type of music they listen to, benefits or hinders their recall ability. The efficacy of listening to music on memory recall has long been debated in the literature. While some studies found no considerable effect of background music on STM (Jancke and Sandmann, 2010, Sandberg and Harmon, 2003), others reported negative impacts on performance when upbeat music with lyrics, such as rap, was played (Bugter and Carden, 2012, Salame and Baddeley, 1989). In addition, a study that used classical or instrumental music found that the Mozart Effect may occur due to more passive background music, which describes the improvement of STM while performing a mental task (Lehmann, 2017). While several aspects of music, such as tempo, genre, and the presence of lyrics have been repeatedly investigated, few studies have investigated the effects of music in an person's non-native language on STM or physiological response. Listening to music in a person's non-native language is more relevant now than it was in the past as iconic songs in non-English languages, such as Despacito by Luis Fonsi and Daddy Yankee, find their way onto many students' study playlists before exams.

Foreign language music played in the background while learning may be responsible for altering cognitive performance and STM. There may be an irrelevant speech effect in which serial recall ability is gravely impaired when speech sounds are present regardless of language recognition, even if the primary stimulus is provided visually (Longoni et al., 1993). Visually presented material is stored in the articulatory loop system of the phonological loop (Hanley and Bakopoulou, 2003). Spoken stimuli are stored in the phonological loop, which is not dependent on the ability to comprehend the stimulus and thus interferes with the encoding process of the articulatory loop (Salame and Baddeley, 1989). Regardless of consideration for this memory mechanism, there has been immense debate over the exact effects of language recognition in the music on STM recall. One study determined that cognitive performance is significantly impaired while simultaneously listening to a song in one's native language, while there was little impact when listening to a language not understood or recognizable by the participant (Zhang et al., 2009). In contrast, another study found that spoken lyrics in the music, both in native and foreign languages, resulted in a greater percentage of errors made while performing a cognitive task (Salame and Baddeley, 1989). Furthermore, students singing along to a familiar lyrical song, consciously or not, may be another major source of disturbance that can lead to a decrease in cognitive performance. Listening to a familiar vocal song while performing a primary cognitive task could be problematic in detracting from the chain of events involved in information processing (Zhang et al., 2009).

Beyond the articulatory loop system, xenoglossophobia, or the apprehension experienced while speaking, learning, or listening to a foreign language, may also explain the relationship between language in the music and cognitive performance (MacIntyre and Gardner, 1994). This fear is often linked to self-efficacy anxiety, which is an evaluation of one's own confidence or ability to perform a task (Tahmassian and Moghadam, 2011). Even though a person may not be trying to interpret a foreign language, the presence of a foreign language could still induce increased stress and hormonal levels, which could result in impaired STM recall (MacIntyre and Gardner, 1994).

Monitoring changes in physiological responses could provide further insight into the stress felt by people while listening to foreign and native languages, and how STM performance is affected. Increased heart rate, shown to occur while listening to upbeat music (Hyde and Scalapino, 1918), could lead to enhanced memory performance because physiological arousal associated with the music stimulus has been shown to be linked to increased recall of that stimulus (Most et al., 2017). When people are experiencing mental stress, respiratory rate has also been proven to increase significantly (Masaoka and Homma, 1997). Importantly, increased respiratory rate associated with arousal or stress is thought to optimize information processing in the brain (Zelano, 2016), suggesting that a person experiencing stress and increased respiration during a STM task would then exhibit heightened performance. Skin conductance also aids in explaining relationships between music and STM, as it is widely known to increase when a person experiences a stressed emotional state (Villarejo et al., 2012). Based on the knowledge of the physiological role of these three variables in stress, learning, and memory, as well as ideas from other scientific literature previously mentioned, further research is warranted to determine the effect of language recognition in music on STM and physiological stress response. Results have the potential to benefit students in effectively studying and awareness of the effects of foreign-language interpretation on cognitive development.

In this study, our aim was to determine the extent to which language recognition in music affects STM performance and changes in physiological variables associated with stress. To answer this question, measurements of heart rate, respiration rate, skin conductance, and STM performance while engaging in a cognitive task and listening to music were explored. Based on past research, it was hypothesized that if a song in an unfamiliar language is played while a participant completes a memory task, their physiological responses and performance on a STM exercise would differ relative to a control group or set of participants that listened to a song in their native language. Understanding how language recognition in music affects STM recall is crucial to analyzing whether trending study habits are obstructive to memory retention due to the irrelevant speech effect or xenoglossophobia. The utilization of results found in this study can be applied to students' study habits in order to have the most effective STM retention.

Materials

Three physiological variables were measured in this experiment: heart rate (HR), skin conductance, and respiration rate (RR). Data was collected with a standard Dell computer (Model: 45775, Austin, TX) equipped with the Biopac Student Lab System (BSL 4.0, MP36), and measurement devices were setup according to the information provided in the Biopac Systems Inc. Student Manual (Biopac Systems, Inc. ISO: 9001:2008). To measure HR in beats per minute (BPM), a pulse oximeter/carbon dioxide detector (Model: 9843, Ninon Medical, Inc. Minneapolis, MN) was used. Likewise, skin conductance was measured in microsiemens (μS) with an electrode lead set Xder, two BSL electrodermal activity finger electrodes (Model: SS3LA, Biopac Systems, Inc. Goleta, CA), and the isotonic recording electrical gel (Biopac Systems, Inc. Goleta, CA). To measure RR in breaths per minute, a Respiratory Effort Transducer (Model: SS5LB, Biopac Systems, Inc. Goleta, CA) was strapped onto the participant's chest. A single word search (atozteacherstuff.com/word-search-maker) of fifteen common words that range from four to six letters was randomly generated and distributed to all participants (Figure 1). To provide a stress stimulus, an Apple iPhone 6s (Apple, Inc. Cupertino, CA) on 'Do Not Disturb' mode displayed a timer to the participant, counting down from two minutes. While the participant completed the word search, either an Altec Lansing Mini Lifejacket 2 Bluetooth Speaker (Model: IMW477-DR-TA, Oklahoma City, OK) or Apple MacBook Pro (Apple, Inc. Cupertino, CA) was used to play "Sabashiya Abazali, Sabela, Thula Mtanami Medley" (Soweto Gospel Choir, Spotify) or "Middle of the Road" (The Pretenders, Spotify) in accordance with the experimental group to which the participant had been randomly assigned. The music was played using Spotify. No music was played for individuals assigned to the control group. The participant who scored the best on the memory task received a Starbucks gift card.

Methods

Consent and Participants

Students from the University of Wisconsin-Madison Physiology 435 course, ages 20-26, volunteered to participate in this experiment. The participants were from varied educational backgrounds with different study habits and language competencies. Prior to participating and beginning, each student completed the consent form which described the low-risk nature of the ten-minute study (Figure 2). Fifty-one participants were divided into three experimental groups. Randomness came from the order in which participants came in to complete the study. Seventeen students listened to "Middle of the Road" by The Pretenders, a song with English lyrics; Seventeen students listened to "Sabashita Abazali, Sabela, Thula Mtanami Medley", a South African song of multiple native dialects; and seventeen students did not listen to any music. We assigned each participant to their respective treatment by repeating no music, African lyric music, and English lyric music assignments for every three participants totaling fifty-one subjects. Figure 3 describes the demographic makeup of our three respective experimental groups. It is likely that our results were not influenced by the demographic composition of each experimental group since all our participants spoke English as their native language or spoke multiple languages including English. None of our participants reported that they spoke any South African dialect which further supports that our results were likely not influenced by the demographics of each experimental group.

Experimental Set-Up and Procedure

Before the participant entered the room, if applicable, the researchers prepared the song on Spotify that was randomly assigned to the participant and made sure the Altec speaker was functioning properly. The experimental groups consisted of the participant listening to either the English song or the

South African song while completing a word search. The negative control group completed the word search without any music playing in the background. The experiment was conducted in a private space to ensure there were minimal external disruptions that could modify the participant's performance. Three researchers remained with the participant throughout the entirety of the study to confirm that both the measurements were normally recorded and to avoid any issues with the participant feeling uncomfortable. Figure 4 shows an outline of the events once the participant enters the room.

Upon entering the experimental room, each participant filled out a consent form, which informed them of the minimal risks involved with the study. Before the participant sat down, one of the researchers asked the participant what their non-dominant hand was in order to attach the physiological measurement devices. When the participant sat down, the BSL Respiratory Effort Xder was wrapped around the his or her chest. In addition, the participant's heart rate was measured by attaching a pulse oximeter to the index finger of the participant's non-dominant hand. The pulse oximeter was not used to measure oxygen saturation. Lastly, electrical gel was added to the participant's middle and ring finger, before placing two electrodermal activity (EDA) electrodes around these fingers. The computer connected to the Biopac system faced away from the participant, so they could not see any measurements being recorded. After the setup, the baseline measurements of respiration rate, heart rate, and galvanic skin response were recorded after having the participant sit with the equipment on for at least a minute. The baseline heart rate was calculated by the researcher that was sitting at the computer connected to the Biopac system. The researcher recorded the participant's heart rate every ten seconds and took the average of those values in order to determine the baseline heart rate (Figure 5). Both the average skin conductance over a minute and breaths per minute were recorded using the Biopac software. The baseline skin conductance was measured by highlighting the minute-long interval in the Biopac software and using the average function to get an average value in microsiemens (μS) (Figure 6). The baseline respiration rate, recorded in breaths per minute, was calculated by taking the number of peaks on the Biopac software (breaths) and dividing it by the one-minute time interval (Figure 6).

Once the baseline measurements were recorded, researchers informed the participant that they would be attempting a word search puzzle. The participant was also informed of a memory test immediately following the word search. To incentivize strong effort, the participant was notified that a $10 Starbucks gift card would be awarded to the person who found and memorized the most words. Once the researchers finished explaining the tasks, the participant was asked to begin the word search. Simultaneously, the researcher started the timer situated in front of the participant for two minutes and began playing the music that corresponded to the participant's experimental group. While the participant was completing the word search, the researcher at the computer began recording respiration and skin conductance data with the Biopac software and recorded the HR every ten seconds. The average experimental HR was calculated by averaging the data points recorded from the last minute of the experiment. This procedure was also applied to calculate the average experimental values of both respiration rate and galvanic skin response. Regarding respiration data, breaths per minute were calculated using the peaks from inhalation. One peak to the next peak constituted a single breath. This information was used to determine the number of breaths taken over the two-minute period and the average breaths per minute. Once the two minutes had passed, the average function was utilized in the Biopac software to measure the average skin conductance.

After the timer had reached zero, the researchers collected the word search and asked the participant to remain seated. Immediately after, the researchers gave a blank piece of paper to the participant and told them to write down as many words as they could remember from the word search. The participant was given forty-five seconds to complete this task. The researcher helped remove all Biopac devices from the participant.

Upon completing the experiment, participants were asked to fill out a short survey (Figure 7) that inquired about their native language, whether they spoke another language, if they normally study with music, and their stress level during the experiment on a 10-point scale in order to get a better understanding of the participant's demographic. This information was recorded to determine potential confounders. After the completion of the survey, the participant was thanked and escorted out of the experimental room. The researchers then recorded the number of words that the participant remembered, as well as the number of words that they found in the word search.

Data Collection Analysis

After the data was collected, the average change in each physiological variable was calculated by subtracting the baseline values from the experimental values. All of this data was compiled in a spreadsheet along with the amount of words each participant was able to recall. One-way ANOVA tests were performed to compare the average change in each physiological variable and the memory test results from each experimental group. Two-tailed T-tests were used to determine the statistical significance of any differences between the baseline and mean for each physiological measurement. Each two-tailed T-test was conducted within each experimental group, while the ANOVA test was used to compare the averages of the experimental groups.

Positive Controls

To ensure functionality of the Biopac equipment used to measure the three parameters in this experiment, all six researchers conducted positive control trials for one minute using BSL Respiratory Effort Xder, pulse oximeter, and GSR monitor. HR was calculated by observing each researcher at rest for sixty seconds. RR was measured by looking at how many breaths each researcher took in sixty seconds. Skin conductance (μS) was measured by taking average conductance over the sixty-second interval. The baseline averages were determined to be 74 ± 5.4 BPM, 17 ± 2.4 breaths per minute, and 3.2 ± 1.1 μS. Another set of measurements were collected for one minute while scary movie scenes were played in order to induce physiological responses associated with stress. The stimulated averages were determined to be 96.4 ± 16.2 BPM, 17.0 ± 3.9 breaths per minute, and 1.6 ± 1.6 μS respectively. Once these measurements were completed, the average change (experimental value - baseline value) in each variable was calculated. The average change for HR following the stress stimulus was 22 ± 13.8 BPM. For RR, the average change was 4.4 ± 4.5 breaths per minute. Lastly, the average change in skin conductance following the stressor was 2.4 ± 1.1 μS. As expected, observed parameter measurements increased in response to stressful stimuli, which indicated all equipment was functional and parameters tested were ready to be utilized during our investigation.

Negative Control

As the negative control, ten participants completed the word search task in two minutes with no music playing in the background. Each participant was given forty-five seconds for the STM recall on the wordsearch puzzle words. The data for RR and skin conductance (μS) was recorded in Biopac while HR was monitored with a Nonin Pulse Oximeter and Carbon Dioxide Detector just as in the experimental trials. The purpose of this control group was to see if there is a difference in the physiological variables and STM performance between those students who listen to songs in English, a song in an unfamiliar language, or no music at all while completing the word search and putting the words into their STM.

Results

When comparing the average baseline heart rate to the experimental heart rate for all three treatment groups, the results showed that there was a significant increase in heart rate during the actual experiment (Control: $p < 0.001$, African: $p < 0.001$, English: $p < 0.001$). The average change in heart rate (BPM) was 6.08 ± 0.81, 6.64 ± 1.61 and 7.01 ± 1.03 for the control group, group that listened to African music, and American music, respectively (Figure 8). After completing a single-factor ANOVA test, it was concluded that there is no significant difference between change in the heart rate among the three groups ($p=0.94$).

Similar to heart rate, the average baseline respiration rate and the experimental respiration rate for all of the treatment groups showed that there was a significant increase in the participant respiration rate throughout the physical experiment (Control: $p < 0.001$, African: $p < 0.001$, English: $p < 0.001$). The average change in respiration rate (breaths per minute) calculated for the control group, African music, and American music were 2.95 ± 0.81 , 3.17 ± 0.68, and 5.27 ± 0.72, respectively (Figure 9). A single factor-ANOVA test was conducted and the results concluded that there is no significant difference between the change in respiration rate between the three different groups ($p=0.97$).

The average skin conductance was significantly higher during the experiment when compared to the baseline measurements for all three treatment groups (Control: $p = 0.0011$, African: $p < 0.001$, English: $p < 0.001$). The average changes in skin conductance (μS) for the control group, African music, and English music were 1.83 ± 0.44, 0.95 ± 0.185 , and 0.88 ± 0.21, respectively (Figure 10). Using a single-factor ANOVA test, no significant difference was found when comparing the average change in skin conductance between all three treatment groups ($p= 0.0566$).

The average words recalled from memory task after the word search was 5.41 ± 0.44, 5.11 ± 0.33, and 6.0 ± 0.36, for the control group, African group, and English group, respectively. No significant difference was found when comparing the average number of words remembered for each of the treatment groups ($p = 0.27$) (Figure 11).

Survey Results

After compiling survey results (Figure 3), it was found that a majority of the participants reported English to be their native language. Only 8% of the participants reported that English was not their native language. 58% of the participants reported that they spoke another language. With the 58% of the participants who said they spoke another language, 40% of those participates speak Spanish. There was an even distribution of participants who listen to music and those who don’t listen to music while studying.

When the participants were asked about how stressed they were, the data follows a bimodal distribution with modes at 4 and 7 on a scale of 1-10 (4 meaning little to no stress, and 7 moderately stress).

Discussion

We hypothesized that listening to a song in an unfamiliar language while performing a cognitive task would have a substantial impact on STM and physiological conduct. Our study demonstrated the expected physiological changes among the three groups completing the cognitive task; however, the results did not reveal any statistically significant differences between experimental groups. Analysis of STM performance revealed no statistically meaningful variation between the control group and either experimental group, even though the means differed slightly. This could imply that music in alternative languages may just act as white noise instead of a stressor, and may not hamper a person's ability to recall short-term information. Other studies have suggested that it is possible for STM performance to be increased by a participant's familiarity with the subject matter (Xie and Zhang, 2016). Throughout our study, it is possible that certain participants could be more familiar with the terms in the word search, which could increase their performance on the word search and memory task. Familiarity, along with other confounding variables that could not be controlled for, could have masked the effects of the language of music and a person's stress on memory performance.

Analysis of our participants' physiological responses, including heart rate, respiration rate, and skin conductance, also failed to produce significant differences between experimental groups, though there were slight observable differences between the means within each group. The upbeat nature of the music used for the experimental groups, rather than induced stress of the experiment, may have caused a higher average heart rate than the control group (Hyde and Scalapino, 1918). Likewise, personal stress levels may vary depending on confounding variables, such as personal issues or school related stresses, varying self-confidence, or even cognitive disabilities. Such discrepancy in stress levels would account for the observable variation in mean values of respiration rate (Zelano, 2016) and skin conductance (Villarejo et al., 2012) mean values. Potential confounding factors were confirmed through analysis of the post-experiment survey results, which reflected a broad range of reported stress levels and why participants did or did not feel stressed.

It is critical to compare our study to previous research in order to better determine the efficacy of our results. Previously, researchers have found that listening to a song in one's native language while performing a cognitive task significantly impaired performance; however, performance was not found to be compromised if the same task was completed when listening to a foreign language (Zhang et al., 2009). Conversely, our results did not find any significant difference between performance with foreign or native language music when compared to the control group. Our results compare more so to data found in other similar studies suggesting that background music has no significant effect on STM (Jancke and Sandmann, 2010, Sandberg and Harmon, 2003). In terms of physiological responses and words recalled, based on previous research, it was predicted that significant differences would be found between the variables among the three groups (Hyde and Scalapino, 1918; Masaoka and Homma, 1997; Villarejo et al., 2012). However, after a statistical analysis, our results showed no significant variations, differing from the previous studies. While these results are not what was predicted, the discrepancies found between our study and other similar studies may be explained by any of the factors listed below.

There are a variety of factors that could have influenced the deviation of our findings from our predictions. For example, the demographic of research participants was limited to only those students enrolled in Physiology 435 during the 2019 spring semester, resulting in some degree of selection bias. This restricted our ability to control for foreign language competencies and also inhibited us from having equal representation of males and females in our sample. Though we accounted for this constraint by randomly assigning participants to the control and experimental groups, we could expect different results from a more diverse group of participants. Furthermore, it is possible that participants revealed information about the study to other students, thereby leading participants to have expectations and biases about the process before completing it themselves. Consequently, our results might have been shaped by the Hawthorne effect, or the tendency for people to change their behaviors in response to being observed (Sonnenfeld, 1991), arising from participants having prior knowledge of the study or from the presence of multiple researchers in the room conducting the experiments. It should also be noted that before beginning the word search participants were informed there would be a brief memory assessment to follow. This could have distracted participants from simply completing the puzzle, and instead focusing on memorizing the list of words.

Beyond participant demographics, general characteristics of our testing environment may also serve to explain the insignificance of our results. The room we primarily used to conduct our experiments had little soundproofing and was in a high-traffic area of the building, producing background noises which could have altered the participants' experiences. Additionally, participants listened to music through a bluetooth speaker instead of headphones, potentially lessening the effect of the stimulus and limiting participants' control of the volume. Importantly, there were also inconsistencies with our testing environment throughout the duration of the study. Based on room availability, we encountered times in which we had to switch locations, altering the setup and flow of our experiment. Also, there were some experiments wherein we did not have the bluetooth speaker, but instead played music from an Apple MacBook Pro for the experimental groups.

The limitations and insignificant results of our study suggest that more research is necessary to better understand the relationship between language recognition, STM, and physiological stress responses. Future studies should focus on how bilingualism may impact language recognition and general memory function. This may include pre-screening participants' familiarity and fluency with foreign languages and using a larger, more diverse sample of participants. To create a more immersive experience and enhance the auditory stimulus, studies should also be conducted with headphones in a quiet environment. Lastly, significant conclusions may be drawn from administering more thorough cognitive tests. An alternative assessment to the word search and 45-second word recall used in this study is the standard concussion test, which assesses both short-term and long-term memory using a variety of measures. This could address some of the reliability issues encountered with the word search and offer more dynamic results.

While this study predominantly focused on music in foreign languages and STM performance, physiological variables were included because they could help analyze how STM was affected by the presence of different languages. Performing cognitive tasks such as word searches can induce stress, which can be quantified by measuring heart rate, respiration rate, and skin conductance. While no significance was found between any of the physiological variables and the experimental groups, the study was able to adequately show that the overwhelming majority of participants became stressed when completing the word search. This ties into the Physiology 435 curriculum quite well, because it highlights the activation of the sympathetic nervous system while performing a cognitive task. When students become more stressed or fixated on a cognitive task, the sympathetic nervous system can stimulate the cardio-accelatory nuclei in the brainstem, which in turn can increase heart rate and stroke volume in order to deliver more blood to tissues that may be working harder during cognitive tasks, such as the brain. The sympathetic nervous system plays a large part in respiration and skin conductance as well, but the main idea is that, regardless of whether a person cognitively feels stressed or not, their sympathetic nervous system will increase its activity in order to compensate for increased use of energy and oxygen in the brain. This study has helped us to understand the everyday battle between the parasympathetic and sympathetic nervous systems, providing insight into how even routine activities such as paying attention in a lecture or doing a homework assignment may cause more stress response than we realize.

In conclusion, music in foreign language does not seem to cause differences in STM or in physiological measurements when compared to music in a person's native language or no music. There are many reasons as to why foreign language may not affect STM, and further studies could help elucidate more specific effects of music in foreign languages during cognitive tasks. Hopefully, more research is done on the effects of listening to music in different kinds of languages so students everywhere can further understand whether listening to music and the type of music benefits or hurts their memory performance before exams.

Bibliography

Bugter, Darragh, and Randy Carden. “The Effect of Music Genre on a Memory Task.” *PsycEXTRA Dataset*, vol. 17, no. 2, 2012, pp. 87–90., Retrieved March 5, 2019.

Hanley, J. Richard, and Eirini Bakopoulou. “Irrelevant Speech, Articulatory Suppression, and Phonological Similarity: A Test of the Phonological Loop Model and the Feature Model.” *Psychonomic Bulletin & Review*, vol. 10, no. 2, 2003, pp. 435–444., Retrieved March 5, 2019.

Hyde, I. H., and W. Scalapino. “The Influence Of Music Upon Electrocardiograms And Blood Pressure.” *American Journal of Physiology-Legacy Content*, vol. 46, no. 1, 1918, pp. 35–38., Retrieved March 5, 2019.

Jäncke, Lutz, and Pascale Sandmann. “Music Listening While You Learn: No Influence of Background Music on Verbal Learning.” *Behavioral and Brain Functions*, vol. 6, no. 1, 7 Jan. 2010, Retrieved March 5, 2019.

Longoni, A. M., et al. “Articulatory Rehearsal and Phonological Storage in Working Memory.” *Memory & Cognition*, vol. 21, no. 1, 1993, pp. 11–22., Retrieved March 5, 2019.

Macintyre, Peter D., and R. C. Gardner. “The Subtle Effects of Language Anxiety on Cognitive Processing in the Second Language.” *Language Learning*, vol. 44, no. 2, 1994, pp. 283–305., Retrieved March 5, 2019.

Masaoka, Yuri, and Ikuo Homma. “Anxiety and Respiratory Patterns: Their Relationship during Mental Stress and Physical Load.” *International Journal of Psychophysiology*, vol. 27, no. 2, 1997, pp. 153–159., Retrieved March 5, 2019.

Most, S. B., Kennedy, B. L., & Petras, E. A. (2017). Evidence for improved memory from 5 minutes of immediate, post-encoding exercise among women. *Cognitive research: principles and implications*, *2*(1), 33. Retrieved March 17, 2019

Salamé, Pierre, and Alan Baddeley. “Effects of Background Music on Phonological Short-Term Memory.” *The Quarterly Journal of Experimental Psychology Section A*, vol. 41, no. 1, 1989, pp. 107–122., Retrieved March 5, 2019.

Sandberg, Kristin, and Sarah Harmon. “Effects of Popular Music on Memorization Tasks.” *Journal of Undergraduate Research at Minnesota State University,* vol 3, no. 6, 2003. Retrieved March 5, 2019.

Sonnenfeld, Jeffrey. "Shedding Light on the Hawthorne Studies," *Journal of Occupational Behavior*, Vol. 6, 1985. Retrieved April 9, 2019.

Tahmassian, K., and N. Jalali Moghadam. "Relationship between Self-Efficacy and Symptoms of Anxiety, Depression, Worry and Social Avoidance in a Normal Sample of Students." *Iran J Psychiatry Behav Sci* 5.2 (2011): 91-8, Retrieved March 5, 2019.

Villarejo, M. V., Zapirain, B. G., & Zorrilla, A. M. (2012). A stress sensor based on Galvanic Skin Response (GSR) controlled by ZigBee. *Sensors (Basel, Switzerland)*, *12*(5), 6075-101. Retrieved March 17, 2019.

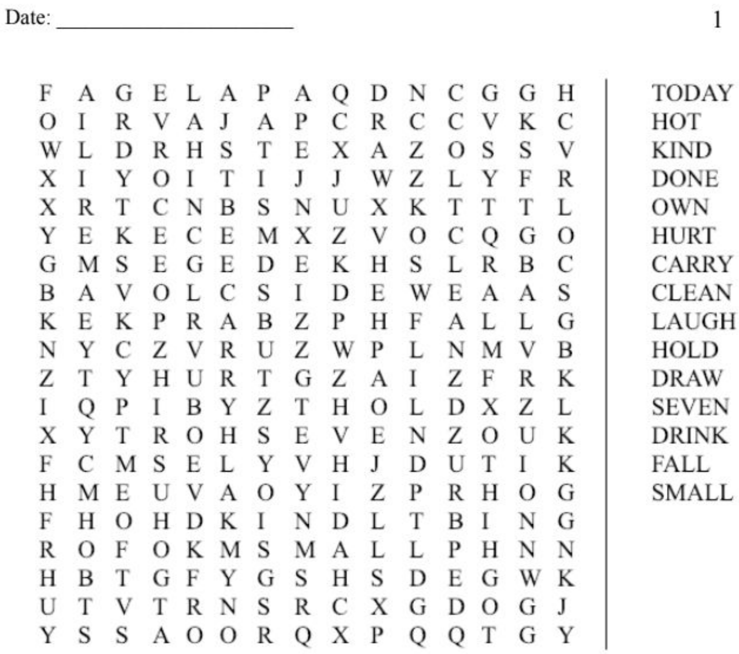
Xie, Weizhen, and Weiwei Zhang. "Familiarity Increases the Number of Remembered Pokémon in Visual Short-Term Memory." *Memory & Cognition*, vol. 45, no. 4, 2016, pp. 677–689.

Zelano, C. (2016, December 07). Nasal Respiration Entrains Human Limbic Oscillations and Modulates Cognitive Function. Retrieved March 25, 2019. http://www.jneurosci.org/content/36/49/12448

Zhang, Xuemin, et al. "A Study of Different Background Language Songs on Memory Task Performance." *2009 International Symposium on Intelligent Ubiquitous Computing and Education*, 16 May 2009, Retrieved March 5, 2019.

Appendix

Figure 1



Date: ____________________ 1

F	A	G	E	L	A	P	A	Q	D	N	C	G	G	H	TODAY
O	I	R	V	A	J	A	P	C	R	C	C	V	K	C	HOT
W	L	D	R	H	S	T	E	X	A	Z	O	S	S	V	KIND
X	I	Y	O	I	T	I	J	J	W	Z	L	Y	F	R	DONE
X	R	T	C	N	B	S	N	U	X	K	T	T	T	L	OWN
Y	E	K	E	C	E	M	X	Z	V	O	C	Q	G	O	HURT
G	M	S	E	G	E	D	E	K	H	S	L	R	B	C	CARRY
B	A	V	O	L	C	S	I	D	E	W	E	A	A	S	CLEAN
K	E	K	P	R	A	B	Z	P	H	F	A	L	L	G	LAUGH
N	Y	C	Z	V	R	U	Z	W	P	L	N	M	V	B	HOLD
Z	T	Y	H	U	R	T	G	Z	A	I	Z	F	R	K	DRAW
I	Q	P	I	B	Y	Z	T	H	O	L	D	X	Z	L	SEVEN
X	Y	T	R	O	H	S	E	V	E	N	Z	O	U	K	DRINK
F	C	M	S	E	L	Y	V	H	J	D	U	T	I	K	FALL
H	M	E	U	V	A	O	Y	I	Z	P	R	H	O	G	SMALL
F	H	O	H	D	K	I	N	D	L	T	B	I	N	G	
R	O	F	O	K	M	S	M	A	L	L	P	H	N	N	
H	B	T	G	F	Y	G	S	H	S	D	E	G	W	K	
U	T	V	T	R	N	S	R	C	X	G	D	O	G	J	
Y	S	S	A	O	O	R	Q	X	P	Q	Q	T	G	Y	

Figure 1. Word search that was generated and used throughout the entirety of the study. The participant number is in the top right corner. The date was added manually by the researchers.

Figure 2

University of Wisconsin-Madison
Consent to Participate in Research

Formal Study Title: The effect of language recognition in music on short-term memory recall and physiological stress response

Where Lead Researcher works: University of Wisconsin-Madison

Invitation
We invite you to take part in a research study about how language recognition in music may affect short-term memory recall and physiological responses. We are inviting you because you are a student enrolled in Anatomy and Physiology 435 at the University of Wisconsin-Madison with a unique set of study habits and language competencies. This study may result in conclusions that can enhance studying strategies in college.

The purpose of this consent form is to give you the information you need to decide whether to be in the study. Ask questions about anything in this form that is not clear. If you want to talk to your family and friends before making your decision, you can. Once we have answered all your questions, you can decide if you want to be in the study. This process is called “informed consent.”

Why are researchers doing this study?
The purpose of this research study is to understand whether one's ability to comprehend the lyrics of a song while completing a cognitive task may impact their short-term memory performance and physiological functioning.

This study is being done at the University of Wisconsin-Madison (UW-Madison). A total of about 50 people will participate in this study.

What will happen in this study?
If you decide to participate in this research study, the researchers will ask you to complete a word search in two minutes with a speaker in place, recall as many words as you can from the word search list, and fill out a post-survey questionnaire about your familiarity of other languages

You may skip any question on the questionnaire or in the interview that you do not wish to answer.

How long will I be in this study?
You will be part of the study for about 10 minutes.

- If you take part in this study, there should not be any deviance from your regular care.
- This study is not part of your health care.

Do I have to be in the study? What if I say "yes" now and change my mind later?
No, you do not have to be in this study. Taking part in research is voluntary. This means that you decide if you want to be in the study. Even if you decide now to take part, you can choose to leave the study at any time.

Let the researchers know if you choose to leave the study.

If you decide not to take part in the study, or if you choose to leave the study, your choice will not affect any treatment relationship you have with healthcare providers at UW-Madison, UW Health or any affiliated organizations, or any services you receive from them. No matter what decision you make, and even if your decision changes, there will be no penalty to you. You will not lose medical care or any legal rights.

Will being in this study help me in any way?

- Being in this study will not help you directly. But your participation in the study may benefit other people in the future by helping us learn more about how language recognition in music may inhibit or increase people's short-term memory capacity. Depending on the results, this study may have you rethink what language of music you listen to while you cram information in your head the night before an exam.

What are the risks?
There is a risk that your information could become known to someone not involved in this study.

Will I be paid or receive anything for being in this study?

- We will not pay you to take part in this study or pay for any out of pocket expenses related to your participation, such as travel costs.

What happens if I am injured or get sick because of this study?

- Being injured during this research is very unlikely. However, accidents can happen.

If you are injured or get sick because of this study, medical care is available to you through UW Health, your local provider, or emergency services, as it is to all sick or injured people.

- If it is an emergency, call 911 right away or go to the emergency room.
- For non-emergency medical problems, contact the study team for instructions.
- Call the Lead Researcher, Meghan Moroni, at (920) 680-7850 to report your sickness or injury.

Here are some things you need to know if you get sick or are injured because of this research:

- If the sickness or injury requires medical care, the costs for the care will be billed to you or your insurance, just like any other medical costs.
- Your health insurance company may or may not pay for this care.
- No other compensation (such as lost wages or damages) is usually available.
- UW-Madison and UW Health do not have a program to pay you if you get sick or are injured because of this study.
- By signing this consent form and taking part in this study, you are not giving up any legal rights you may have. You keep your legal rights to seek payment for care required because of a sickness or injury resulting from this study.

How will the researchers keep my research information confidential?

We have strict rules to protect your personal information. We will limit who has access to your name, address, phone number, and other information that can identify you. We will also store this information securely. We may publish and present what we learn from this study, but none of this information will identify you directly without your permission.

However, we cannot promise complete confidentiality. Federal or state laws may permit or require us to show information to university or government officials responsible for monitoring this study.

Who at UW-Madison can use my information?

- Members of the research team
- Offices and committees responsible for the oversight of research

Will information from this study go in my UW Health medical record?

- None of the information we collect for this study will be put in your medical record.

What if I have questions?

If you have questions about this research, please contact the Lead Researcher, Meghan Moroni, at (920) 680-7850. If you have any questions about your rights as a research subject or have complaints about the research study or study team, contact UW Health Patient Relations at 608-263-8009. The Patient

Relations Representatives work with research subjects to address concerns about research participation and assist in resolving problems.

Agreement to participate in the research study

If you sign the line below, it means that:

- You have read this consent form.
- You have had a chance to ask questions about the research study, and the researchers have answered your questions.
- You want to be in this study.

____

Printed Name of [Subject/Participant]

____

Signature of Research [Subject/Participant] Date

____

Signature of Person Obtaining Consent Date

****You will receive a copy of this form****

Figure 2. Full consent form received by participants prior to completing the study.

Figure 3

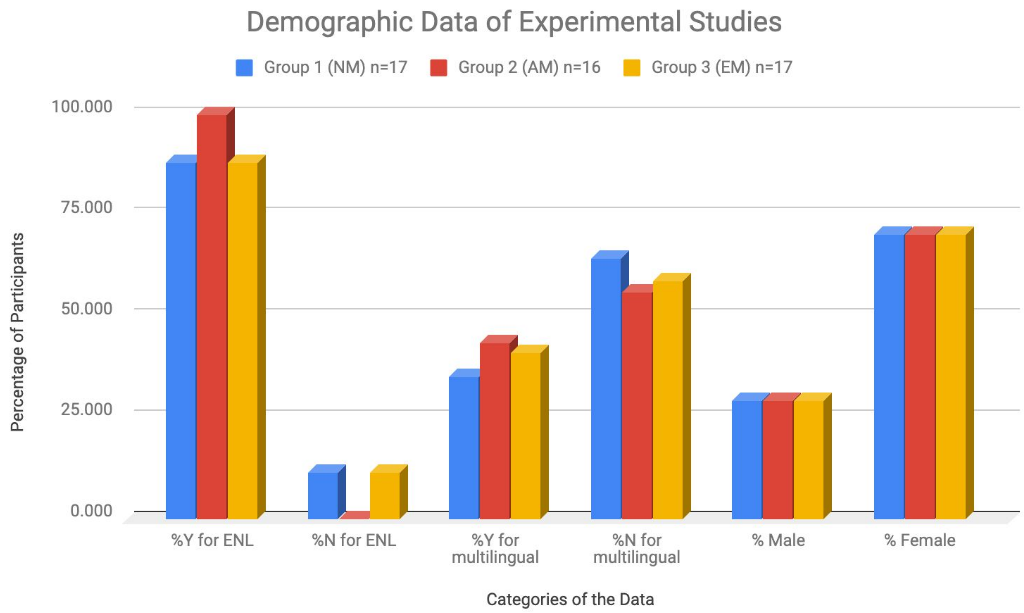


Figure 3. Demographic makeup of each respective experimental group (NM meaning "No Music", AM meaning "African Music", and EM meaning "English Music"). Group 2 had 17 participants however, we omitted one participant from Group 2 because their post-experiment survey was incomplete thus making it impossible to account for this participant. On the x-axis, "Y" indicates yes, "N" indicates no, and "ENL" indicates English as native language.

Figure 4

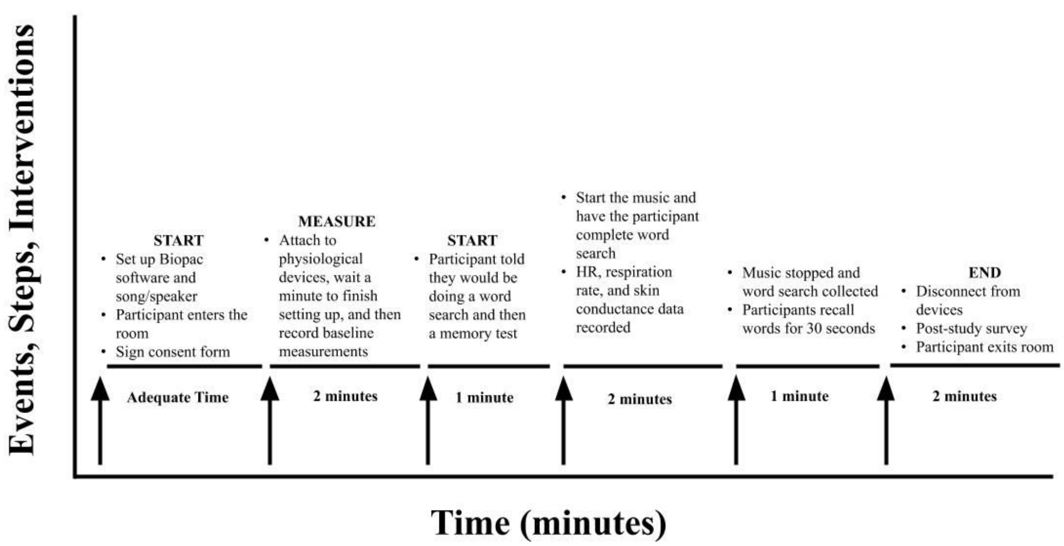


Figure 4. Timeline of experimental procedure. 17 participants listened to "Middle of the Road" by The Pretenders, 17 listened to an African gospel choir song, and 17 did not listen to any music.

Figure 5

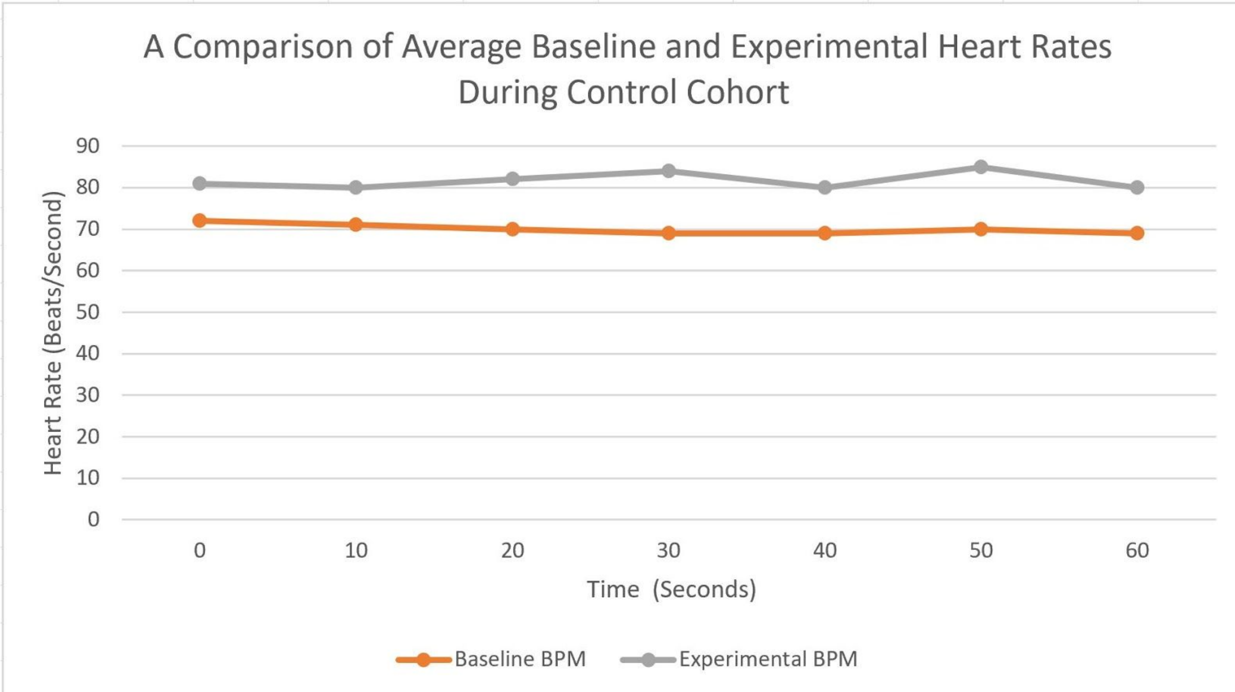


Figure 5. Representative data collected from participants during baseline measurements and the last 60 seconds of their experimental measurements. The average of these data points was calculated. This data was carried out for a participant in the control group, however, similar graphs were seen for the experimental groups.

Figure 6

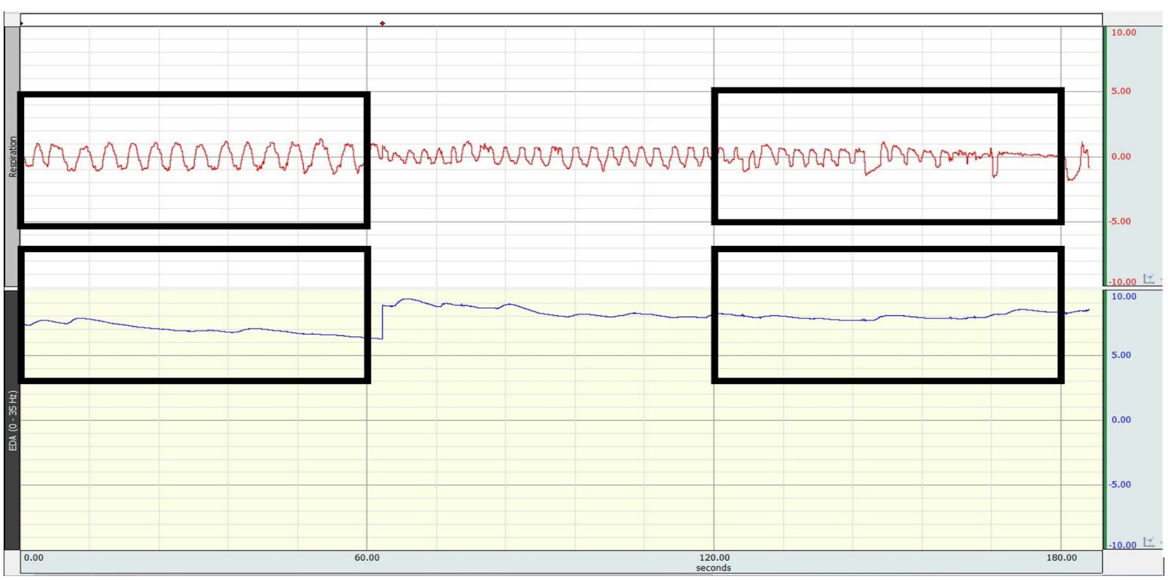


Figure 6. Representative screenshot of EDA and respiration data from BIOPAC software of typical participants. The average EDA and Respiration rates was calculated using the software, and the Baseline (first 60 seconds) and end of experimental data (last 60 seconds) of data was compared as indicated by boxes on the trace. The peak to peak function was used to measure respiration in breaths per minute, measured to the nearest 0.1 breaths. The average function was used to calculate the average skin conductance.

Figure 7

Post Experiment Questionnaire

This questionnaire is part of the research project conducted by researchers at University of Wisconsin-Madison. Thank you for your willingness to fill out this questionnaire so that we can better understand how languages can have an impact. Please answer all the questions in the questionnaire to the best of your ability. You may fill in more than one answer for a question, and if there are questions that you do not want to answer, you may skip those questions. If you have any additional input or information you may enter this in the comment box provided at the end of the questionnaire. By answering the questionnaire, you give us permission to use this information in any publications that result from the research. In any of these publications we will keep your identity confidential and we will not misuse any of the information that you provided. If you have any questions or comments, please let the researcher who is administering the questionnaire know.

1. **Is English your Native language? Y / N**
2. **Do you speak another language? If yes, list what other languages you speak. Y / N**

____

3. **How did the music make you feel? If no music was provided say N/A.**

____

4. **How do you normally study? With music? No music?**

____

5. **If you study with music, what kind of music do you usually listen to?**

____

6. **On a scale from 1-10, how stressed were you doing the timed word search?**

   1 2 3 4 5 6 7 8 9 10

<u>Additional Comments:</u>

Figure 7. A post experiment questionnaire that will be given to the participants after the research experiment.

Figure 8

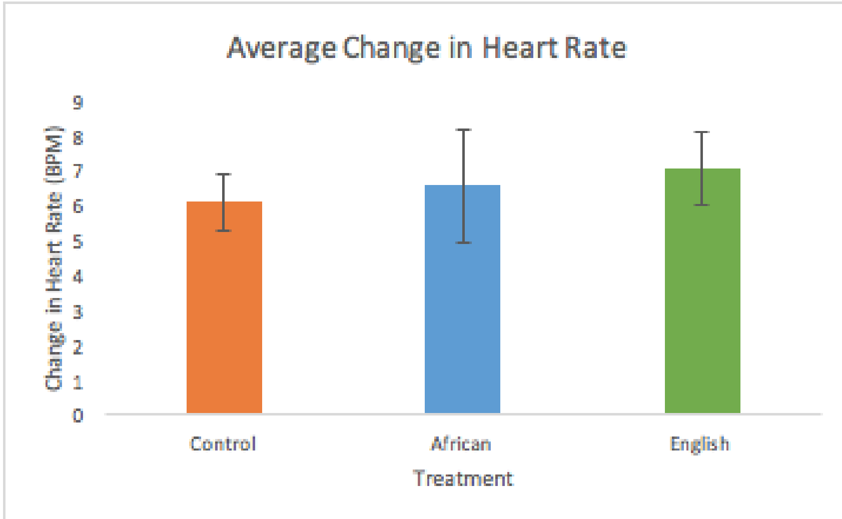


Figure 8. Measurements of heart rate (BPM) while completing the word search and listening to no music, African music, or English music. Plotted values are the average heart rate values (BPM) for each treatment group and the error bars represent the standard error for each treatment group. An ANOVA test showed there was no significant difference between the average heart rate of the treatment groups.

Figure 9

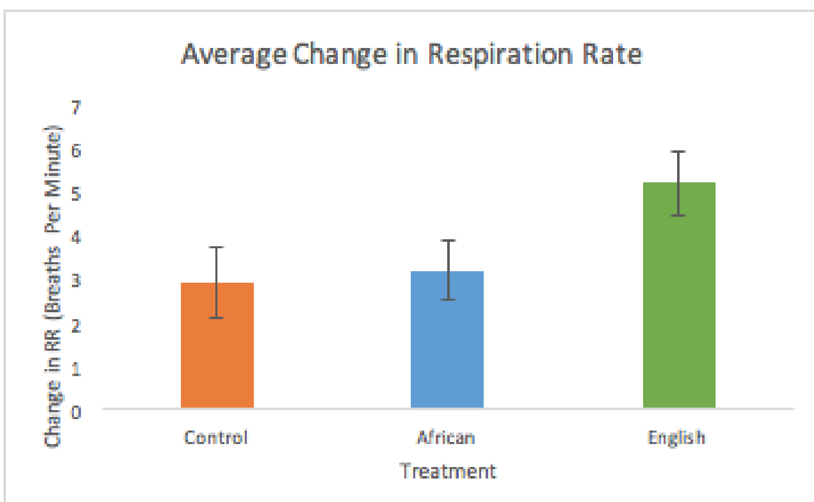


Figure 9. Measurements of respiration rate (breaths per minute) while completing the word search and listening to no music, African music, or English music. Plotted values are the average heart rate values (breaths per minute) for each treatment group and the error bars represent the standard error for each treatment group. An ANOVA test showed there was no significant difference between the average respiration rate of the treatment groups.

Figure 10

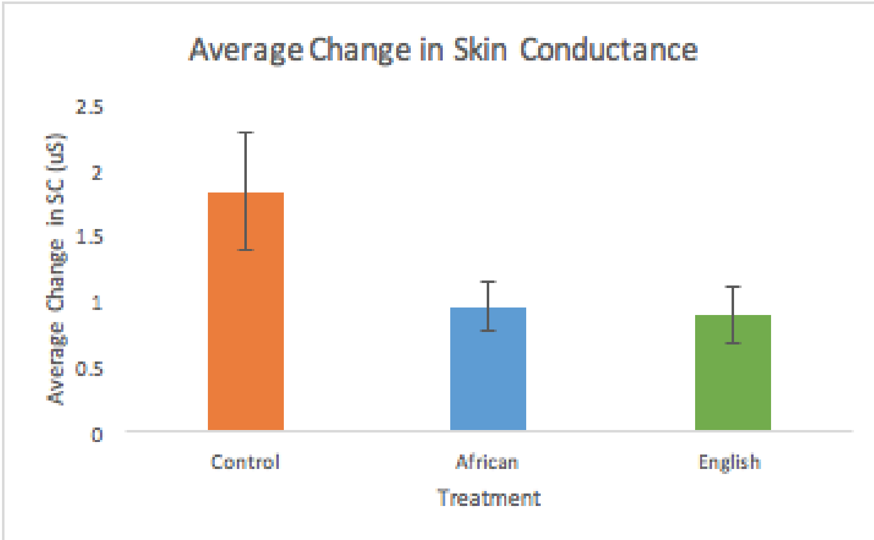


Figure 10. Measurements of skin conductance (µS) while completing the word search and listening to no music, African music, or English music. Plotted values are the average skin conductance (µS) for each treatment group and the error bars represent the standard error for each treatment group. An ANOVA test showed there was no significant difference between the average skin conductance of the treatment groups.

Figure 11

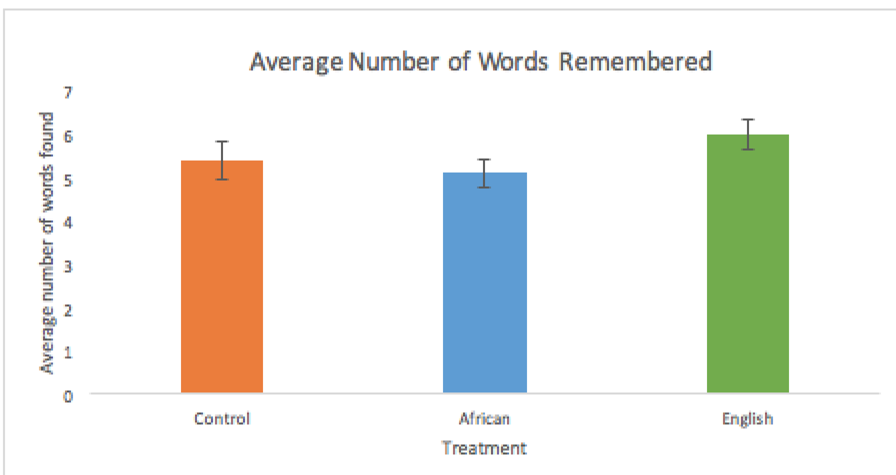


Figure 11. Recorded data of words remembered by each participant after completing the word search and listening to no music, African music, or English music. Plotted values are the average number of words found for each treatment group and the error bars represent the standard error for each treatment group. An ANOVA test showed there was no significant difference between the average number of words found for the treatment groups.