The effect of music tempo on memory retention

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Abstract

This study's objective was to investigate if an individual's memory retention improved while listening to music with a controlled tempo. A memory retention test was run by allowing the participant to partake in an online pattern-recall exercise. The test began at level one and the participant's score was based on the highest level achieved. While the participant performed the memory test, their heart rate (HR), and respiratory rate (RR) was measured throughout. Additionally, the participant was exposed to either fast tempo (FT), slow tempo (ST), or no music (NM). All participants (n=30) in the study performed the same memory test and were provided with noise-canceling headphones to isolate the testing environment. After analyzing the data, no statistically significant difference between music tempo and memory retention was found, therefore leading to no effect being discovered. Additionally, the physiological measurements of change in heart and respiratory rate showed no large variations between the experimental groupings. Overall, there was no statistically supportive evidence that music tempo affects memory retention or change in heart and respiratory rate.

Introduction

Whether it is a child working on their homework, a college student studying for an exam, or an adult working at their desk; they may find themselves listening to music while stimulating their brain. It is then that the question arises of how the human brain functions in the presence of music, and how music is able to affect retention of memory. There are two major temporal classifications of memory: long-term memory and working (or short-term) memory. Long-term memory can last for days, weeks, or even years depending on the event and its associations. Working memory lasts for a few minutes and is easily forgotten due to the limited capacity it has. The fundamental difference between long-term and working memory is that protein synthesis is required for long-term memory, and they are similar in the fact that repetition enhances all types of memory (Tom Yin, Dept. of Neuroscience, Spring 2013). There have been previous studies that have explored music in relation to memory retention. One such study found that both memory recall and retention increased while listening to music (Morton, L. L. et al. 1990). The results were interpreted as an arousal response to the music that enhances neurotransmission in certain pathways. Similarly, another study contained a memory-recall experiment in which the participant was exposed to both the same or varied music tempos while attempting to memorize certain words. The study found that listening to music with a constant tempo while memorizing words triggered a mood-dependent effect that caused the participant to experience heightened memory retention (Balch, William R. *et al.* 1996). To oppose these findings, Salamé (1989) claims that listening to music while attempting to perform a memory task causes mental disruption and therefore, a decrease in memory retention.

To further explore the effect of music on memory retention, the effect of music tempo on the ability of a participant to recall a visual sequence pattern was studied, therefore focusing on the short-term or working memory of the participants. The goal was to determine whether the tempo of classical music, specifically Mozart, has a statistically significant effect on memory retention. Interest arose in this test because it could uncover the effect of the music on the ability to retain memory, which opens more doors for all age groups to expand their knowledge and experience through music. In fact, Jausovec, N., et al., (2006), found what they named the "Mozart effect." This explained that Mozart's music, by means of activating task-relevant brain areas, lead to an enhancement of learning. To counter that research, the investigators at Appalachian State University were unable to reproduce the Mozart Effect. They concluded that with lacking statistical significance, there was little evidence that improved memory retention is related to listening to the music of Mozart (Steele, K. M., *et al.*,1999). With these two arguments in mind, tests were based on music tempo and looked for relationships between slow and fast tempos with regard to memory retention. Further investigation went into Mozart's music by using the different music tempos to test the hypothesis that a statistical significance exists in the relationship between music at a controlled tempo and memory retention.

Material and Methods

Participants

The 30 participants in this study were University of Wisconsin-Madison students enrolled in Physiology 435. Of all participants, 17 were female and 13 were male. Participants were randomly assigned to one of three experimental groups of 10 participants each: No Music (NM), Slow Tempo Music (ST), and Fast Tempo Music (FT).

Variables

Three variables were measured throughout the experiments: a memory task score, heart rate (HR), and respiratory rate (RR). The memory retention measurement were obtained via a sequence pattern memory task from the brainmetrix website (http://www.brainmetrix.com/memory-test/) which gave a score of increasing value based on the participant's ability to remember the given pattern. Heart rate was measured using a pulse oximeter, while respiratory rate was measured using the BioPAC Systems, Inc, BSL Respiratory Effort Xdcr.

Procedure

Participants were briefed and then connected to both a pulse oximeter and a respiration belt. In order to ensure accuracy from participant to participant, the BioPAC Systems, Inc, BSL Respiratory Effort Xdcr was calibrated each time a new participant began the study. If the participant was in either the slow or fast tempo experimental groups, the participant had the music turned on for 30 seconds prior to beginning the memory task. These participants listened to a selected segment of Mozart, andante or allegro, depending on their experimental grouping**.** If the participant was in the NM group, then the participant was allowed to start the memory task following calibration of the respiration belt. Initial heart and respiration rates were recorded at the start of the memory test. Heart and respiration rates were monitored throughout the duration of the memory test. When the participant failed to complete the last successful level of the sequence pattern memory task, heart and respiration rates were recorded again. The pulse oximeter and respiration belt were detached after the last measurements were taken, and the level of the latest successful round of the memory task was noted. The average time per participant from briefing to completion was 7.5 minutes (Figure 1). Following data collection, analysis was performed using ANOVA to infer if there was a statistically significant difference between the NM, FT, and ST groups.

Analysis

First, the raw data was collected, followed by calculations of change in heart and respiration rate before and after the memory task. The differences in heart and respiration rates were compared between experimental groups using ANOVA. Finally, a comparison was made between the levels achieved in the memory task between all three groups using ANOVA.

Results

Memory Test

Figure 2 represents the comparison of music tempo and memory test level achieved. The median score obtained by NM participants is greater than that of ST followed by FT. There is significant overlap of the quartile ranges in all three categories. Using ANOVA to compare the values of the achieved score on the memory test (n=30, p=.2168 at α= .05), no statistical significance between categories was found.

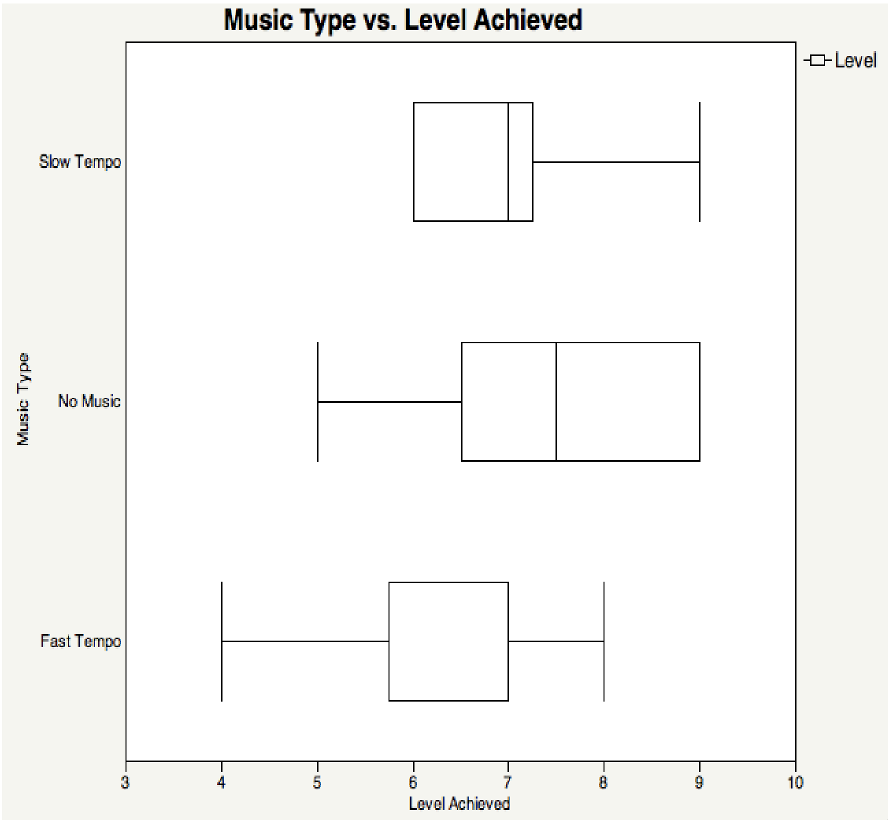

Figure 2. Music Type vs. Level Achieved. Comparison of music tempo and memory test level achieved by the participant. Use of Box and Whisker plots demonstrating the spread of data as well as the comparison between experimental groups. The median value of the NM is the highest followed by ST then FT.

Respiratory Rate

Figure 3 compares music tempo and change in RR. Here the median values are ordered as follows: FT > NM > ST. The FT values (Q1 to Q3) are completely overlapped by both the NM and ST quartiles, which have large IQRs. Additionally, there is great overlap between the NM and ST quartiles. This overlap expresses the fact that when using ANOVA to compare the change in RR between categories there was no statistical significance (n=30, p=.31, α= .05).

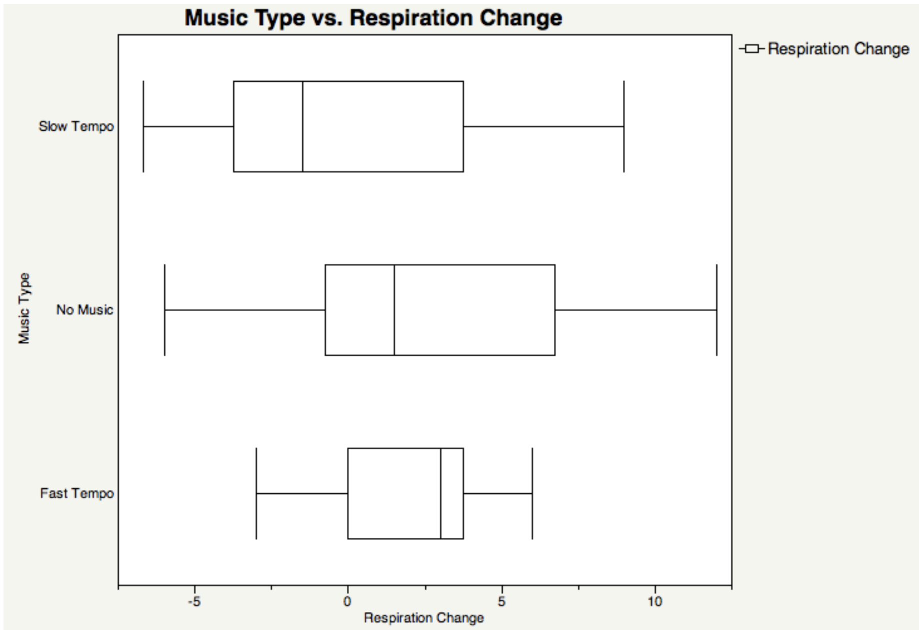

Figure 3. Music Type vs. Respiration Change. Comparison of music tempo and change in respiration rate. The median value of FT if the largest followed by NM then ST.

Heart Rate

Figure 4 is a comparison of music tempo and change in heart rate. The FT median HR change was largest followed by ST and then NM. The values in each group are widely distributed with each quartile range almost completely overlapping the other. Again, as expected with such great overlap of the quartile ranges the ANOVA proved that there is no statistical significance in change in HR between the three categories (n=30, p=.382, α= .05).

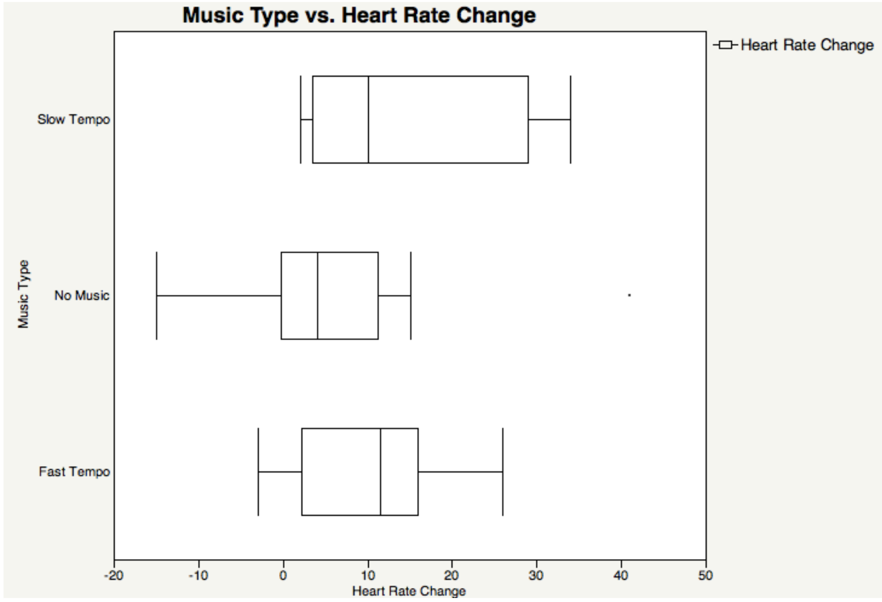

Figure 4. Music Type vs. Heart Rate Change. Comparison of music tempo and change in heart rate. The FT median change in heart rate was larger than ST, followed by NM.

Discussion

The purpose of this study was to determine whether a participant's ability to retain memory could be altered in response to listening to classical music with controlled tempos. After analyzing the data gathered from the experiment, we concluded our results to be insignificant to this study, thus not allowing the hypothesis to be supported. While the differences in the median values between the three groups supported the idea that music tempo affects memory retention in general terms, the analysis of data provided no significant differences. As expected, the median score of the NM group was the largest followed by ST and lastly FT, indicating that music in general negatively impacts memory retention, with a higher tempo having a greater negative effect (Figure 2). However, statistically, there was not a significant difference, and therefore, this conclusion cannot be drawn. This result was similar to change in RR. The largest change in RR occurred in the FT group followed by NM then ST (Figure 3). The general trend of a larger change in FT supports the idea that the participant is more physiologically aroused during testing, but again, it is not statically supportive. Finally, the general trend of change in heart rate being greatest in FT and least in NM reinforces the same concept of music being more physiologically stimulating, especially with a faster tempo, but again, this is not quantitatively significant (Figure 4).

With the lack of statistical significance in the results allowing the conclusion that music tempo does not affect short-term (or working) memory retention, one must consider the limitations of this study as well as how it can be improved in the future. While we had a fairly large sample size (n=30), it is possible that there is a more optimal sample size that can be calculated, and therefore provide a more accurate representation of the population. Additionally, our sample size was limited to students of ages 20-25. Since these students partake in a similar environment, using other ages or exploring other demographics may yield useful results. With that said, it may be advantageous to repeat this study with a larger sample size in future studies.

Secondly, the memory test used in this experiment is an online memory recognition game that tests the user's recognition of a pattern formulated by the computer. An argument can be made that this test does not accurately depict typical memory retention. Some students may simply not excel in recalling a pattern, while other students may do exceptionally well with this type of recognition. Additionally, the difficulty of this particular memory test commonly yielded the achieved levels 7-9. Thus, when comparing these averages using ANOVA it would be difficult to achieve significant differences (p value<0.05) between the three groups. For example, the highest achieved score was a 9, with most participants scoring around 7 regardless of their group. Therefore, it was hard to draw conclusions with such a narrow range of scores. The original study conducted by George Miller tested how many items an individual was able to recollect from short term memory (1956). The study concluded that an average person could recall 7 +/- 2 items, which is in agreement with our study because the range of our scores was 5-9, which represents our participants being able to recall 7 +/- 2 items. In the future, it would be best to use a different memory test that would have a more achievable score range rather than 7-9 in order to have significant differences between conditions. Perhaps a new memory test that focuses on various aspects of memory retention involving a combination of words, patterns and images can be more beneficial to this study. For example, an experiment could have participants memorize a word or image list while being under one of the experimental conditions. After a certain period of time the participant can be asked to recall the prior list and a record of the amount of words remembered could be used to score memory retention. Also, maybe the use of a long-term memory test could be used to compare differences between the music tempo's effect on short-term versus long-term memory. Additionally, the different memory tests used in previous studies could explain the difference in results between this study as compared to studies that found a correlation between music and memory retention. The consideration of the type of memory test used is vastly important to future research methods.

Lastly, there are the fundamental limitations of the technology used to measure physiological variables. For example, the computer software program used to run the respiration monitor and heart rate is a basic student program used for several different applications. Although this system is very useful to gather general data; we found the system to provide inaccurate respiration and heart rate readings at times. The results may have been more accurate using professional equipment and more careful observation. In particular, respiration rates were obtained by experimenters due to the lack of program capability in doing so. Therefore, it is possible that the respiration rate values were not as accurate as computer calculations would have been. However, these issues aside, it is possible that there was not a significant relationship between music tempo and memory retention because the relationship is not present or strong in general.

In conclusion, based on our results, we are currently unable to find a significant relationship between music tempo and working memory retention. We can attribute this conclusion to the limitations described above. Moreover, it is important to note that memory retention is a phenomenon that involves a vast amount of physiological processes. In our study, we tested few physiological responses and only one memory test. Possibly in the future, other physiological measurements, such as an EEG, could enhance our study results or achieve more significant findings. While our experiment concluded no effect between music tempo and working memory retention, there can be many modifications done to our study that may yield successful reproduction in the future. Music is already a part of everyday life; expanding this study may open new doors in medical research that could improve the way and the reason why children, students, and adults listen to music.

Figures and Legends

The Effect of Music Tempo on Memory Retention Methods

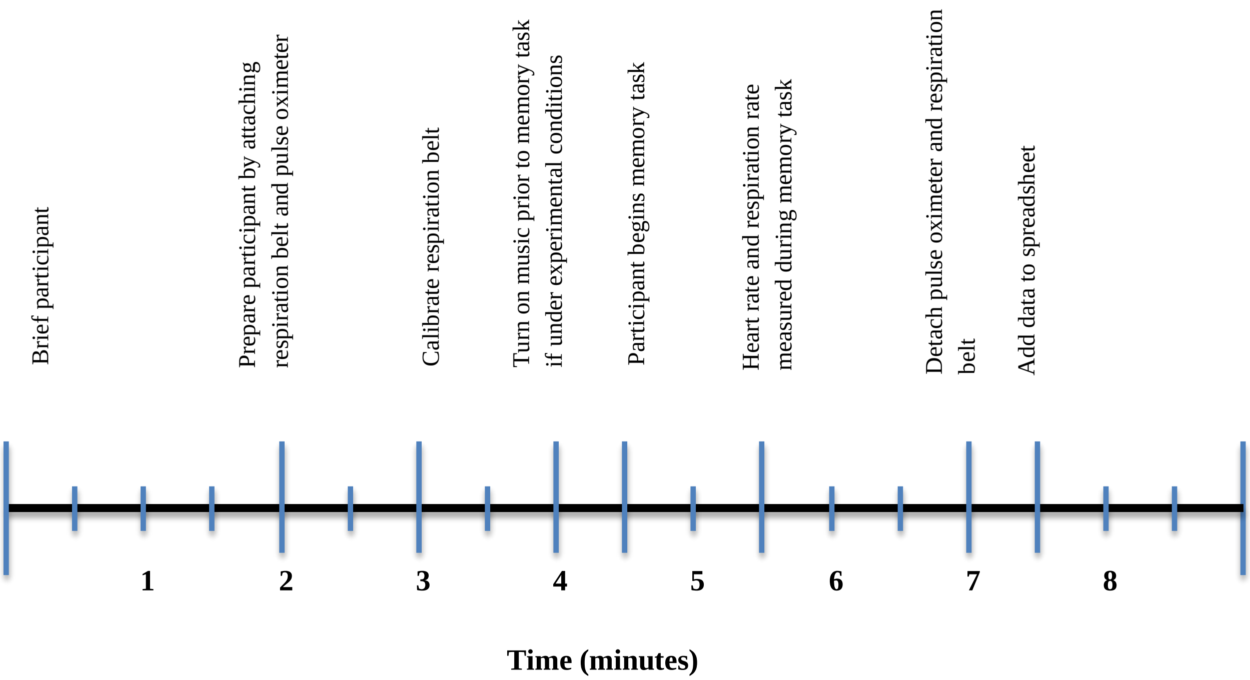

Figure 1. Timeline of Events. Diagram depicting the time intervals for each event in the study and how long each test will take.

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