The Effects of Music Tempo on Concentration and Task Performance

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Abstract

A frequently visited topic in cognitive physiology is music's influence on simple tasks. Our study addressed the effect of differing music tempos on a subject's typing performance. Utilizing EEG, ECG, and a sphygmomanometer, we recorded alpha and beta brain waves, heart rate, and blood pressure while a total of fifteen subjects completed a two-minute online typing test. This typing test was performed three times, once as a control without music, once with a song of 40 beats per minute, and once with a song of 80 beats per minute with a rest period between each trial. When compared to no music, slow tempo music did not significantly affect typing performance ($p=0.479$), heart rate ($p=0.249$), blood pressure ($p=0.221$), nor brain activity. Similarly, fast tempo music did not change typing performance ($p=0.364$), heart rate ($p=0.0689$), blood pressure ($p=0.519$), nor brain activity. Future research in this area must reconcile individual tastes in music, base-level typing proficiency, and should aim to increase the sample size.

Introduction

Every culture in the world has developed some form of musical expression, and it is readily accepted that music can evoke emotional responses. While music has a place in our everyday lives, its physiological effects often go unnoticed despite significant scientific evidence that music has a profound effect on brain activity and bodily responses. Many of the direct physiological effects of music are well documented, including the ability to reduce general stress, improve aerobic recovery, increase cognitive performance, and improve sleep quality (Labbe et al, 2007; Jing and Xudong, 2008; Mammarella et al, 2007; Harmat et al, 2007). Furthermore, musical therapy has effectively been used to treat depression, pain, dyslexia, and as a post-stroke recovery method (Siedliecki and Good, 2006; Overy, 2003; Sarkamo et al, 2008).

Classical music has been shown to increase memory capacity in aging adults and combat the effects of Alzheimer's disease and general background music has been shown to increase spatial reasoning and linguistic processing (Young 1999; Angel et al. 2010).

Listening to music has become a common behavior while studying or working, and with the recent growth in online music services such as Pandora and iTunes, this practice will likely continue. There is a general consensus that music plays many underlying roles, including reducing boredom, masking ambient noise, and increasing attention to tasks (Hargreaves & North 1997). However, research on the physiological effects of music is often conflicting and little research has been done to apply the effects of music tempo to task performance. It has been suggested that because the tasks performed in musical studies are so varied, it is expected that results would be conflicting and that the musical effects on each task must instead be studied individually (Day 2009). Most studies specifically focusing on differing music tempos have focused on the musical augmentation of human emotions and, as with most physiological studies of music, have been plagued with mixed results (Kellaris & Kent, 1994). A 2011 study found that music with a high tempo led to an increase in perceived tension and alertness (van der Zwaag, 2011). Fast music tempo has also been shown to increase spatial reasoning in addition to positive effects on mood (Husain, 2011). In a 2002 study, “calming relaxing music had a positive effect on the number of mathematics problems completed, remembering words from sentences and on reported prosocial behavior in children aged 10–12 years” while “arousing, unpleasant and aggressive” music had a “negative effect on performance on a memory task” (Hallam, 2002).

Regardless of the conflicting findings on the effects of music on physiological and cognitive function, in this study we examine the effect of music tempo on the concentration and accuracy of a common task: typing on a computer keyboard. Subjects were asked to complete an online typing test which gauged both typing speed and accuracy while listening to music of varying tempos. As discussed by (Ellis 2009 unpublished observations), using music of different genres and instrumentation introduces potential confounding effects. We used a single instrumental musical score that was edited to alter tempo in an attempt to eliminate these variables. Before and after each test, subjects had their blood pressure and resting heart rate recorded to establish indices of stress and arousal; during the test, heart rate and brain wave function were also monitored.

Hypothesis

We believe that while listening to music with a higher tempo, concentration on the typing test will be hindered due to distraction and increased stress induced by the music's higher rate of beats per minute. This will be evidenced by both increased heart rate and increased blood pressure, in addition to a lower score on the typing test. Furthermore, we believe that brain wave activity will be increased with lower performance on the typing test. Additionally, the brain must alter activity to accommodate reception of comparatively higher input from high-tempo music versus low-tempo music to foster concentration on the task at hand.

Materials and Methods

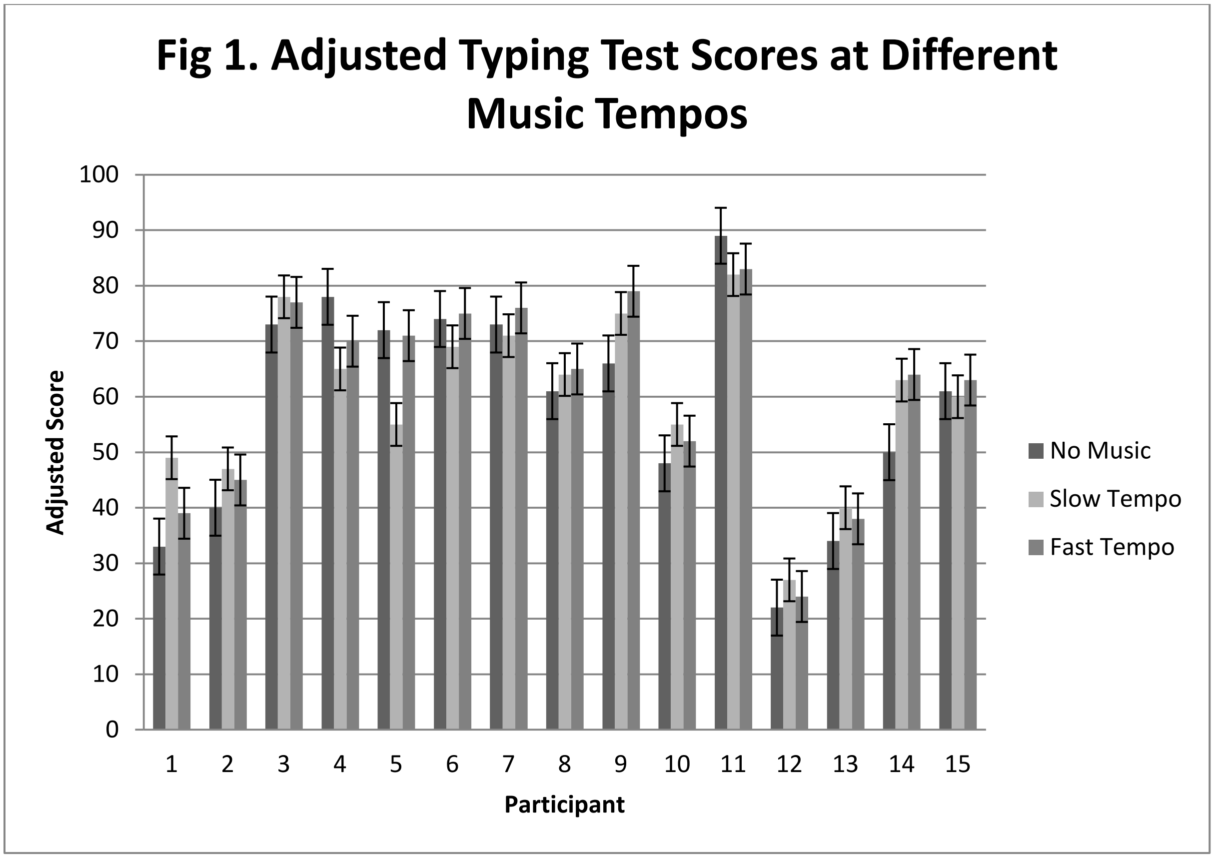
Fifteen student participants (9 males and 6 females) were selected from the University of Wisconsin Madison. Subjects ranged in age from 20 to 24 years old. All subjects voluntarily consented to participation in this study.

Subjects were asked to perform a typing test in three different scenarios: listening to no music, high tempo music, and low tempo music. The song "Moonlight Sonata" composed by Ludwig van Beethoven was used at the original 40 beats per minute for the slow tempo treatment and recomposed to 80 beats per minute for the fast tempo treatment using the audio editing program Audacity. Subject heart rate and blood pressure were measured manually with a blood pressure cuff and stethoscope before and after each typing test for each tempo of music, as well as at rest before beginning the study. An ECG was also used to track changes in heart rate and an EEG was used to measure brain-wave activity during the typing test, as described by the Biopac Student Lab manual (Pfanzer, et all 2008). EEG and ECG data were recorded and analyzed using the Biopac Student Lab program. In using the EEG we examined beta waves and alpha waves since low amplitude beta waves have been demonstrated to be important in maintaining attention and concentration and alpha wave frequency range is correlated to cognitive performance (Baumeister, et al 2008 and Klimesch W, 1999). Alpha and beta wave activity was quantified by measuring the mean frequency of beta-wave measurements across the duration of each typing test treatment. Furthermore, we also analyzed the overall range in amplitude of the beta wave activity by calculating the standard deviation in amplitude of the recorded beta waves for each test.

To reduce the effects of improved typing skill from subsequent tests, subjects were given each tempo of music in a random order and the content of the typing prompt was changed for each test. The typing test, administered through "typingtest.com," was two minutes long and recorded both typing speed and accuracy, providing a composite score of words per minute minus the number of grammatical errors.

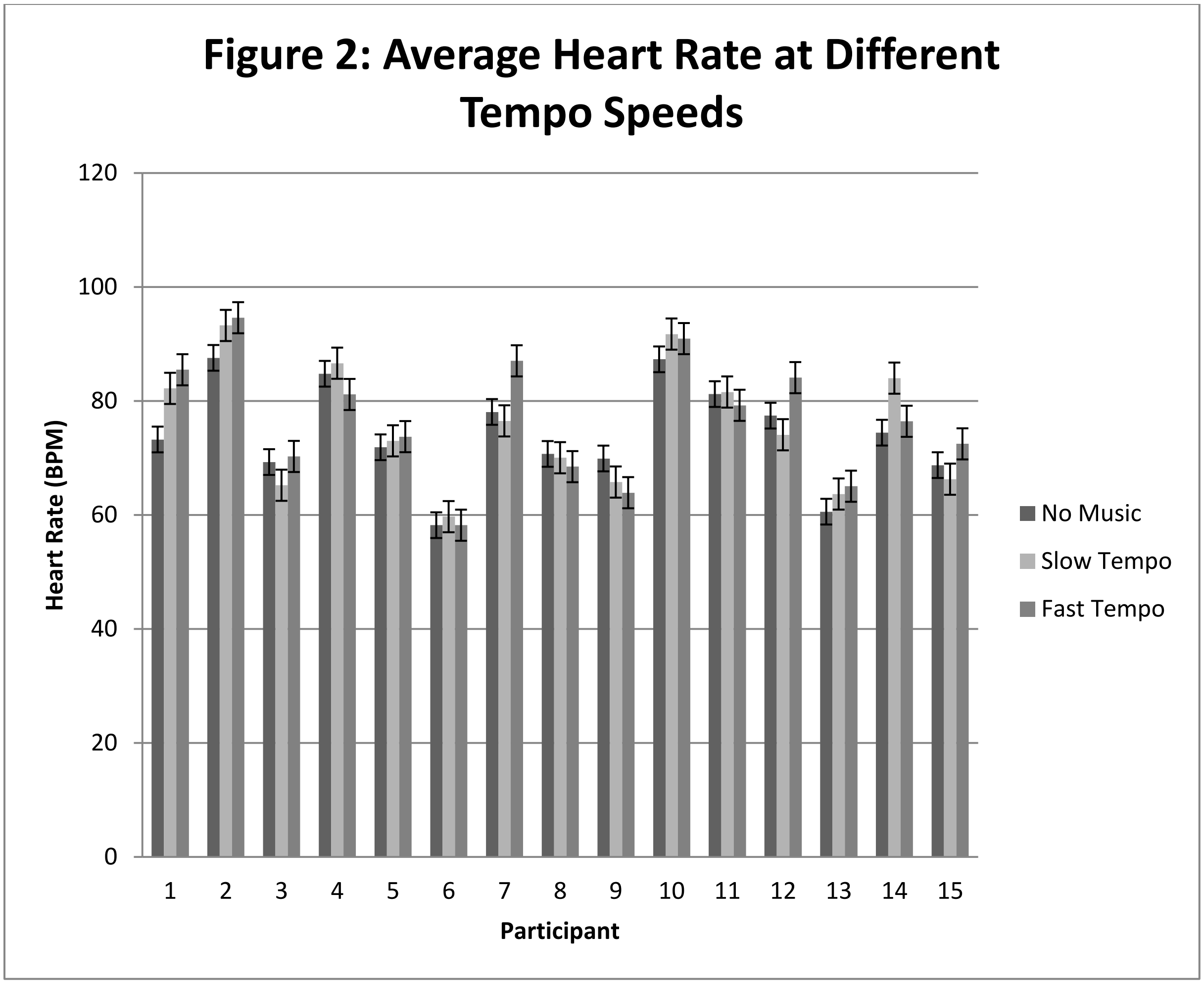
Results

The results from the typing tests were analyzed using T-tests and were entirely statistically insignificant ($p>0.05$). We measured participants' typing speed, number of errors,



and by subtracting the two created an adjusted score for comparison. We compared the adjusted score of all the participants in the no music session to their scores in the fast and slow tempo sessions. We also used T-tests to compare the fast tempo scores to the slow tempo scores. Listening to slow tempo music had no apparent effect on the adjusted typing score when compared to the no music control ($p=0.479$). Similarly, fast tempo music was also shown to be statistically insignificant ($p=0.364$). Furthermore, there was no significant difference in the adjusted score between the fast tempo and slow tempo sessions ($p=0.0531$). The variability in the adjusted scores can be visualized in Figure (adjusted typing test scores).

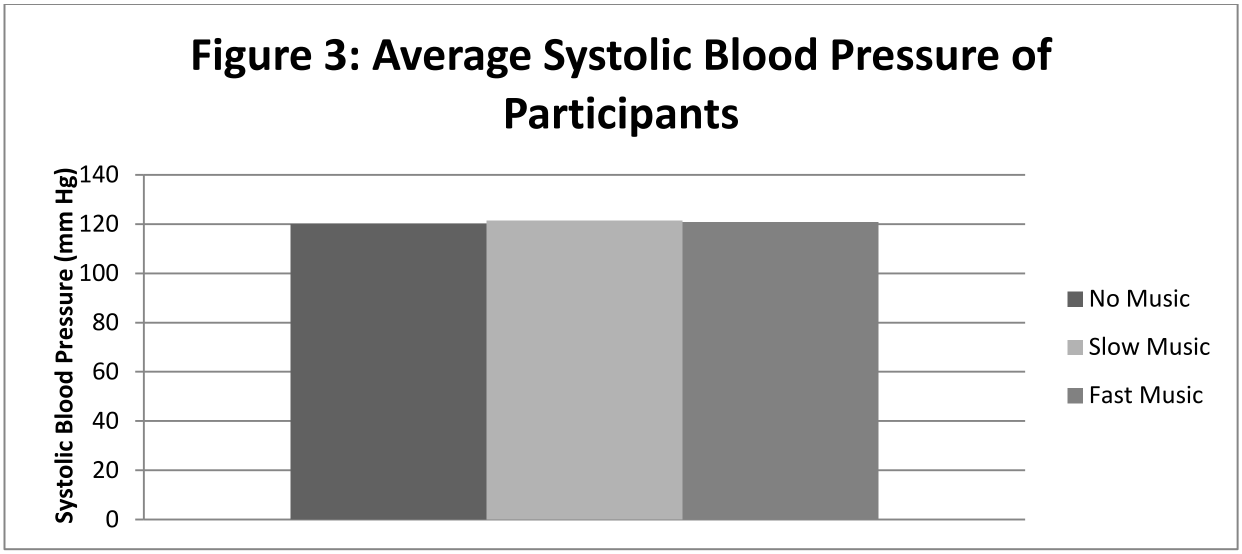
After our initial analysis of the typing data yielded no significant correlation, we decided to change our approach by normalizing each individual's score in order to take into account the variations between all the participants. This way we could measure and compare the percent change from baseline, the no music score, to the slow and fast tempo data. We used a T-test to



compare the normalized slow tempo scores to the normalized fast tempo scores and found no statistically significant difference (p=0.946).

To conclude our analysis of the typing data we tried performing the Mann-Whitney test. The Mann-Whitney test is a non-parametric test that compares independent variables. We used the Mann-Whitney test to compare the normalized typing scores, described above, and once again observed no change in performance (p=0.998).

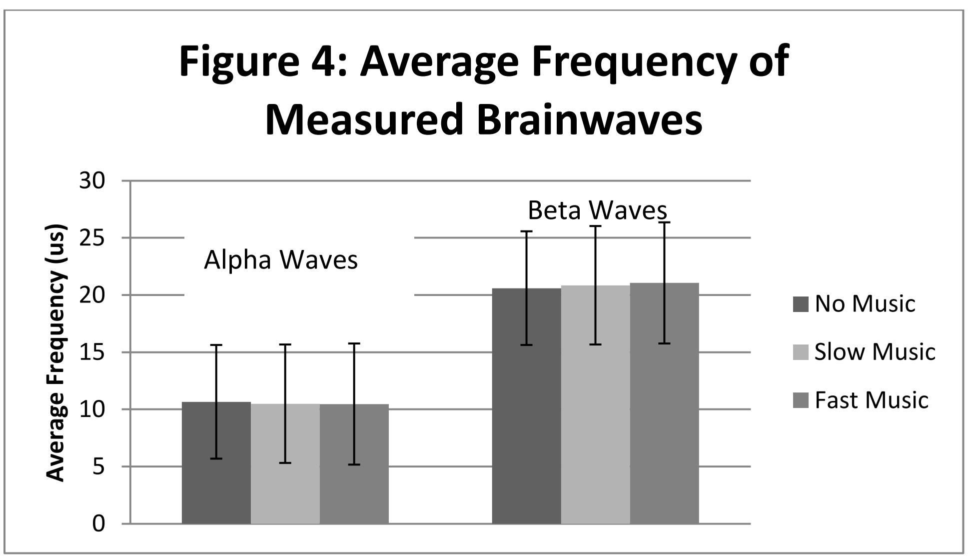
Listening to music while typing did not increase heart rate or blood pressure as we anticipated. The slow tempo music made no significant difference on heart rate (p=0.249). Likewise, heart rate did not change while listening to fast tempo music (p=0.0689). There was



also no statistically significant difference in heart rate during slow tempo music compared to heart rate during fast tempo music (p=0.397). Figure (average heart rate) shows the average heart rate during each typing test for each participant and illustrates the absence of any discernible trend. Blood pressure was also not affected by music and typing. We compared the systolic blood pressure after the no music session to both the fast and slow tempo sessions. The slow tempo music did not affect blood pressure (p=0.221) and neither did the fast tempo music (p=0.519). We averaged the systolic blood pressure of all subjects after each session, as seen in Figure (blood pressure graph), and observed no trend.

As we did with the typing data, we normalized the heart rate and blood pressure data. For each participant, we divided the average heart rate from the slow tempo and fast tempo sessions by the average heart rate from the no music session. We compared the population's normalized slow tempo heart rates to the population's normalized fast tempo heart rates and found no statistically significant difference (p=0.375). We repeated this procedure for blood pressure and found no meaningful trend (p=0.705).

Finally, we compared alpha and beta waves from our EEG data and again did not find anything statistically significant in regards to music tempo and brain activity. We measured the frequency of the waves and used the standard deviation to measure amplitude. We found no correlation in the alpha wave frequency during no music versus slow music (p=0.397), no music versus fast music (p=0.325), nor slow music versus fast music (p=0.900). Similarly, we found no correlation in the beta wave frequency during no music versus slow music (p=0.695), no music versus fast music (p=0.543), nor slow music versus fast music (p=0.733). The average frequencies for both alpha and beta waves were not significantly different (Figure (frequency graph)). We also found no correlation in the standard deviation of the alpha waves during no music versus slow music (p=0.161), no music versus fast music (p=0.209), nor slow music versus fast music (p=0.284). Likewise, we found no correlation in the standard deviation of the beta waves during no music versus slow music (p=0.114), no music versus fast music (p=0.143), nor slow music versus fast music (p=0.315). The variability in the standard deviation of alpha and beta waves for each subject can be visualized in Figures (SD graphs). Taken together, these results indicate that there was no statistically significant difference in brain activity while typing with no music playing, slow tempo music playing, nor fast tempo music playing.



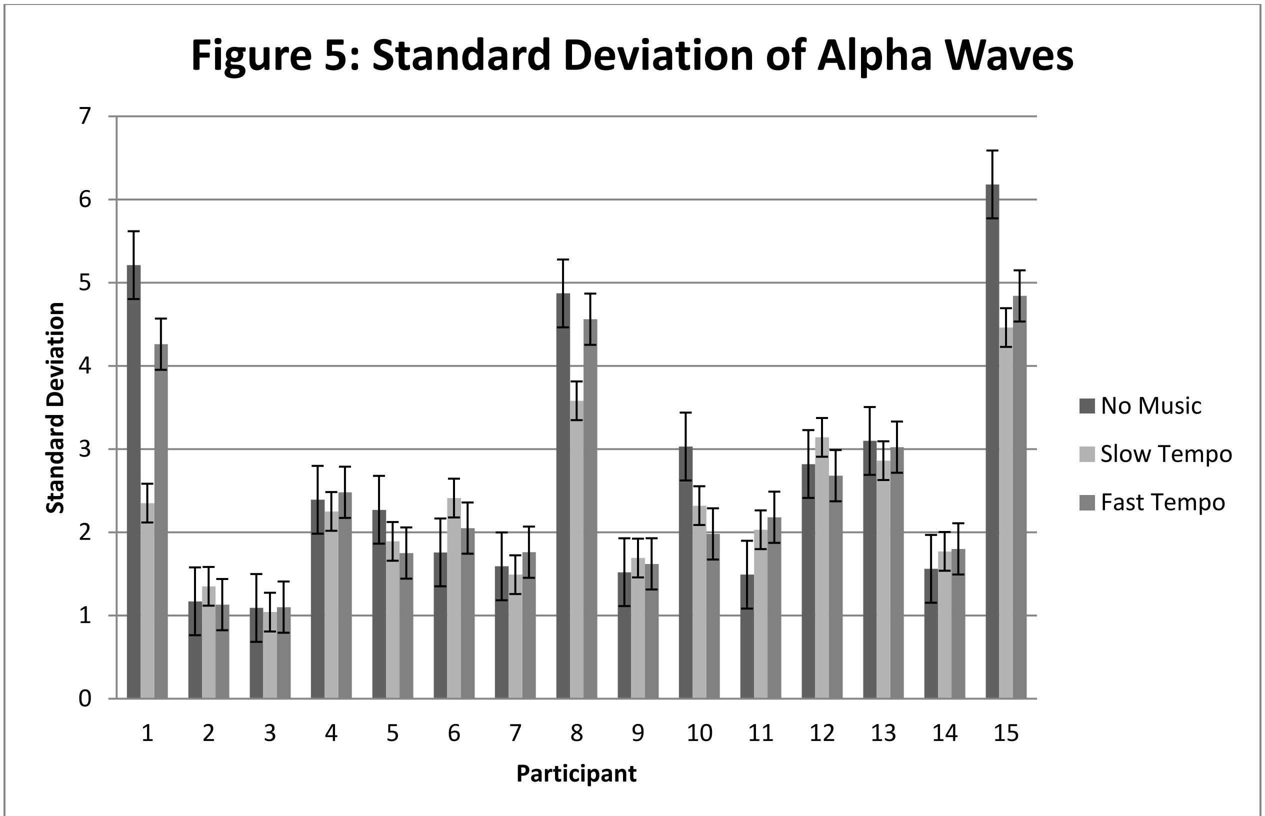


Figure 5: Standard Deviation of Alpha Waves
Standard Deviation
Participant
No Music
Slow Tempo
Fast Tempo

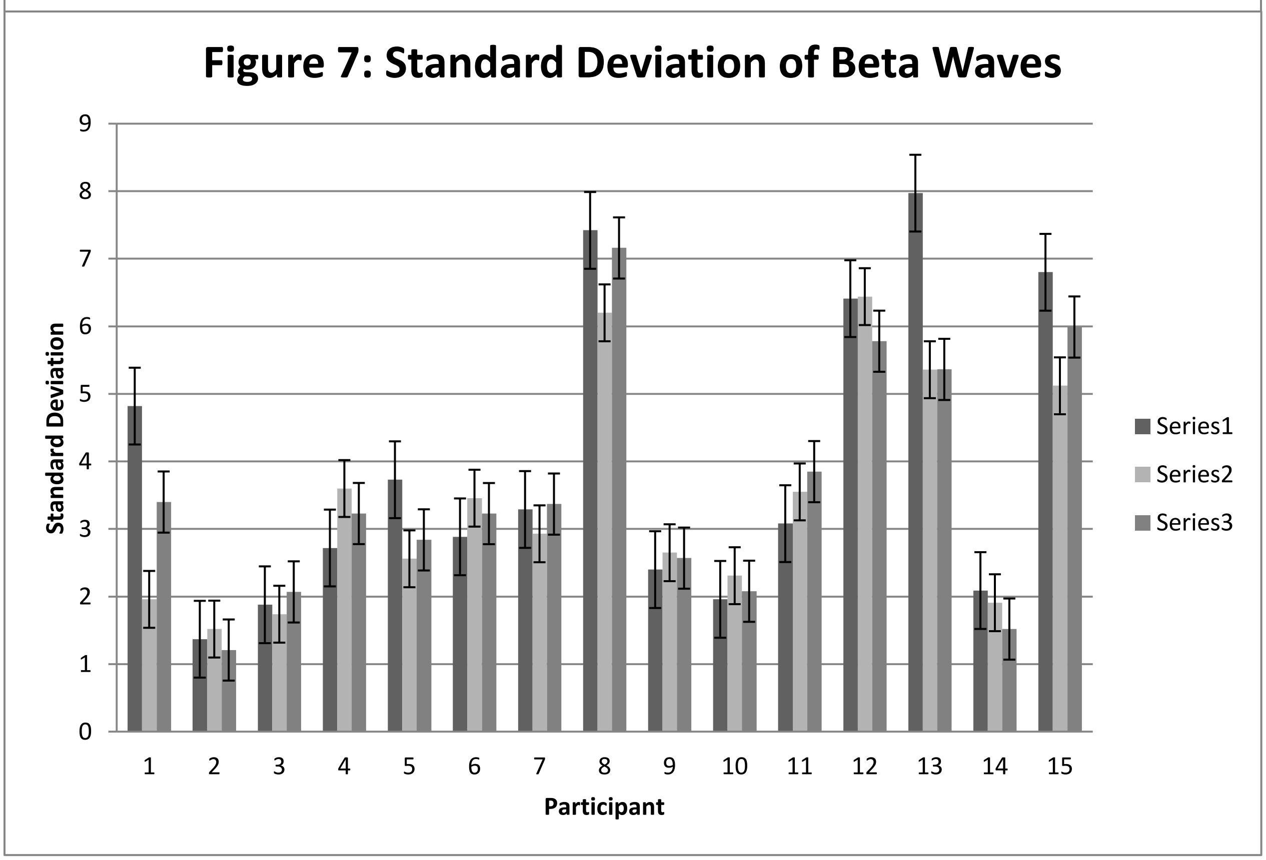


Figure 7: Standard Deviation of Beta Waves
Standard Deviation
Participant
Series1
Series2
Series3

Discussion

Our research yielded the somewhat unexpected results that music tempo does not play a significant role in affecting concentration or stress when doing a simple task like typing. Our data analysis did not reveal any significant correlations between tempo and the measured physiological responses indicative of stress and concentration (heart rate, blood pressure, brain wave activity, and typing accuracy).

A critical evaluation of our methods offers several aspects that may have affected our results and could be altered for further investigative research. The length of the trials, musical preference, and typing habits are important factors for consideration.

The length of the typing test and refractory intervals played a large role in obtaining the results above, and as such, are important to consider for future studies. We chose to use two minute intervals for the typing tests to reduce the effects of fatigue and boredom experienced by the participants as well as to reduce the effects of practice. However, two minutes may be too short of an interval for differing music tempos to produce a measurable physiological response. Similarly, the interval between typing trials may have been too short to allow participants physiological responses to return to baseline. In future studies, increasing the length of this refractory period may improve the quality of data.

We must also address the individuality of the subjects, including subjectivity of the music used for the study, work habits, and standard typing proficiency. Understanding our test subjects' music preference could allow us in supplemental studies to control for a subject's familiarity with our base song. Any previous exposure to our base song, or ones of a similar genre, could affect a subject's physiological response to the music thus altering the data we were able to analyze. A subject's preference for listening to music while performing standard tasks is also relevant to their physiological response. As some test subjects may not usually listen to music while typing, their physiological response would likely differ from a response from a subject who usually does listen to music. Thus, variation between the control, slow tempo, and fast tempo results are subject to confounding variables. The typing test itself could prove to have an effect on physiological responses depending on a test subject's typing techniques. Subjects who must look at the keyboard in order to properly type will have a disadvantage in our study as the typing test requires the subject to transcribe an on-screen passage provided by the website. For future studies, it would be prudent of us to control for music preference and work habits. Additionally, it could be helpful to select subjects who are proficient at transcription-style typing in order to eliminate this potentially confounding variable.

A number of technical difficulties hindered our collection and analysis of data. Due to time constraints, we were only able to test 15 subjects. Further studies would benefit from a larger sample population. Additionally, one may consider using a more sensitive EEG device with more electrodes capable of taking finer measurements. Another technical difficulty was identified in the blood pressure monitoring procedure. Because test subjects were typing throughout the trials, blood pressure had to be measured manually using a sphygmomanometer at the beginning and end of each typing trial. Ideally, blood pressure would have been monitored continuously throughout the trial and changes tracked automatically on a computer. Our study experienced a further limitation due to the software used; we found the *Biopac Student Software* to be difficult when it came to data analysis and manipulation. Extracting raw data was an arduous task, and coupled with the time constraint, our data collection and analysis was restricted.

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