The Effect of Nintendo's NES Tetris Theme Music and 28 Hertz High Beta-Frequency Binaural Beats on a 233 Hertz Carrier on Attention Span

Purpose

The purpose of this project is to determine the effectiveness of binaural beats (28 Hertz beat frequency on a 233 Hertz carrier) and video game music (Nintendo's NES Type A Tetris Theme) on improving attention span. It aims to find the differences between the efficacy of two types of auditory stimuli relative to silence, which was used as the control group.

Hypotheses

1. **Listening to either binaural beats or video game music while performing a focus task will be effective in improving attention span compared to not listening to any audio.** This hypothesis was informed by research that studied the effects of binaural beats on seniors and found a significant increase in cognitive function. Video game music may similarly affect attention span since it is designed to keep players focused in-game. Studies have supported this function.
1. **Video game music will have slightly less efficacy in improving attention span than high-frequency beta waves.** This is inferred because video game music may also have distracting qualities, such as a busy rhythm. Thus, the order of efficacy in terms of lengthening attention span would be as such: 1) binaural beats, 2) video game music, and finally 3) silence.

Background Research

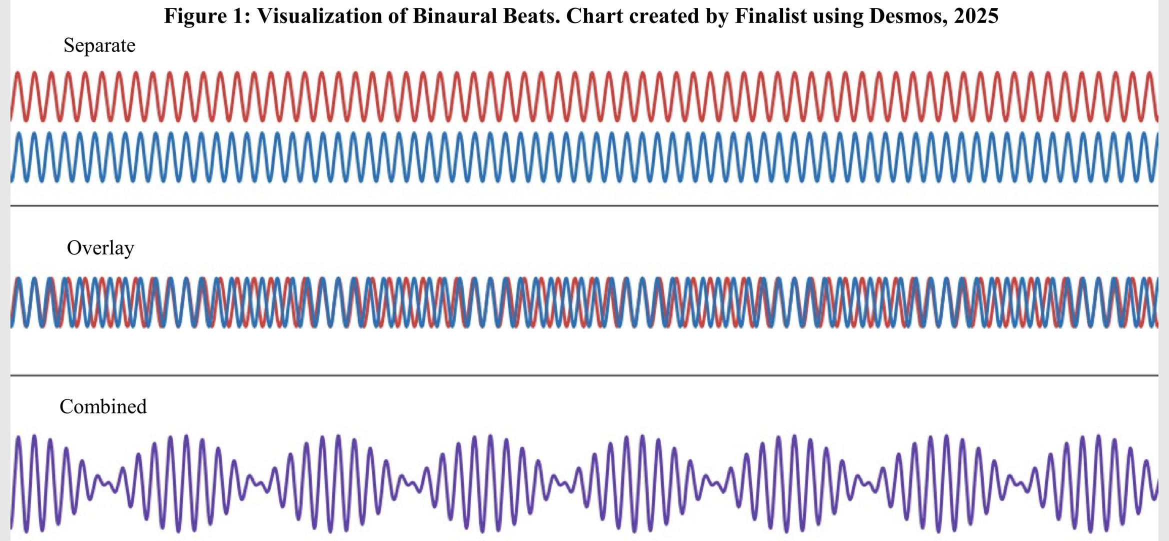
In fifth grade, I conducted an experiment that found that listening to music can improve mood. Other studies have similar findings, including a study by Ahmed, N. et al., which found that music can increase and decrease happiness based on the mood of the music. Dr. Anne Fabiny from Harvard Health writes that music activates parts of the brain that control mood, memory, and other cognitive functions. In sixth grade, I extended my previous project and found that certain music was effective in promoting memorization. Still, other studies have found varying results: some find that the music is a distraction, while others find astounding improvements to memory.

After reviewing my last project, I realized that there is one more variable worth looking into that may affect memory: attention span. Attention itself is the process that takes sensory information and transforms it into short-term memory. In other words, if one is distracted during a memorization session, less information will be remembered. Thus, given that music increases short-term memory retention, it is possible that music can also impact our attention spans.

The digital and social media era has been associated with shortened attention spans. According to Samba Recovery, the average attention span dropped to 8 seconds in 2023 — less than the attention span of a goldfish. The same year also showed one of the lowest average SAT scores since test changes in 2016, almost 40 points less.

How can we address this issue? Many studies have investigated promising effects that binaural beats may have on our attention spans. Binaural beats occur when two different sound waves are simultaneously played to each ear, creating a pulsing effect as the waves interact. The difference in frequency determines the rate of pulses.

Figure 1: Visualization of Binaural Beats. Chart created by Finalist using Desmos, 2025



Interestingly, the pulse frequencies of binaural beats are similar to brainwave frequencies. According to Ruth Maria Ingendoh, et al., as binaural beats are heard, the brain then matches or "entrains" onto those frequencies. Beta-frequency brainwaves (20-29 Hertz) are linked to focused thought and problem solving; creating a pulse frequency close to that range may encourage focus from the brain.

Study results have been contradictory. In a study led by Lorenza S. Colzato, 40 Hz gamma-wave binaural beats boosted focus and reaction time. Another study, led by Leistiko N. M., similar 40 Hz gamma-wave binaural beats brought no change in "efficacy of the attention networks."

Studies show video game music boosts focus in-game, but its effects out-of-game are less studied. One article argues that it should improve focus, even out-of-game. Writing for the McKendree Review, Kristina Ferry says that, "[video game music] is designed to help focus … successful video game music [balances] being engaging and exciting, but also not [annoying]."

Since beta-frequency brain waves are linked to focus, this study used beta-frequency binaural beats, while also being near to the gamma-wave spectrum to keep with previous research; 28 Hertz fit this criteria. Tetris video game music was chosen because the game Tetris requires focus and quick thinking as you manipulate the blocks.

Variables

Independent Variable	The sound or auditory stimuli that participants listen to.
Dependent Variable	Participant reaction time and error rate, derived from the SART Test.
Control Variable	SART test length, survey order, participant sound setting, among others.

Materials

Google Colab Notebook	SART (Sustained Attention to Response Task)
Google Sheets Document	Survey Creation Software (Psytoolkit)
Computer	28 Hertz Binaural Beats on a 233 Hertz Carrier
Headphones	Nintendo's NES Type A Tetris Theme

Data and Results

A total of 65 people participated in the experiment: 30 male, 31 female, and four who did not disclose their gender. Seven were under 12 years old, 18 were between 12 and 24, 15 were between 25 and 44, 17 were between 45 and 64, and one was older than 65 years old. There were 19 binaural beats participants, 23 control, participants and 21 Tetris participants.

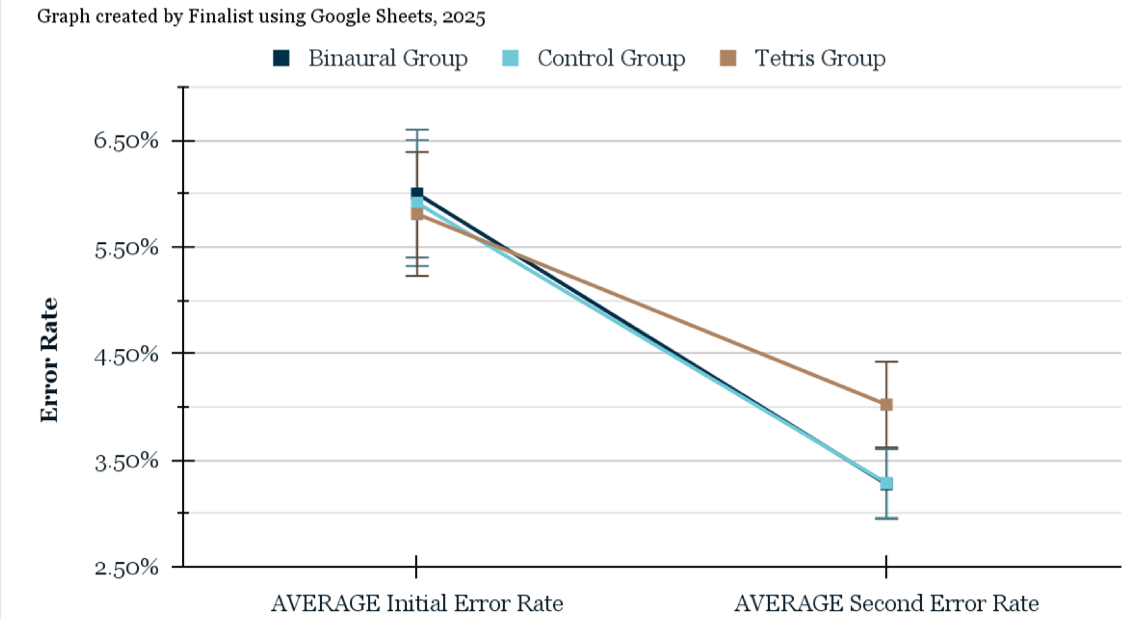
Figure 2. Overall Change and Improvement Between Tests, by Group
Data table created by Finalist, 2025

Group	Error Rate Change	Reaction Time Change	Performance Index Change
Binaural Beats	-2.73%	+33.52 ms	0.0001 %/ms
Tetris Group	-1.79%	+44.88 ms	-0.0005 %/ms
Control Group	-2.63%	+36.46 ms	-0.0005 %/ms

The results show that listening to either binaural beats or video game music affects focus in error rate, reaction and performance index. In error rate, the binaural beats group improved the most. In reaction time, the Tetris group worsened the most. In performance index, the binaural beats group improved, while the other groups worsened. There is a slight negative correlation between reaction time and error rate. However, the results are not statistically significant.

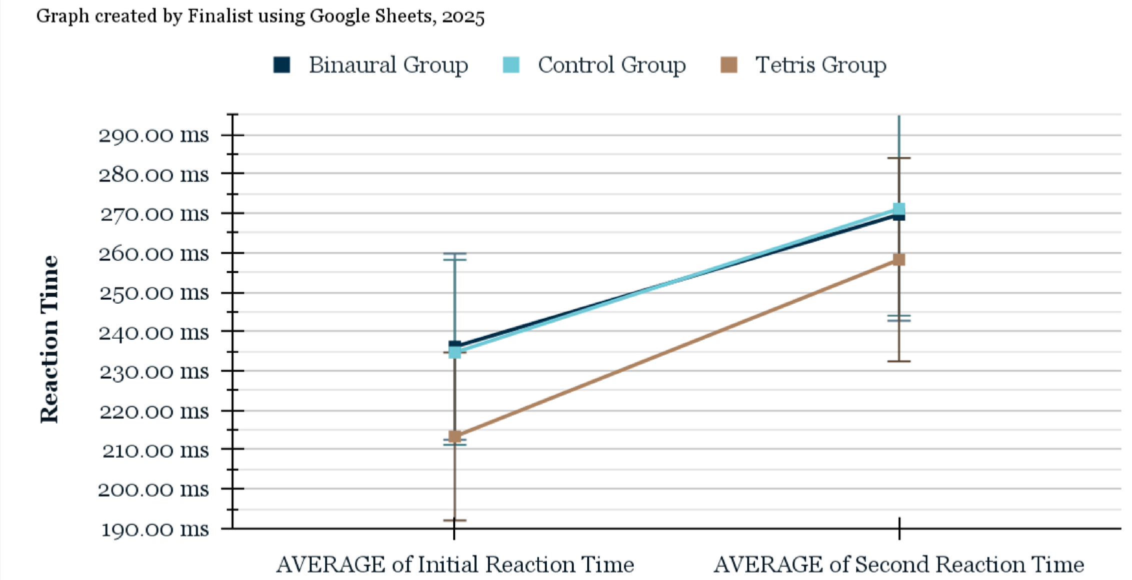
Analysis

Figure 3. Average change in error rate, per group



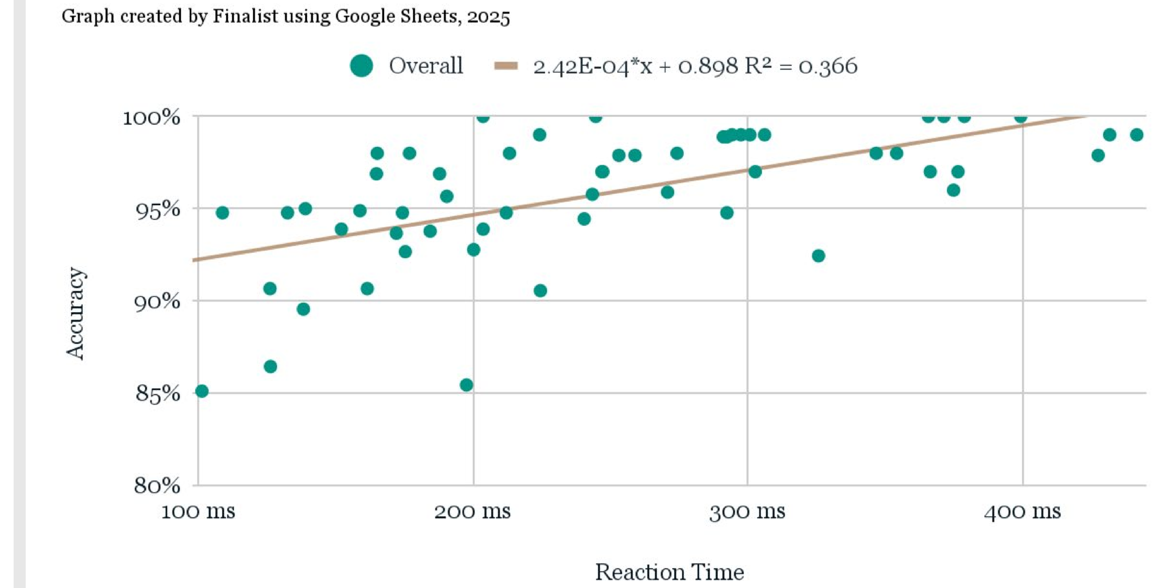
If a participant decreases in error rate, they are improving in accuracy. In Figure 3, it can be seen that the groups generally started with a similar error rate around 6%. However, the Tetris music group does not improve as much as the binaural beats group and the control group, suggesting that it does not help as much as binaural beats in increasing accuracy. Note that all participants decreased their error rate.

Figure 4. Average change in reaction time per group



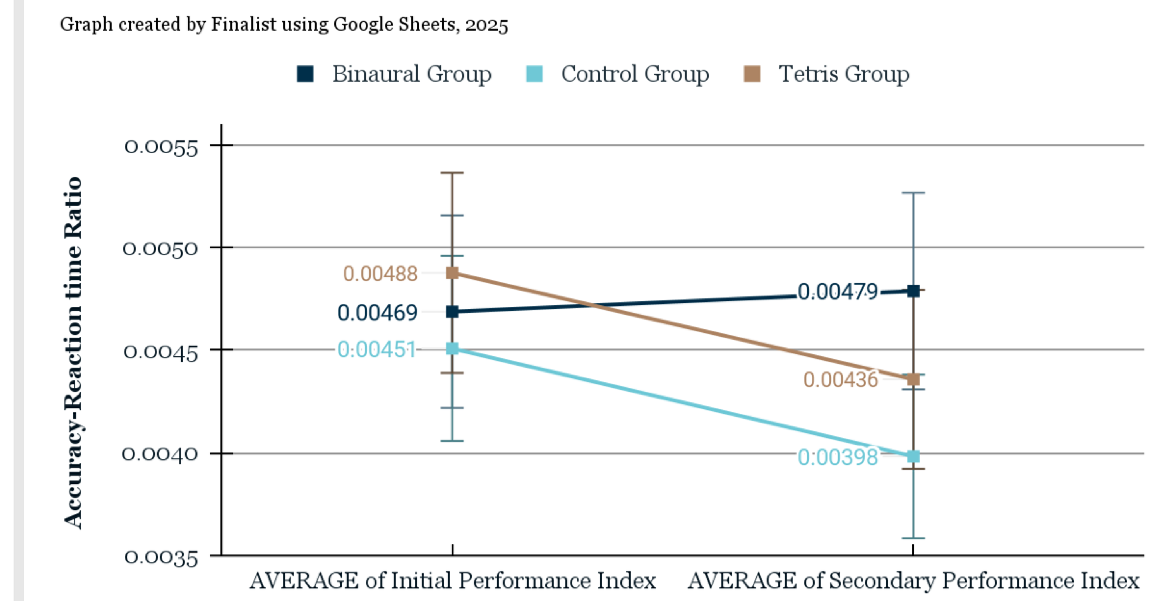
As seen in Figure 4, the groups initially varied slightly more at the beginning than at the end, though it is interesting that they generally keep the same trend. All groups increased in reaction time, most likely because if someone observed the digit for longer, accuracy increased, which was rewarded more than reaction speed. The Tetris group, out of the three, increased the most. This may not be a good thing however, as slower reaction time may correspond to lower focus.

Figure 5. Reaction time compared to accuracy



In Figure 5, each green dot signifies a participant and the tan line represents trend. It can be seen that as reaction time increases, accuracy increases. The trend is not strong, as is shown by the low R^2 value, at 0.37. Nevertheless, this makes sense given the structure of the SART. The longer one takes to determine their response, the less likely to make a mistake, and vice versa. It is thus intriguing if one has a lower error rate but not a longer reaction time.

Figure 6: Average Change in Performance Index by Group



This graph shows the average value of the participants' accuracy divided by their reaction time in milliseconds, a ratio that can be called the performance index (PI). A high performance index indicates fast, accurate responses and high focus, whereas a low PI indicates slow, inaccurate responses and low focus. All groups started out with a similar PI. Interestingly, in the second test, the Tetris group and the control group both worsened while the binaural beats group improved, suggesting that binaural beats are better for focus.

Conclusion

The results partially support the hypothesis: only binaural beats is more effective in improving focus. The first hypothesis stated that binaural beats and video game music would be superior to the control group in attention span improvement. The binaural beats group had more improvement than the control group in all metrics, especially in performance index, where it improves while the control group worsens. However, the Tetris group improved less than the control group by all metrics, suggesting that it is detrimental to focus.

The second hypothesis stated that binaural beats would be more effective than video game music. Binaural beats participants on average did about 1% better than Tetris music participants in accuracy, and were about 17 milliseconds faster in response time. As binaural beats participants did better in both error rate and reaction time, we can conclude that binaural beats is generally more effective in improving visual attention. This finding could be a result of the video game music being hard to focus with, due to its busy nature. Many participants also gave anecdotal evidence that of this, stating that it was hard to focus while listening to video game music. Thus, the second hypothesis was supported by the experiment results.

However, none of the statistical tests show any statistical significance. This includes differences between groups in error rate, reaction time, and performance index. In fact, some of the p-values are greater than 0.50, meaning that they are most likely to be due to random chance and that there is a very low chance of a consistent effect of the auditory stimuli tested on focus. Thus, we do not have enough evidence to make concrete, reliable conclusions based on the data.

This test is far from perfect, and there are many aspects of the project that can be improved on if this project is to be continued or replicated. One point of improvement is to recruit more participants, potentially leading to stronger, more conclusive results. Another point that can be changed would be the order of the survey and the amount of time participants listen to the auditory stimuli. This change would give more time for the sound to make an impact on participant attention. It may also create clearer differences between groups and results that are more concrete. Additionally, the scope of this project can be widened by testing other types of auditory stimuli, such as Lo-Fi music, movie soundtracks, or classical music. Other types of binaural beats could be tested as well.

In summary, the most effective auditory stimuli for encouraging attention and focus out of the stimuli tested is binaural beats, followed by silence and lastly video game music. More research regarding auditory stimuli and focus is needed to draw more reliable conclusions.

Procedure

Survey Creation

The survey was created using Psytoolkit, a survey platform, for its simplicity and compatibility. It consisted of 1) a consent form, 2) background questions, and 3) the attention span test.

1. The consent form included terms on privacy, safety, and parental consent requirements.
2. Background questions included gender, age, occupation, musical background, multitasking preferences, and favorite tasks.
3. The Sustained Attention to Response Task (SART), an attention span test that was sourced from Psytoolkit, with slight visual changes made by the Finalist. The task details are shown in 4a.

Data Collection

1. The online survey was shared through the Finalist's school, email, social media, and a survey-sharing platform.
2. Participants opened the survey in a browser and were asked to provide their consent. Those who did not consent were not required to continue.
3. Next, the survey randomly assigned participants to three groups: 1) Nintendo's NES Tetris Type A Theme, 2) 28 Hertz binaural beats on a 233 Hertz carrier, and 3) control (no audio).
4. The survey asked participants to go to a quiet setting (less than 70 decibels of ambient noise, measured by an audio test) and wear headphones. Participants were then asked to complete the SART without listening to audio. The following describes this focus task.
   a. First, a digit between 1 and 9 was randomly shown to the participant for 200 milliseconds (ms).
   b. If the digit was not a three, they had to press the spacebar within 1,100 ms. Otherwise, the participant was not to press the spacebar.
   c. A white circle covered the digit after 200ms with the spacebar function still active.
   d. If the participant incorrectly pressed or did not press the spacebar, the game paused for 2,500 ms to display an error message. If the participant correctly pressed or did not press the spacebar after a 3, the white circle turned green.
   e. Participants repeated steps 4a-4e fifty times.
   f. Data about the participant's test, such as the digit shown, the reaction time, and the response correctness was recorded automatically by the survey.
5. Participants then completed the attention span test a second time, though this time they instead listened to the stimuli relevant to their group. This allows for difference-in-difference analysis, a technique that eliminates initial bias due to skill.
6. After completing both SART, participants responded to the prepared background questions.

Statistical Test

Figure 7: Statistical Tests. Data table created by Finalist using Google Sheets, 2025

Test Type	Statistic	Compared Groups	Variance Type	P-Value
2-Tailed T-Test	Error Rate Improvement	Binaural, Control	Heteroskedastic	0.95
		Control, Tetris	Homoskedastic	0.64
		Binaural, Tetris	Heteroskedastic	0.54
	Reaction Time Improvement	Binaural, Control	Heteroskedastic	0.93
		Control, Tetris	Heteroskedastic	0.73
		Binaural, Tetris	Heteroskedastic	0.35
	Performance Index Improvement	Binaural, Control	Heteroskedastic	0.34
		Control, Tetris	Heteroskedastic	0.99
		Binaural, Tetris	Heteroskedastic	0.38

Figure 7 shows varying statistical hypothesis tests. The variance type is determined by comparing the variances of the groups (heteroskedastic is mixed variance, homoscedastic is same variance, and they are all 2 tailed, since change can be both positive and negative. The first three tests are t-tests comparing error rate improvement between two groups at a time. The second three tests are again t-tests, but in this case, they compare reaction time between groups. The third set of three tests measure the improvement in the previously defined Performance Index (calculated as accuracy/reaction time). The color of the p-value corresponds to the None of the tests show statistical significance, with all p-values being above 0.3. This suggests a high likelihood of the results being due to random chance, and we cannot reject the null hypothesis (H_0). This means that the differences between the type of music listened to either had little effect or no consistent effect on the performance of the individual.

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