The Analysis of the Mozart Effect on Visual Search

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1 ABSTRACT

1.1 Author Keywords

mozart effect, visual search

2 INTRODUCTION

Over twenty-five years ago, researchers began to study the effects of music on the brain and cognition. The Mozart Effect is a term that was first coined by Dr. Alfred Tomatis in 1991 in his book titled "Porquoi Mozart" in which Tomatis advocated the use of Mozart music as alternative medicine for those suffering from dyslexia, autism, and other learning disorders. [Sorensen 2008] This effect, originally called "The Tomatis Effect" was observed by Tomatis during therapy sessions with his patients. From his observations, Tomatis claimed that Mozart music helped promote healing and could even cure depression. The definition of the term evolved over time; in the present day, the term "Mozart Effect" is typically used to refer to the phenomena of improved spatial reasoning after exposure to Mozart music.

Studies conducted in the 1990's [Rauscher et al. 1993] gave rise to supposed evidence for the use of Mozart music in increasing abstract or spatial reasoning, or even general reasoning and intelligence quotient (IQ). In these studies, participants displayed improved performance in spatial reasoning or abstract tasks after exposure to Mozart music for several minutes. However, future studies would proceed to contest these studies and their results, pointing out their flawed design and refute their evidence.

Today, the effects of music on cognition are still up for debate, though the Mozart Effect is now typically considered ethereal at best, either having little or no effect on thinking or cognitive development. However, there appear to be no studies specifically focusing on the Mozart Effect and its relation to eye movements and visual cognitive tasks. This study aims to further grow the body of knowledge concerning the Mozart Effect by studying its relationship with visual search in two ways: performance on visual puzzles and gaze patterns. Due to the lack of any substantial modern evidence supporting the Mozart Effect, it is hypothesized that it will not have any significant influence on performance with visual search tasks.

3 BACKGROUND

The Mozart Effect phenomenon was first popularized by a 1993 study [Rauscher et al. 1993] from which there was evidence that exposure to Mozart music for several minutes led to an improvement in spatial reasoning. In this study, three groups of thirty-six college age participants were split into three groups, each of which receiving one kind of audio stimulus for ten minutes: Mozart's sonata for pianos in D major, a relaxation tape, or complete silence. Of these three groups, the Mozart music group was found to have scored the highest on average on a given Stanford-Binet abstract/spatial reasoning task than the other two groups, leading by eight to nine points. The study claimed these were statistically significant results, while also mentioning that the cognitive boost was temporary, lasting only around ten to fifteen minutes.

Rauscher would proceed to release more research findings backing the Mozart Effect, including a study to replicate the results of her first study [Rauscher et al. 1994] and a study that appeared to give evidence that playing music for rats in utero led to improved maze learning. [Rauscher et al. 1998] The evidence given by Rauscher's first study led to the Mozart Effect becoming a popular sensation. [Jenkins 2001; Sorensen 2008] Soon after the publication of the 1993 study, Alex Ross from New York Times misinterpreted the findings of the study and claimed that Mozart music makes people smarter, not that it just may help improve spatial reasoning. This claim took root in the academic community and the general public. Other writers and researchers took advantage of the popularity of the phenomenon and published articles backing the Mozart Effect, such as Don Campbell with his 1997 paper on the subject that later

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allowed him to sell collection of Mozart music as learning aides for children and adults.

Around the beginning of the 21st century, further research on the Mozart Effect led to the results of original 1993 study coming into question. Other researchers found that it was difficult or impossible to replicate the results of that first study. A 1999 study by Steele et al. tried and failed to reproduce the 1993 experiment results, [Steele et al. 1999] despite being given the list of key procedural components to produce the effect by the original authors. It was later found that the 1993 study had a significantly flawed experimental design. [Sorensen 2008] To start, it only used a partial Stanford-Binet score since it only tested spatial reasoning; this score was then tripled to resemble or estimate a full score. Critics claimed that its sample size was too small, and that it had poorly controlled tests. Participants weren't properly assessed prior to testing to check for variables that would affect test scores, such as giving a hearing test, asking if they had eaten, or asking if they liked or disliked Mozart music. Other studies would go on to either debunk the Mozart Effect entirely, stating that there were alternative explanations for its results, or support the notion that the Mozart Effect simply isn't as powerful as the original studies made it out to be. Another study [Chabris 1999; Lerch 2000] didn't viciously debunk the Mozart Effect, but simply found evidence that any cognitive enhancement offered was small, and that it doesn't reflect any change in IQ or general reasoning skills.

Several studies gave an alternative explanation for the Mozart Effect. One prominent explanation is that any improvement in test performance can be attributed to emotional arousal and other factors that influence learning and memory formation. Thompson et al. [2001] found evidence that the Mozart Effect was simply an artifact of arousal and mood. Later, Thomspon et al. [2002] conducted a similar study and came to a similar conclusion Cognitive neuroscience [Sorensen 2008] suggests that there are two types of memory that affect learning and test performance: procedural memory—the ability to remember steps and procedures, and declarative memory—the ability to remember facts. There are some factors that affect the establishment of these memories, such as repetition, expecting reward, sufficient sleep, and excitation at the time of learning. This implies that emotional arousal enhances memory function and learning, and could account for the results of the first 1993 study. For example, entering a test environment and listening to stimulating and enjoyable classical music might provide enough stimulation and emotional arousal to produce a noticeably higher spatial reasoning score. This notion was supported by the 2002 study by Thompson et al., which showed that musical tempo and mode (major or minor) manipulation affected arousal and mood, respectively, regardless of whether or not it was Mozart music or another artist or genre. [Thompson et al. 2002] More studies further debunked the Mozart Effect, even going so far as to say that it didn't affect spatial or abstract reasoning either. Evidence was shown that the Mozart Effect didn't have any effect on the spatial abilities of children, [McKelvie and Low 2002] as the type of music given to the children didn't make a difference on spatial task performance. Another study [Bridgett and Cuevas 2000] debunked the Mozart Effect as having any influence on mathematical performance, as the music made no difference between a pre-test and post-test of mathematical performance.

A more modern study [Pietschnig et al. 2010] took one last look at the original 1993 study and picked it apart, finding evidence for publication bias that would explain why all the studies done by Rauscher were published as giving positive results for the Mozart Effect. It concluded by showing a negligible effect between two types of music and task performance, further showing that any musical stimulus has the potential to positively influence test performance, not just Mozart or classical music.

After being refuted time and time again, the Mozart Effect is now seen more as a flawed theory gone out of control, and now considered more so a myth than a significant phenomenon. While the Mozart Effect holds little weight in the present day, it is still worth exploring whether or not Mozart music—or any music at all—can influence visual search patterns and performance on visual puzzles.

4 METHODOLOGY

4.1 Experimental Design

The experiment consisted of two trials per participant. Each trial consisted of a visual search task in which the participant had to find a certain colored letter 'O' amongst a "letter soup" of similarly colored letter 'N's and differently colored letter 'O's. There were two versions of this search stimulus that differed only in the colors and placement of the letters; one stimulus uses red and green letters while the other stimulus uses blue and orange letters. One of the two stimuli was used as the stimulus for each trial. Performance would be measured in the form of the time it took for the participant to complete the visual search task. The experiment used two test conditions. One condition was wearing headphones with no music playing, while the other condition was wearing headphones playing the classical music piece "Eine Kleine Nachtmusik" by Wolfgang Amadeus Mozart. Each participant was tested with both test conditions and both stimuli.

This created a 2 x 2 within-subject design, where all participants were tested with both test conditions with similar stimuli to compare performance between listening to no music and listening to classical Mozart music. Because this was a within-subject design, counterbalancing needed to be used to mitigate the order effect. Therefore, the twenty-four participants were split into four groups depending on the order of test conditions used (category A or B), and the order of stimuli used (category 1 or 2.) This yielded groups A1, A2, B1, and B2, where the participants' individual experiences are "randomized:"

- A1: no music with Stimulus 1, then music with Stimulus 2
- A2: no music with Stimulus 2, then music with Stimulus 1
- B1: music with Stimulus 1, then no music with Stimulus 2
- B2: music with Stimulus 2, then no music with Stimulus 1

Participants were assigned to a group as they were recruited and came to the lab; Participant 1 was assigned to A1, Participant 2 to A2, Participant 3 to B1, Participant 4 to B2, Participant 5 to A1, and so on.

4.2 Participants

We planned to recruit twenty-four participants for this study. However, due to time constraints, we were only able to recruit and test twenty participants. All participants were Clemson University undergraduate students in the 20-29 year age range. Seventeen were male, while three were female. Eighteen of the twenty participants had normal or corrected vision, while two were uncorrected or didn't have their glasses with them, but claimed that their vision wasn't significantly impaired.

4.3 Stimuli

Participants were exposed to varying combinations of three stimuli, two visual and one audio. As seen in Figure 1, visual stimuli were composed of the letters 'O' and 'N' in a random "letter soup" in which the letter 'O' occurred in a particular color once amongst similarly colored 'N's and differently colored 'O's. The goal of the visual search was simply to find this odd 'O'. There were two versions of this stimulus that only differed in letter color; one version used red and green letters, while the other version used blue and orange letters. The audio stimuli was in the form of "Eine Kleine Nachtmusik" by Wolfgang Amadeus Mozart, played through headphones connected to a smart phone belonging to one of the research team members. The audio and visual stimuli are presented concurrently, and participants are exposed to them in an order determined by their group.

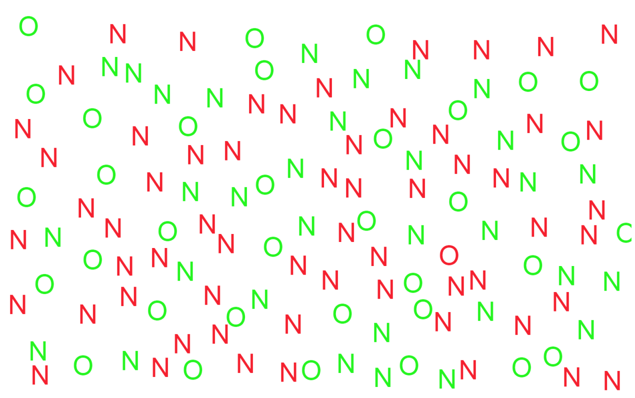

Figure 1: A sample of the stimuli used in the study.

4.4 Apparatus

In order to collect eye movement data, a Gazepoint GP3 Eye Tracker was fitted below the participant's computer monitor. The GP3 has a foveal accuracy of .5 degrees and a sampling rate of 60 Hz. The participants were seated in sturdy chairs 18-24 inches from a 19 inch Dell P2213 monitor with a screen resolution of 1680 x 1050 pixels. The headphones used were Bose QuietComfort 35 headphones. A smart phone was used to play the music through the headphones.

4.5 Procedure

Participants were recruited through verbal announcement from the research team and a recruitment email sent by one of the research team members. Upon acceptance, the participants met the researchers in the computer lab individually, where they were instructed to sit down in a chair in front of the testing computer. An overview of the experiment was given and each participant was given an informational and consent letter and given time to read the letter and ask any questions. After being given verbal consent, one of the researchers presented the participant with a pre-experiment demographic questionnaire, in which the participant gave his/her age, gender, and vision. A research member then opened up the GazePoint Analysis software to begin collecting data. Written instructions for the trial were included with the set of stimuli to be displayed on the screen, along with a sample of the target image that the participants would be looking for in each trial.

The participant then performed eye tracker calibration and then proceeded to a nine-point calibration for use with the experiment. Following calibration, the participant was then shown a blank black screen so as not to prematurely expose the participant to the stimulus. The participant then put on the provided pair of headphones. Depending on which group the participant was in, he/she would perform the first trial with no music or with "Eine Kleine Nachtmusik" playing through the headphones and with Stimulus 1 or 2. The participant was tasked with visually search the stimulus for the target image (either a red or blue 'O') and then fixate on the target image once he/she found it and press the spacebar on the keyboard while still looking at the target to advance the experiment. After completing the first trial, a blank image would again be shown on the screen until the participant was ready for the next trial. The participant was offered a short break and asked if they wished to continue. If and once the participant was ready, the second trial was conducted with the other test condition and stimulus. Both trials were timed using the Gazepoint Analysis software. The stimuli images were set to 0 duration, and the trial timer would stop once the participant pressed the Escape key. Once both trials were completed, the participant was given a post-experiment questionnaire in which he/she filled out a few Likert scale questions and could give any additional comments. After filling out the questionnaire, the participant was thanked and dismissed.

5 RESULTS

Table 1 and Figure 2 show a comparison between the average trial completion times between the four groups for each test condition. For the "No Music" condition, groups A1, A2, B1, and B2 had an average completion time (in seconds) of 6.78, 7.53, 5.51, and 7.46,

Average Completion Times (in seconds)				
Group/Condition	A1	A2	B1	B2
No Music	6.78	7.53	5.52	7.47
Music	7.30	7.34	6.99	8.10

Table 1: Average task completion times between groups.

respectively, for an overall average of 6.82 seconds for the "No Music" condition as a whole. For the "Music" condition, groups A1, B1, A2, and B2 had an average completion time (in seconds) of 7.30, 7.30, 6.99, and 8.10, respectively, for an overall average of 7.42 seconds for the "Music" condition as a whole. From this data, it may seem that the presence of the classical music actually led to increased search times. However, this data had a rather large p-value ($p = 0.602 > 0.5$), indicating that it is statistically insignificant.

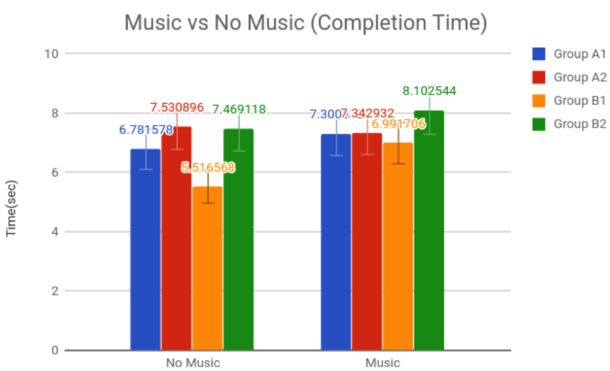

Figure 2: A graphical comparison of the completion times of each group.

The participants' numbers of fixations and their durations were also recorded. The "No Music" condition averaged 16.45 fixations over all the trials, while the "Music" condition averaged 18.25 fixations over all the trials. Once again, the data had a large p-value ($p = 0.602 > 0.5$), indicating that it is statistically insignificant. Figure 3 shows the average number of fixations between the four groups for each test condition.

Average fixation durations between the groups were noticeably close. The "No Music" condition averaged a fixation duration of 0.409 seconds, while the "Music" group averaged a duration of 0.405 seconds. Again, the p-value for this data ($p = 0.894 > 0.5$) was too large to indicate statistical significance. Figure 4 shows the average fixation duration between the four groups for each test condition.

We also did not notice any distinguishable gaze patterns between the two test conditions, or among our participants in general. Figures 5 and 6 show sample scanpaths from actual participants, shown in a screenshot from the GazePoint Analysis software. Since these screenshots also captured the view of the participant from the eye tracker's camera, there is a gray box over this camera image to maintain confidentiality.

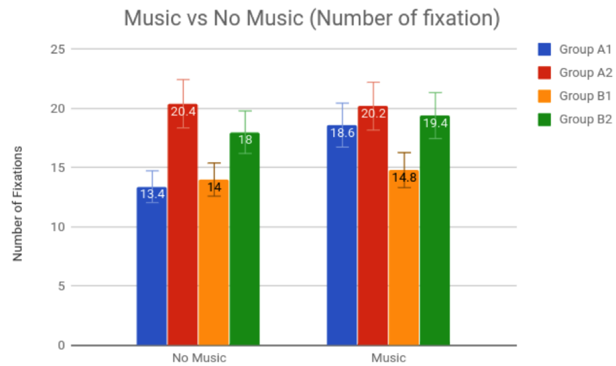

Figure 3: A graphical comparison of the number of fixations of each group.

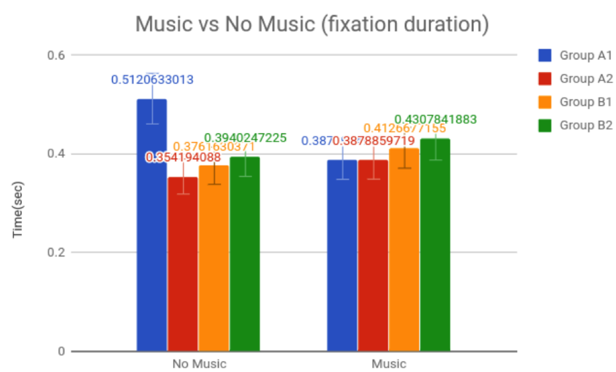

Figure 4: A graphical comparison of the fixation duration of each group.

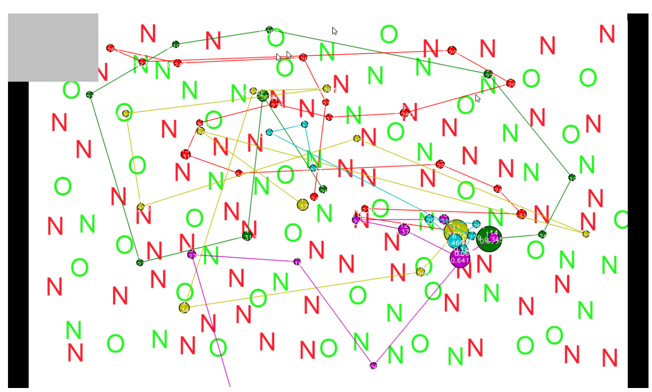

Figure 5: A sample scanpath for Stimulus 1

The post-experiment questionnaire provided some subjective data, namely the participants' opinions on the "Music" condition. Overall, participants did not express a particularly positive opinion of having music played for them while completing a simple visual puzzle.

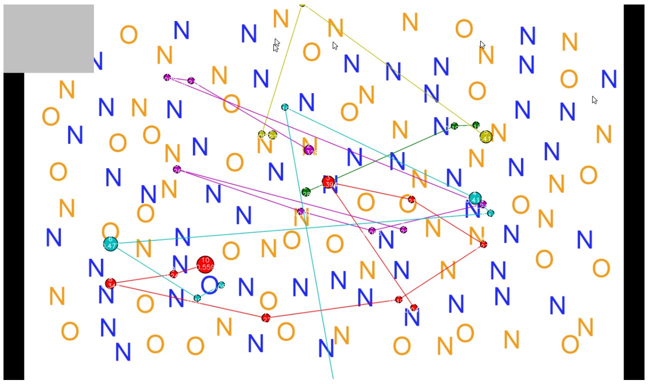

Figure 6: A sample scanpath for Stimulus 2

- Eleven participants reported that the music was distracting. Four were neutral.
- Nine participants reported that the music didn't help them feel more focused. Four were neutral.
- Eight participants reported that the music didn't help them feel calmer. Five were neutral.
- Nine participants reported that the music didn't help them feel more alert. Six were neutral.
- Thirteen reported that they didn't enjoy the music. Three were neutral.

We only received five comments from individual participants, and only four of them had any considerable feedback related to the music stimulus.

- One commented that he/she usually doesn't listen to music while doing work.
- One commented that "the headphones helped," possible referring to focusing on or completing the task.
- One commented that he/she enjoyed the choice of music.

The last comment considered will be more relevant to the Discussion section later in the report.

6 CONCLUSION

The data collected from this experiment does not support the notion that listening to classical music increases performance in visual search tasks. We failed to reject our hypothesis that the music would have no significant effect on visual search completion times. Any differences in completion times is rendered statistically insignificant by the very large p-value of the data.

7 DISCUSSION

While the Mozart Effect is now generally unsupported by modern experiments, there could possibly be other factors affecting our results that should be considered. To begin, our sample size was rather small, only comprising twenty individuals. While the participants were all roughly the same age, there was a noticeably large proportion of male participants. Though, we cannot be certain if this gender difference influenced the value of the resulting data in any way. It's also possible that our choice of only one stimulus per test condition may have decreased the value of our data set by giving it fewer data points to work with. Our small sample size and number of trials likely contributed to our large p-values. It's also always possible that simple analytical errors could have occurred, as our team had to work with pre-made analysis code written in Python that we had to modify to fit our experiment.

As mentioned earlier, one participant made a constructive comment more relevant in a discussion context. Said participant cautioned us about the Hawthorne Effect (also known as the observer effect), a reactive phenomenon seen in psychological studies in which a research participant will modify his/her behavior in response to his/her awareness of being observed. While we cannot determine if the Hawthorne Effect occurred in our experiment, it does bring up the idea of letting participants complete trials unwatched in any future studies. On a related note, conducting trials in a more quiet and isolated environment might also help improve data accuracy and consistency; the computer lab we used for testing was also being simultaneously used by other research groups, creating potentially distracting noise and sights from people talking, moving about, and entering/leaving the room.

This participant also expressed an interest in seeing a similar study done with different tempos and/or beats of music, instead of just testing one specific genre. This idea has possibly interesting applications for future studies. As mentioned earlier in the Background section, any kind of music has the potential to positively influence cognitive performance, depending on the listener's emotional reaction to it. This observation may raise the question of whether a specific genre of music, tempo, or beat produces an overall stronger or more consistent increase in performance than others do. It's possible that this kind of study could be done in a similar way to our experiment.

While our study did not do anything to change the fact that the Mozart Effect is now considered non-existent, it could possibly raise a few questions about music's general effect on cognitive performance, if there is one, and encourage studies focusing on more specific aspects of music, rather than just its genre.

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