

1 **Music Versus No Music Effectiveness On Cognitive Response Time and Typing**
2 **Efficiency**

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8 A two-part test was conducted to determine if there was a correlation between the effectiveness of music versus no music on cognitive
9 response time and typing efficiency. A participant would take a typing test and quantified behavioral test (QBTest) with three conditions.
10 The conditions would be instrumental music (music with no lyrics), lyrical music (music with lyrics), and lastly no music. While the
11 participant takes the QBTest, the EyeWriter 2.0, a type of eye tracker, will track the participants eye movements. Individually the
12 two tests were not statistically significant. The typing test's *p* value was 0.1172 whereas the QBTest's *p* value was 0.0818 when ran
13 through ANOVA. There was correlation between the effectiveness of the two on response time. This can be seen in a heat map of eye
14 movements that is generated from the EyeWriter when inputted into GISPro, a program that analyses geographic information systems
15 which a heatmap is considered.
16

17
18 CCS Concepts: • Music, Typing Efficiency, Cognitive Function;
19

20 Additional Key Words and Phrases: Typing Efficiency with Music, Cognitive Function, Quantified Behavioral Test
21

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27 **1 INTRODUCTION**

28 This project will focus on people's ability to type with distractions such as different types of music playing. It will then
29 test their cognitive ability to focus on a hand/eye coordination test in which we will test how well they can match
30 shapes by measuring speed and accuracy. The two-part test aims to help test if the music is too distracting or will
31 help the people be more efficient at their work. This is important because many people do their homework or jobs
32 while listening to music and should they make a mistake, it could end up costing someone their grade or the mistake at
33 work has a cascading effect to cause more errors. According to the arousal-mood hypothesis, changes in arousal and
34 mood when exposed to auditory stimulation can influence cognitive function [2]. The two-part test will help determine
35 if there is a correlation between the effectiveness of music versus no music on cognitive response time and typing
36 efficiency.
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53 **1.1 Eye Tracking**

54
55 Eye tracking technology, such as the EyeWriter 2.0, has become increasingly valuable in cognitive research, allowing
56 for precise measurement and analysis of visual attention and eye movements [12]. In this study, we incorporate the
57 EyeWriter 2.0 to track participants' eye movements during the QBTest, a hand-eye coordination task. The EyeWriter
58 2.0 offers high-resolution tracking, accurately capturing gaze patterns and fixations. As Chen [3] points out while
59 exploring the relationships between distractibility and Eye Tracking during online learning assessments they found
60 significant differences between more distractions meant more distracted eyes. We believe by analyzing participants' eye
61 movements during the QBTest under different music conditions, we aim to understand how distractions, such as music,
62 influence visual attention and cognitive performance. Understanding the impact of music on cognitive response time
63 and typing efficiency, as measured by the QBTest and eye tracking, can provide valuable insights for improving work
64 and study environments where music is commonly used as a background stimulus.
65
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67 68 **1.2 QBTest**

69
70 The Quantified Behavioral Test (QBTest) is a well-established tool for assessing cognitive function, particularly in
71 measuring hand-eye coordination, speed, and accuracy. It is usually used to diagnose ADHD in adults and children
72 as mentioned by [15] Stevanovic in their study of 'The Structure and Diagnostic Accuracy of the QbTest in Pediatric
73 ADHD. Developed as a standardized measure, the QBTest provides valuable insights into cognitive performance across
74 different tasks and conditions. In this study, the QBTest serves as a central component for evaluating participants'
75 cognitive response time and typing efficiency under various music conditions. By administering the QBTest alongside
76 eye tracking using EyeWriter 2.0, we aim to understand the impact of music on cognitive function and task performance.
77 The QBTest's ability to quantify cognitive performance makes it an ideal tool for this study, allowing us to measure
78 the effects of music on participants' ability to focus, process information, and perform tasks fairly accurately. It is also
79 important to understand that it is not completely accurate as discussed by Hult [7]. Through this research, we seek to
80 provide insights that can enhance our understanding of how environmental factors, such as music, influence cognitive
81 processes.
82
83

84 **1.3 Typing Test**

85
86 Typing proficiency is a fundamental skill in today's digital age, essential for academic and professional success. However,
87 various factors can influence typing efficiency, including environmental stimuli such as music Silverberg [14] found that
88 the results of their typing test showed that although there was a significant difference in the times between paragraphs,
89 there were no significant differences in typing speed between the audio distractions being played. Understanding how
90 music affects typing speed and accuracy is crucial for optimizing work and study environments. This study uses a
91 typing test to assess participants' typing performance under different music conditions. The test presents participants
92 with lyrics from popular songs, simulating a real-world typing scenario where individuals may listen to music while
93 working or studying. By measuring typing speed and accuracy under conditions of music with lyrics, music without
94 lyrics, and no music (silent condition), we aim to determine the impact of music on typing efficiency. This research will
95 contribute to our understanding of how environmental factors, such as music, can affect cognitive processes related to
96 typing and may have practical implications for improving productivity in various settings.
97
98

105 2 RELATED WORKS**106 2.1 Music While Working**

108 While there is not necessarily a concrete answer for whether music or background noise is effective on cognitive
109 function, there have been many studies that attempt to determine the answer. The other studies attempted to search
110 for this answer by focusing on word processing on a computer with the background music and the user's ability to
111 formulate sentences [13], or determining if background music helps users to keep their attention on their task at
112 hand [8]. Similar to Kiss and Linnell [8], Mathew [10] also examined how motivation and music were used hand-in-hand
113 on "a time-consuming task and task performance". A different study done in 2010 again found similar results of music
114 both being a hindrance and benefit [14]. According to Gonzalez and Aiello [6], the degree of cognitive function may be
115 based on an individual's personality. Furnham et al., also determined this was based on personality in a study done
116 between extraverts and introverts although "no significant interactions were found" [5].
117

118 The research done by Komlao found that music or background music was again based on an individual's personality
119 but that music, even music that the participants were familiar with, were a distraction and "was found to negatively
120 impact task performance" overall [9]. This was contrary to the previous studies found by Komlao where the "music could
121 help increase productivity for simple, monotonous tasks" [9].
122

123 Although Ransdell and Gilroy [13] suggests that the music is a detriment, those with "musical training and high
124 working memory span wrote better essays with longer sentences". This suggests that while the music slowed down the
125 participants, it did not necessarily lower their cognitive ability in typing on their computer while focusing on forming
126 text for the written essay for this particular study. For Silverberg [14], the music caused enough of a difference in the
127 time that was taken for writing a paragraph but "there were no significant differences in typing speed between the
128 audio distractions". This again may suggest that the participant's cognitive ability was not hindered when typing and
129 may transfer directly after should the participants have taken a test measuring their cognitive function. The slow timing
130 was again seen by Gonzalez and Aiello [6] in which "music generally impaired performance on a complex task but
131 improved performance on a simple task".
132

133 The study done through Kiss and Linnell [8] saw opposite results as to Gonzalez and Aiello [6]. The music or
134 background noise "enhanced" the reaction time and performance of the tasks that are given to be completed. The
135 results from Mathew [10] were split. The music was a detriment for logic puzzles in the user's accuracy but aided in
136 the efficiency of a writing task. According to Bramwell-Dicks et al., the instrumental music used in their study had
137 better results on typists in speed and accuracy whereas music with vocals, the participants fared worse [1]. While
138 only a quasi-experiment, Oldham et al., found that personal headphones and Walkmans for employees had a positive
139 correlation if the job complexity was not complex but also that employee satisfaction at this company was higher if
140 they were allowed to use their walkman while working [11]. Dobbs et al., also found the correlation that while music
141 produced lower scores than silence it was better than just "noise" [4].
142

143 2.2 Eye Tracking and Quantified Behavioral Test**144 3 METHODOLOGY****145 3.1 Equipment**

146 Participants used two different MacBook Pros in this study due to the nature of the eye tracker setup although both
147 were running on Sonoma or MacOS 14. One MacBook Pro was used to administer the QBTest, and it had the eye tracker
148 mounted on it. The positioning of the eye tracker made it challenging to use this MacBook Pro for the typing test and
149

157 QBTest. Participants used the MacBook Pro with the eye tracker for the QBTest to ensure that the eye tracker could
158 accurately track their eye movements during the test. A Bluetooth keyboard allowed participants to press the space bar
159 in the Quantified Behavioral test easily as the mounting of the eye tracker made it harder to access the space bar on the
160 MacBook. Using two separate MacBook Pros allowed for the independent administration of the QBTest and typing test,
161 ensuring that participants could perform each task without any physical hindrance from the eye tracker.
162

163
164 *3.1.1 EyeWriter 2.0.* The IR camera captures the eye movements of the participant. It is mounted on the laptop that
165 participants use for the QBTest, allowing for the tracking of eye movements during the test. IR LEDs are used to
166 illuminate the eye to enhance the visibility of the eye for tracking purposes. These LEDs are also mounted on the laptop
167 along with the IR camera. The mounting system holds the IR camera and IR LEDs in place relative to the participant's
168 eye. It ensures that the camera has a clear view of the eye for accurate tracking. Cables are used to connect the IR camera
169 and IR LEDs to the laptop. These cables transmit data and power between the components. An Arduino microcontroller
170 allowed the computer to communicate with the camera, infrared LED lights, and computer.
171

172
173 *3.1.2 Typing Test.* The typing program was written in Python and compiled using Python3.9. While python can run
174 on any device that has python installed, this study only used the two Macbook Pros. The singularity of the devices was
175 used as the center of the screen for the typing test was hard coded when setting the starting position of the window for
176 the typing test.
177

178
179 *3.1.3 Quantified Behavioral Test.* The Quantified Behavioral Test program was written in Python and compiled using
180 Python3.9. The package pygame was used for this interface compared to the package tkinter used for the typing test.
181 The Bluetooth keyboard allowed the participant to hit the space bar when the QBTest said to hit the space bar.
182

183 **3.2 Procedure**

184 Each participant was instructed to read and then sign the consent form. While the consent form had the basis of what
185 they would be doing, they were given more detail as to the instructions when they were ready to begin. The two
186 computers were set up side by side so that it would be easy for the participant to switch between the typing test and
187 QBTest. This setup also made it simple for the music component as the participants did each level together (e.g. typing
188 test then QBTest without having to change the music or swapping to no music) before moving on to the next level.
189 Because of the way that the heatmap was coded, we had to make sure that each level was done in the same order for all
190 the participants. We made sure to always do instrumental music, lyrical music, and then no music.
191

192 **3.3 Participants**

193 Twelve participants were recruited from Colorado State University or Fort Collins, Colorado. Two males and eight
194 females all in the age range of 18-23. There were no restrictions in regards to their major as long as they were able
195 to type on a keyboard with no tilt on the keys. They have all previously either learned to type at primary school or
196 through necessity.
197

198 **3.4 Design**

199 After obtaining consent from all participants, they proceeded to take the typing test. The test presented lyrics from
200 popular songs within a graphical user interface (GUI). The interface automatically calculated typing accuracy and the
201 time the attempt took in the program's backend, allowing participants to focus solely on completing the test. Each
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Fig. 1. Images of what the user will see in the typing test

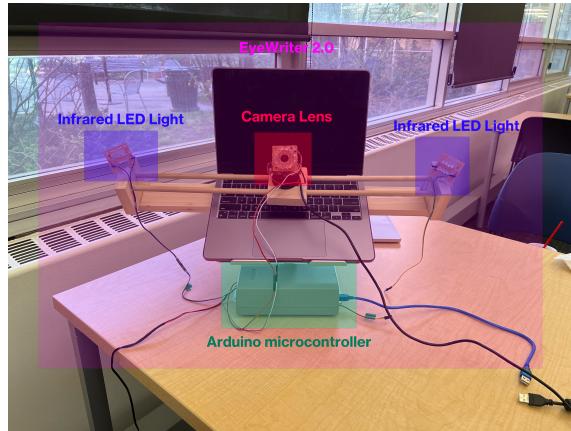


Fig. 2. EyeWriter 2.0 Setup

participant completed the typing test under three conditions: music with lyrics, music without lyrics, and no music (silent condition). Multiple levels of music intensity were utilized within each condition to assess varying degrees of distraction. The GUI of the typing test was built with simplicity in mind. The starting window was pulled up so as not to confuse participants with the code as seen in Figure 1a. The participants saw Figure 1b while the test was running, while Figure 1c was the signifier that the typing portion was finished.

They were given the instructions in the GUI with the text area where their text is clearly visible and the only button in the window to start the test and timer. After they hit the “Get the Typing Test” button, the lyrics of the randomly selected songs were displayed for the user to type. The text box for the users was already in focus with a “Done” button. After the users hit “Done”, their accuracy and speed were presented.

Following the typing test, participants proceeded to the cognitive task component of the study, which was also conducted under the three aforementioned conditions. While the participants did the cognitive task of a quantified behavioral test, their eye movement will be tracked by the EyeWriter 2.0 camera that we specially built for this study. The EyeWriter 2.0 system consists of a camera mounted on the participant’s laptop, which tracks eye movements and allows for precise measurement of gaze direction and fixation duration. This can be seen in Figure 2.

Participants were seated in a comfortable position facing the laptop screen. The laptop is placed on top of a laptop stand while the eye tracker is mounted on a wooden frame. While the eye tracker is on a moveable slider, it is centered in front of the screen. At the ends of the wooden frame are infrared lights that flash at sixty frames per second. Although not pictured, a Bluetooth keyboard is used by the participant for the quantified behavioral test (QBTest).



Fig. 3. Images of what the user will see in the QBTest

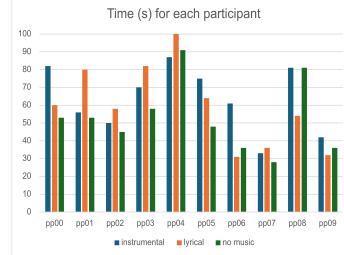


Fig. 4. Time (s) of participants for typing test

During the cognitive task component of the study, participants performed a Quantified Behavioral test or QBTest while their eye movements were tracked by the EyeWriter 2.0. The QBTest is a computerized test designed to assess various aspects of cognitive function, including attention, impulsivity, and response control. The user will then see Figure 3. Figure 3a is the screen that will be displayed before the participant is ready to begin the QBTest. Figure 3b is what the user will see during the test. Figure 3c also displays what the user will see when they are correct and incorrect. Figure 3c displays for only two minutes but shows the user their score.

4 RESULTS AND DISCUSSION

Within-subjects testing was used for our ten participants. Individually the typing test and QBTest scores were not statistically significant, whereas the ANOVA from the heatmap with the eyetracker, the results were statistically significant. The ANOVA for the typing test was done twice for the dependent variables, time and accuracy, as GoStats did not allow for multiple dependent variables. The accuracy for all participants were not necessarily an indicator of good results as all the participants were allowed to use the backspace to re-try any letters that were mis-typed.

While not statistically significant, the p value for time was 0.1172 whereas the p value for accuracy was 0.2334. The bar graph in Figure 4 for time in seconds for the typing test was quite telling. The condition for no music was consistently faster than both lyrical music and instrumental music. The typing tests unfortunately did not record which typing test of the five that each participant did so we were unable to compare each test against another participant with the same test.

5 CONCLUSION AND FUTURE WORKS

While the typing test was not statistically significant, there were at least two factors that should be changed should someone else recreate this study or further expand. The typing test should record which typing test a participant does. While the ones included are similar in length and difficulty, some participants said that some were easier because they recognized the lyrics from the songs used in the typing test and that they found the ones they recognized easier and

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faster for them to type. Although time may be a constraint, more text should be added to the typing test. It is not necessarily known if recognizable songs were a factor but older songs or different text completely could be implemented.

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