Evaluating Musical Experience Through Gaze Tracking of Sheet Music Comprehension

Michael Parks
Clemson University
mjparks@clemson.edu

Parker Myslow
Clemson University
pmyslow@clemson.edu

Kirubha Rajadhas
Clemson University
krajadh@clemson.edu

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ABSTRACT

The use of eye tracking equipment to scan human eye movements can be used to analyze how different environments and personal backgrounds affect how humans learn, process, and communicate. This experiment used eye tracking to determine how a readers' level of competence and experience with sheet music reading and composition affected their abilities to identify songs by their sheet music, interpret it, and the speed at which they do so.

KEYWORDS

Sheet music, music reading, eye tracking, scan path analysis

1 INTRODUCTION

Sheet music is a standardized form of musical notation that has been used for centuries worldwide. It is a handwritten or printed document containing the "recipe" for any musical instrument player to turn into song. Sheet music varies across instruments, however there is a consistent pitch, known as a clef, to the notes written within the bars, known as measures. Certain instruments, such as the cello, bass, and trombone use what is called the bass clef, while others, such as the violin, flute, saxophone, and the majority of others use what is called the treble clef. This creates a standardization to the formatting of sheet music, wherein a flute player can read and play violin music, or vice versa. However, in the case of the piano, the player's hands are focusing on two clefs at once. The left hand focuses on the lower notes of the bass clef, while the right focuses on the higher, treble clef notes. This duality creates complicated sheet music, which will be the focus of our study.

2 BACKGROUND

When learning to read sheet music people struggle to visualize the notes they read. One of the main aspects of music reading is alternating between saccades and fixations. Saccades are the rapid movement of eyes from one location to another on a music sheet. Fixation is where when a person looks at the note for 250-400ms. Most of what people comprehend usually happens during the fixation time. Fixations is usually about 90 percent of music reading (e.g., Goolsby, 1987; Smith, 1988). Eye movement in music is a very complex topic and understanding what people look at while reading music can help us better teach people how to read music more efficiently and correctly.

2.1 Areas of Concern

By using beginner-level music such as the "Happy Birthday" song and the easily-identifiable "Jingle Bells," combined with more complicated musical pieces such as "America the Beautiful," we expected a variety of results from the different subjects taking part in the experiment. Expert level musicians were expected to easily identify the beginner level music whereas beginner musicians were not expected to identify the more advanced musical pieces. One area of concern was that beginner musicians would not be able to identify any of the pieces of music due to the lack of a title or lyrics, and their results would come back invalid. Another area of concern was the matter of the stimulus being noninclusive to certain musicians. This concern was alleviated by including the bass clef. The decision was meant to aid in the process of identifying the piece for participants with more knowledge of bass instruments and piano, and can be ignored by less experienced participants. The final area of concern was that the stimulus would be overwhelming to participants without lyrics or titles, which was alleviated by the fact that the pieces were specifically chosen because they could be identified by their treble clef melodies alone, while ignoring the rest of the piece entirely.

3 MATERIALS AND METHODS

3.1 Apparatus

The Gazepoint GP3 eye tracker is a standalone eye tracking device. The eye tracker is able to be positioned at the top or bottom of the computer screen. For this particular experiment all Gazepoint GP3 eye trackers were mounted at the bottom of the computer monitor and were out of the way of the user. The Gazepoint GP3 tracks where the user looks on the screen with a degree of accuracy of half a degree according to the manufacturer. The Gazepoint eye tracker can track the gaze of both eyes and the distance of the eyes from the screen at 60 Hz. The stimuli utilized were displayed on a Dell monitor with a refresh rate of 59 Hz.

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Figure 1: Gazepoint GP3 Eye Tracker

3.2 Stimuli

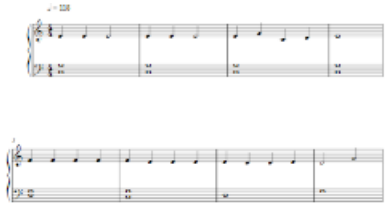

Figure 2: Jingle Bells (Level 1 Difficulty)

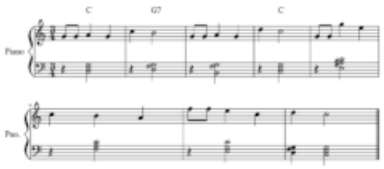

Figure 3: Happy Birthday (Level 2 Difficulty)

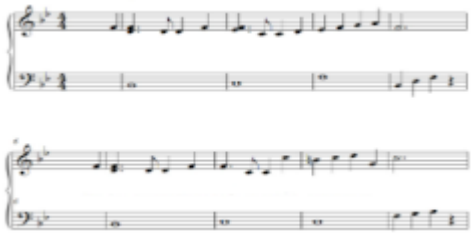

Figure 4: America the Beautiful (Level 3 Difficulty)

Figure 5: Amazing Grace (Level 4 Difficulty)

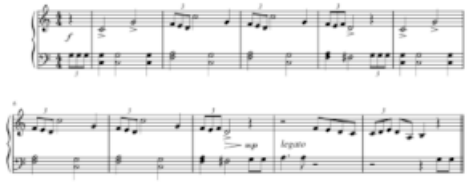

Figure 6: Star Wars Theme (Level 5 Difficulty)

3.3 Subjects

Eleven university students from various backgrounds and majors were chosen for this experiment. Their ages ranged from 20 to 23, with a mean age of 21.9, median age of 22, and standard deviation of 1.04. These subjects all had normal or corrected vision. Half of the subjects had minimal music reading or playing experience, while the other half self-identified as musicians or had significant personal interest in music.

3.4 Experimental Design

Prior to any stimuli being shown, a pre-experiment questionnaire was given to each participant, gauging their knowledge of music, piano, and sheet music. This information was in turn used to identify any trends in their eye movements and speed of music recognition. The participants were given pieces of sheet music that were graded on a scale of difficulty from 1 to 5, with 1 being the easiest piece to identify and 5 being the most difficult to identify. This scale was created based on the frequency of notes within measures, the complexity of said notes, and how identifiable the note patterns were. The participants were given 30 seconds to identify each song based on its sheet music, and were given points based on how many seconds it took (5 points for 5 seconds, 10 points for 10 seconds, and so on). If the participant gave up on trying to identify the piece, they were given an automatic 30 points for the level.

This created an experimental design where the lowest score was the best. In addition, eye tracking was implemented during the 30 seconds, so any trends in speed of identification and where participants looked could be more easily deciphered by analyzing participant fixations. After the eye tracking data was collected, the participants were given a post-experiment questionnaire, wherein they were asked what was hard about identifying the pieces, what they could have done better, and what information could have helped them. These questions coupled with data collection provided the necessary components to identify a trend in music experience and sheet music identification.

4 RESULTS

Of the results of the experiment, the use of eye tracking technology yielded some quantifiable results, however they revealed little about the subjects' interpretations of the music. The results of the use were a heat map of points on the screen, which showed the participants' gazes mainly viewing the notes one at a time for short bursts, to keep up with the tempo of the piece of music. Some participants were able to identify the pieces fast when reading it, but with the 30 second timer designated on each piece of music, the participant had extra time after guessing correctly to look around the piece

of music, when they read it from the top left to the bottom right. Another notable common hot spot on the map was in the direct center of it, where most participants tended to fixate for most of the study. This trend could be because many tend to look directly at the middle of a screen when it transitions, and our transitions were sudden. Another hot spot was in the bottom left and bottom right of each piece, which was likely due to the transition time from the first measures of music to the next, second set of measures below it. There was a trend of much more viewing of the first measures than the second measures, which is likely due to participants guessing correctly immediately, but could also be due to the short time of the experiment.

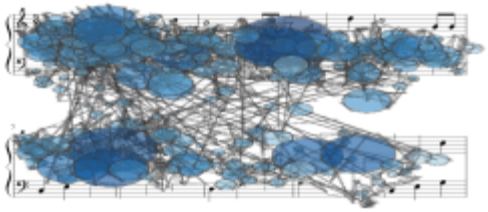

Figure 7: Eye Tracking Data of Expert Reader (Placed Over Happy Birthday)

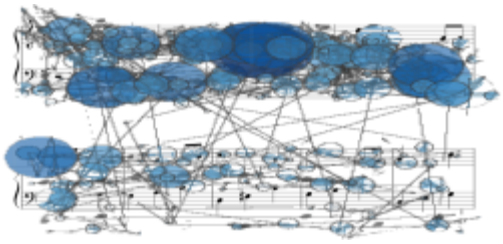

Figure 8: Eye Tracking Data of Novice Reader (Placed Over Happy Birthday)

4.1 Novice vs. Expert

In the case of the novice vs. expert approach to the study, the experiment's conclusion and the data retrieved from it did not provide any notable differences between the eye movements of a self-proclaimed expert at sheet music reading, and a self-proclaimed novice. The data collected showed a heat map of the most fixated-upon areas of the screen, but provided no other data that could be used to ascertain anything about a participant's skill level in reading the music. Furthermore, use of the questionnaires before, during, and after the study provided a deeper look into the thought process of the participants. By gauging how the participants were viewing the pieces of music during the study, insights into how the brain processes music without hearing it were revealed. Many participants with backgrounds in music could process the note progression and general tune, but could not link it to its common title. However, given a very small hint of auditory music, every participant was unanimously able to identify the songs. Overall, this area of the study provided a foundation for future work ideas, and allows for expanding in the future.

5 AREAS TO IMPROVE

Beginning with experimental design, the study could have improved on the scoring system and technology used, and how they were used to interpret the data. By using different scoring methods, it would allow for different implementations such as having actual music during the eye tracking exercise. This could allow for further dissertations into the eyes' use during music reading. In addition, a change to the amount of participants, amount of time allotted for each difficult piece, or a different selection of music pieces could have improved our study much more, as the songs chosen were not as common or uncommon as they were originally scored. The implementation of the eye tracking technology was base level, and further experimentation into the use of it could yield more accurate and quantitative results, such as when the subjects viewed what parts of the piece, how long they looked at those parts, and many more details that could reveal more quantifiable information. Overall, longer time of study as well as further use of the eye tracking technology could yield a better and scientifically significant study.

6 FUTURE WORK

The effects of the eye tracking apparatus on this study of musical experience in sheet music reading are a surface level dive into the potential of the technology. After reading *Eye Movements and Music Reading: Where Do We Look Next?* a study into the movement of eyes in reading music, it was apparent that there were many unique traits to the eyes when engaged in a fast paced activity such as music. The use of eye tracking technology in the performance of music is an area of study that could give new insight into the brain and its function during fast-paced, professional sheet music reading. This could in turn teach new techniques in music, changing the fields of science and music for the better.

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