Eye Movements During Simple Sight-Reading Tasks: From Simple Fixation Times to Process Analysis

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Abstract. Perceptual processes in music reading is a little explored area in graphics comprehension, and the topics unique features present methodological challenges for research on eye movements. Previously, the concepts of first pass fixation time and look back time, originating in text reading studies, have been applied in the context of music reading. In this study, eye movements during 99 performances of simple sight-reading tasks by 12 experienced amateur musicians manifested a first pass effect for notes with particular music-structural characteristics. In order to elaborate the findings, also the percentages of non-linear arrivals to the above-mentioned notes were examined, the results demonstrating an effect within one of the two task types. Finally, to combine the information on fixation times and transitions between visual areas for the purpose of future analyses, we introduce the so-called jump process presentation. The findings give guidelines for the methodological development concerning research on music reading.

Keywords: Eye tracking, jump process presentation, music reading, sight-reading.

Introduction

Studies on eye movements in music reading are relatively scarce (for a recent review, see Madell & Hébert, 2008). Due to the small numbers of participants and the variability of the stimuli used in the earlier studies, there has been a lack of systematic focus on the effects of specific music-structural features on eye movements. In our previous studies we have targeted this problem by applying analytical concepts from text reading research. Specifically, the distinction between *first pass fixation time* and *look back time* (see Hyönä, Lorch & Rinck, 2003) has allowed us to focus on differences between the fixation time allocated to specific notational symbols on first and during later inspections. It was noted, *e.g.*, that early skill development in sight-reading was manifested in the diminishing of first pass fixation time for notes forming large pitch intervals (Penttinen & Huovinen, forthcoming).

The above-mentioned distinction between first and second pass fixations does not fully take into account one music-specific feature: the time constraint. Unlike text reading, musical notation typically has to be processed in accordance with a set tempo. Thus, processing difficulties at some problematic visual areas would have to be compensated for at other areas. Even though such aspects of the temporal process of sight-reading are reflected in the uneven patterns of fixation times allocated to distinct symbols, such an analysis does not reveal the exact processes leading to these patterns. In this study, we add to the examination of first pass fixation times and look back times investigation on the transitions between particular notes, and expect this to provide additional information on the effects of music-structural features on visual processing. Finally, we highlight the usefulness of the *jump process*

presentation as a condensed way to graphically present eye movement processes. This presentation form may serve as a basis for more multifaceted analyses on eye movements during music reading.

Method

Participants. The participants were 49 Finnish future elementary school teachers (MA students).

Stimulus Materials. Twelve simple quarter-note melodies were designed (see Figure 1). The melodic movement in the five-bar melodies was primarily stepwise, with the exceptions of two larger intervals. According to the placement of these intervallic skips, the melodies were divided to two task types: *Bar line* in which the two skips occurred at bar lines, and *Mid-bar* with the skips located in bars 3 and 4.

Procedure. The participants attended three laboratory sessions. A computer screen behind an electric piano was set at a distance of ca. 60 cm from the participant's eyes. Four short melodies were displayed on the screen one by one, and the participant was instructed to perform the melodies in time with a metronome set at 60 beats per minute. Eye movements during playing were recorded with Tobii 1750 Eye Tracker and the keyboard performance with sequencer software (Power Tracks Pro Audio).

1a)   1b)

Figure 1. Examples of the two task types; a Bar line task (1a) and a Mid-Bar task (1b).

Data Analysis. We will restrict our attention only those performances which (i) were performed by participants with more than 7 years of prior musical training, (ii) were played in accordance with the metronome, and (iii) which included no pitch or tempo errors in the large melodic intervals. 51 Bar line and 48 Mid-bar task performances by 12 participants (11 women) were included in the analysis.

Results

A Kruskal-Wallis analysis on the mean percentages of first pass fixation times of notes in bars two, three and four between the two task types revealed three significant differences concerning the 3rd notes of each bar[1]. In bar 2, the third note received a *shorter* first pass fixation time in the Bar line task, whereas in bars 3 and 4, the value was *greater* in Bar line tasks ($\chi^2(1) = 4.99$; $p = .026$, $\chi^2(1) = 4.58$; $p = .032$, and $\chi^2(1) = 9.60$; $p = .002$, respectively)[2]. Curiously, all the above-mentioned notes have a special role in the notated melodies; the 3rd note of bar 2 is the first of a pitch repetition in Bar line tasks, whereas in bars 3 and 4 the same note is in Mid-bar tasks the beginning of a melodic group (see Figure 1). For these latter two notes, the basic result is that the beginnings of melodic groups (due to pitch difference) tend to receive relatively short first pass fixations.

Next, the non-linear first pass transitions to the three above-mentioned notes were examined with a Kruskal-Wallis analysis. No significant differences emerged between the two task types. In Mid-bar tasks, however, the percentage of incidents when first pass fixations arrived from other than the preceding note differed significantly between the 3rd notes in bar 3 ($M = 39$ %, $SD = 29$ %) and bar 4

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[1] Mean percentages (with SD's in parenthesis) for the 3rd note of bars two, three and four. Bar 2; Bar line: 5.80 (4.11), Mid-bar: 7.89 (4.42). Bar 3; Bar line: 7.87 (5.36), Mid-bar: 5.49 (3.55). Bar 4; Bar line: 7.01 (4.40), Mid-bar: 4.41 (3.26).

[2] No significant differences emerged concerning the look back times of individual notes between the two task types.

(M = 15 %, SD = 17 %; $\chi^2(1)$ = 4.89; p = .027). Thus, in Mid-bar tasks, the note in the 1st large interval was more often inspected non-linearly than the note involved in the 2nd large interval. The same effect was not present in Bar line tasks.

Figure 2 shows the jump process presentation of one participant's eye movements. This presentation combines information on fixation times and transitions. The y-axel shows the number of the area in question (here notes in bars 2, 3 and 4), and the x-axel the relative gaze duration. The line demonstrates the moving of the gaze from one area to another (vertical) and the relative length the gaze remained on one area (horizontal). By combining the information from multiple recordings, we aim at simulating sight-readers' eye movements in the two task types. The work is ongoing.
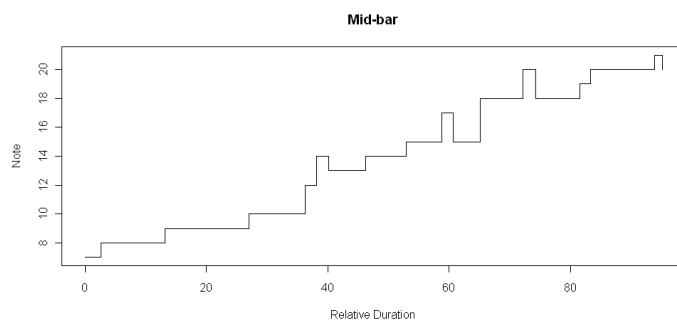

Figure 2. A jump process presentation (relative fixation times per each note) of one participant's eye movements during the performance of Mid-bar task (1d).

Conclusion

Music reading offers a little-explored area for future research on eye movements in graphics comprehension from the perspectives of, *e.g.*, expert behaviour and skill development. With the present study, we hope to arouse interest around this topic. In addition, we aim to demonstrate various ways of analyzing eye movements in music reading and further develop the existing tools. Since the process of music reading often contains similarities comparable to text reading, the findings of this line of research are also applicable in eye tracking studies around this related topic.

Acknowledgment

References

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