TESTING MUSIC READING WITH EYE TRACKING
IN THREE EUROPEAN COUNTRIES

<u>Zsuzsa Buzas*</u>, János Steklács, Damien Sagrillo ***,**
Ágnes Maródi **, Iván Devosa *****

*Assistant lecturer, Kecskemét College, Kecskemét, Kaszap str. 6-14, 6000 buzas.zsuzsa@tfk.kefo.hu **Dean, Institute, Kecskemét College, Kecskemét, Kaszap str. 6-14, 6000, steklacs@gmail.com Associate professor ***, University of Luxembourg, Université du Luxembourg , Maison des Sciences Humaines 11, Porte des Sciences L-4366 Esch-sur-Alzette, damien.sagrillo@uni.lu ****External lecturer, Kecskemét College, Kecskemét, Kaszap str. 6-14, 6000, agimarodi@gmail.com *****Assistant lecturer, Kecskemét College, Kecskemét, Kaszap str. 6-14, 6000, devosa.ivan@gmail.com

ABSTRACT

In our research we examined 10-14 years old students' music reading skills with eye tracking analysis in different music schools in Luxembourg, Germany and Hungary. Our aims were to explore certain music reading strategies, reveal the characteristics of expert sight-readers and also to find text characteristics. During the examination students got six different musical examples (three for rythm reading, three for singing from Zoltán Kodály) that appeared on a computer's screen, and after one minute silent reading they performed them.The results suggest that the knowledge of musical patterns strongly influences not only the duration and accuration of a musical performance, but the fixation counts, and also gender differences were revealed. Our further aim is examining the relationship between the development of reading and music reading skills.

EYE-TRACKING IN EDUCATION

Eye-tracking is becoming a popular methodological tool that is used in a wide variety of different research fields - from commercial usability to scientific psychology, education or vision research. This research technology enables us to learn more about the development of students' cognitive competences and to get guidelines for their effective development in the area of teaching reading, visual education, music, and mathematics and gives suggestions about how to utilize research results for the better understanding and development of the students' cognitive, learning, reading, information processing and problem-solving strategies. Eye tracking is used by linguistic researchers to investigate human language development, language skills, and reading behaviour. According to previous research in connection with eye-tracking, experienced music readers read more units ahead, that could be called 'chunking' process. Orifessional readers' eyes fix on the structurally important functions, such as certain chords or phrases, and then they glide towards the less important details. The perception of visual information occurs almost entirely during fixations and little information is picked up during saccades.

In music reading, fixations comprise about 90% of music-reading time, the average fixation duration has been reported to lie between 200 and 400 ms, though this is subject to variance between individuals as well as music-reading tasks. Sloboda (1974) proposed that eye-voice span in reading research could be named as eye-hand span in instrumental music reading. During reading a normal eye-voice span usually is five to seven words, in music reading it is normally five to seven notes and the distance could be larger (two bars) (Sloboda, 1974).

MUSIC READING SKILLS

According to Singer (1983) between 1880 and 1970 thousands of research studies have been dealing with reading, however in the same period with the music reading is less than 250. The standard system of Western musical notation forms one of the bases of musical literacy and consists of unique symbols for every element of musical grammar that are taught in general and specialized musical education. The ability to read and notate music facilitates musical understanding. Music literacy may be defined as the ability to translate notation into vocal sound (reading) and sound into notation (notating) and allows students to be independent, well-rounded musicians (Ester, 2010). According to Waters et al. (1997) expert musicians develope an efficient encoding mechanism for identifying patterns of notes rather than reading the score note by note. Improving musical memory could also enhance the efficiency of music reading. As memory research predicts, context is a critical factor when moving information from the sensory register to working memory and for the eventual encoding to and retrieval from longterm memory (Ester, 2010). According to Sloboda's (1974) the ability to read ahead while singing unrehearsed music is a condition for successful sight-reading.

In McPherson's theoretical model (1997) music reading and sight reading are distinguished aspects of musical performance beside improvisation, playing from memory and playing from ear. Erősné's model of basic musical skills (1992) does include features of music reading, such as melody, chord, and rhythm reading, but on a higher reading skill level we should complete the model with tone and dynamic reading, as well.

Table 1
Erősné's model of basic musical skills (1992)

	Hearing	**Conveyance**	**Reading**	**Writing**
Melody	Melody - hearing	Melody- conveyance	Melody- reading	Melody - writing
Harmony	Chord - hearing	Chord - conveyance	Chord - reading	Chord - writing
Rhythm	Rhythm - hearing	Rhythm - conveyance	Rhythm - reading	Rhythm - writing
Tone	Tone - hearing	Tone - conveyance	Tone -reading	Tone - writing
Dynamics	Dynamic - hearing	Dynamic - conveyance	Dynamic - reading	Dynamic - writing

The knowledge of musical styles, improvisation, music memory (Lehmann and Ericsson, 1996), a person's technical skill by sight playing with many subskills can be components of music reading and also it can contain the skill of anticipation, that is, the preliminary imagining the length of the upcoming musical surfaces within the process of performing music. According to Gromko (2004) music sight-reading involves audiation of tonal and rhythmic patterns, comprehension of a graphic notation system with both spatial and textual qualities, and a highly coordinated kinesthetic action in performance. Some other components of music reading skill; the knowledge of musical syntax and grammar, the knowledge of tonal patterns, the ability to identify notes during the process of sight reading, individual's ability to inner-hear or audiate, sight-singing practice, the knowledge of musical styles, improvisation, music memory (Lehmann & Ericsson, 1996) and person's technical skills with many sub-skills, such as hand-eye coordination, independence of fingers, weight controls of the fingering, and agility count.

INFLUENCE OF TEXT CHARACTERISTICS

Awareness about text structure and the expectations engendered by certain common features of text may be useful aids for readers, helping them to invoke relevant background information and schemas to facilitate their construction of meaning-based representation. Knowledge about the organization of texts increases throughout childhood, as does the ability to generate well-structured coherent stories. Perfetti (1994) proposed that possible source of comprehension failure is inadequate knowledge about text structures and genres, which may arise because of insufficient reading experience. Instruction in expository text structure aids reading comprehension, and that could be a useful support in the field of music teaching, as well.

Comprehension arises from a series of cognitive processes and activities, including word decoding, lexical access, syntactic processing, inference generation, reading strategies and post-reading activities. These contributes to a reader's ability to connect the meaning of the musical text into a coherently connected mental representation of the overall meaning of the composition. Students read the text for different purposes, and reading purposes could be also closely associated with the text genre.

METACOGNITIVE MUSIC READING STRATEGIES

However there is a great deal of evidence for the importance of reading strategies, until a few number deal with them in the field of music. Teaching reading strategies is also the task of solfege or music teachers, with the help of them students could become successful music readers. Flavell (1979) proposed a formal model of metacognitive monitoring which included four classes of phenomena and their relationships. The four classes were (a) metacognitive knowledge, (b) metacognitive experiences, (c) tasks and goals, and (d) strategies or actions.

Different texts need the use of different strategies, which are not revealed yet. In music we can distinguish music reading comprehension strategies that are also important for many musicians who consider themselves to be skilled readers. Metacognitive reading strategies are classified into three groups of planning (pre-reading), monitoring (during reading), and evaluating (post-reading) strategies and each group has a variety of strategies that require readers' metacognitive processing.

MOTIVATION AND ENGAGEMENT IN MUSIC READING

Music concepts, like Kodály's method can be particularly useful not only in teaching students how to read but also to increase their curiosity and enjoyment for reading music. To enhance students' interest and desire to learn music reading, the teacher should encourage the students' personal choice of compositions and collaborative discussion and enjoyable interaction with peers.

Several pre-reading activities also could be motivating, melodic contour, body or handsigns, visual icons can help to build children's understanding of pitch placement and create curiosity for seeing how familiar sounds will look on the staff. Later more realistic, but challenging tasks, teaching interesting texts, the use of reading strategies, coherence among strategies and methods applied during music instruction increase reading motivation (Józsa and Steklács, 2012).

THE KODÁLY CONCEPT

According to the Kodály concept musical training should be an integral part of the general curriculum. Musical literacy, the ability to read and write music could be as important as general literacy. Research studies show that there is a positive transfer effect of musical training to several other areas of the elementary school curriculum - such as grammar, spelling, reading, arithmetics and physical education (Barkóczi & Pléh, 1982). Inspite of its importance, with music literacy - music reading - deals only a few researches.

One of Kodály's most strongly held convictions was that the ability too read and write musical notation is fundamental to the development of musicality (Király, 2012). Just as literacy culture cannot exist without reading and writing a language, so music culture cannot exist without reading and writing music. Zoltán Kodály composed reading and singing exercises needed for practicing from primary to professional levels, and he claimed that music reading and writing (like the alphabet) can be learnt by anyone. In music eucation primarily Solfege lessons build on thhe pedagogical compositions of Kodály. These works not only improve music reading and writing, musical memory or intonation, but they introduce stuudents to the common musical activities, to the group or choir singing.

ABOUT THE RESEARCH

Our researches were conducted in music schools of three different countries, Germany, Hungary and Luxembourg. The participants (N=53) were music school students between the ages of 10-14. The sample consist of 33 girls and 20 boys.

Table 1
Participants of the research

	Luxembourg n=19		Germany n=16		Hungary n=18		
	boys	girls	boys	girls	boys	girls	
10 years	9	5	3	5	6	5	33
14 years	3	2	2	6	5	2	20

The participating students study different musical instruments, 55% of students' study wind instruments, most of them (32%) play brass instruments, and pianists are 16% of the sample. Only 14% of the students play different string instruments.

Apparatus

Eye movements during playing were recorded by a Tobii T120 eye tracker with Tobii Studio 2.2.7. Software. The infrared cameras tracing the position of the participants' pupils were integrated into the body of the same computer monitor from which the stimuli were presented. The eye movement tracking device made video and audio recordings, as well.

Stimulus materials

In our research the participant students got 3-3 increasingly complex tasks, three rhythm exercises and three melodies composed by Zoltán Kodály. After half minute studying and reading silently the music score on the computer screen, students should perform them. The first three scores contain only rhythm tasks in different metres. One rhythm and all melody tasks for students were eight-bar exercises and resemble the style of a period. Albert Siklós (1912) considers periods those eight-bar units in which their content or thematic occur varying in the second phrase of the period. Eight-bar, period-like songs are common in every music book that contains usually four two-bar motifs and two four-bar half-periods. Timing is essential in music and much of the musical information is coded in the meter and the rhythm. The stimulus rhythmic exercises were created for the experiment, considering the novice participants can read them according to music school curriculum. Example of the rhythmic exercise:

The second rhythm exercise is more complex and longer (16 bars), and includes several rhythmic patterns. The third rhythm task includes ties, repetition, and various dotted rhythmic values.

The melodies were from Zoltán Kodály 333 reading exercises, all with different time signatures. The eight-bar melodies were composed in different pentatonic scales (do, sol and la pentatons). The melodies were previously unknown to the participants, providing an authentic sight-reading task in each measurement. The melodies only contained quarter and semiquarter notes, they contain smaller intervals and they are primarily stepwise, to ease the recognition of the notes.

We devided our musical examples into special areas of interests (AOIs) that are examined in a more detailed way for identifying the important structural elements (certain melodic elements, intervals, scales etc. and rhythm patterns) of a particular type of musical text.

RESULTS

During fixation perception of the music reading occurs. The results of rhythm reading of the first musical example, the means of total fixation duration are similar in students of the three countries. After analysing all recordins the mean of total fixation duration during silent reading is 27s while for the same musical example in loud reading that is 16.91 s. That means a thorough rewieving, and mapping the difficulties help in the process of music reading.

Table 2
*Means and sums of Total Fixation Duration (s)*

	Kodály silent reading			Kodály loud reading		
	N	total fixation dur.mean	Total fix.duration sum (s)	N	total fixation dur.mean	Total fix.dur. sum (s)
Luxembourg	8	26,26	210,1	8	18,6	148,76
Germany	8	25,47	203,77	8	16,87	134,97
Hungary	11	24,47	269,13	11	17,41	191,54

We devided the examples into specific research areas. Interestingly the fixation time on the initial time- and key signature is very low (6 ms).

Effects of musical structure

We divided the rhythmic tasks and Kodály's composition into specific research areas (AOIs), namely into two four-bar half periods and also four two-bar musical motifs. In the first rhythmic exercise we found that the fixation counts means of all participants on the first two bars was almost twice longer, than on the second four bars, which have a similar and familiar form, metrical structure and melody. All selected groups show similar results in the three countries. The collected data reveals the significance of the knowledge and understanding of musical structures, and also the knowledge of musical styles. Melodies with good musical forms or structures enhance and facilitate music reading.

Table 3
Total fixation duration mean of two selected areas of the musical period
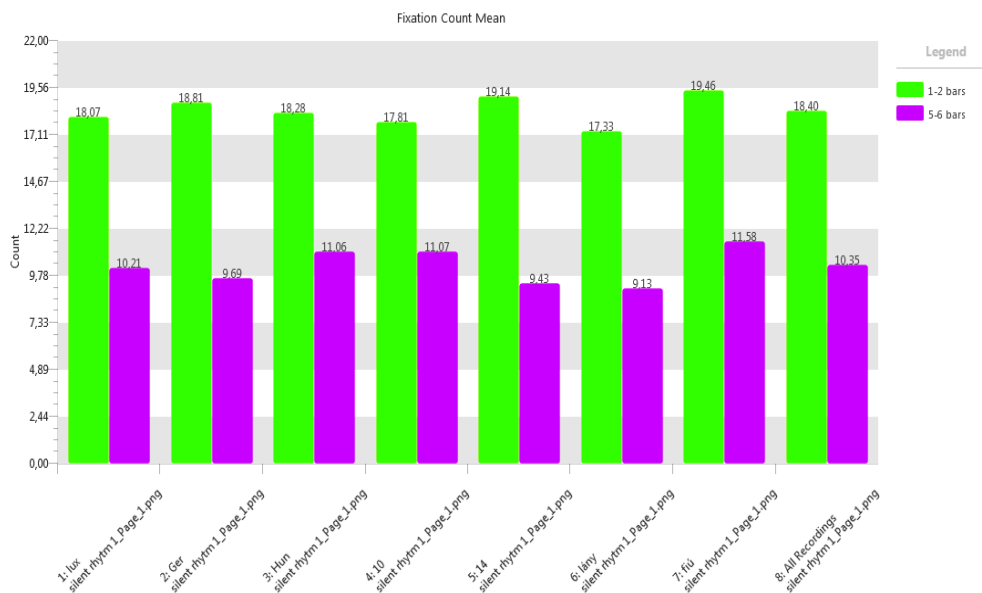

Results of heat maps

A number of conclusions in connection with music reading can be drawn on the basis of the thermal images of the eye movement tool. On the thermal images we can see where the eyes fixate the longest, these parts highlighted in red, and also where students looked rarely; these areas are shown in green colour. The importance of this research is that those areas in different music materials could be discoverable where students have difficulties during music reading. With the help of heat maps the effectiveness of different music books for educational purposes could be also examined. The heat map of all students' silent reading of rhythmic exercieses, reveals the cognitive process of music reading, how students become more familiar with the rhythmic elements of the task towards the end of it. The eye fixates the longest period in the beginning of the music score, and also fixates on the more complex rhythms and intervals, however the meter and the different key signatures get less attention.

Individual differences can be found on the base of heat maps. The following example shows a ten-year old music student's reading process. As the separated fixations reveal, the musical notes are perceived individually, and get less attention toward the end.

The next example is the heat map of a pentatonic song of all students. We can see that fixations usually occur in the middle of the bars there are less attention on barlines. The bigger intervals, for example perfect fifth or fourth, mean longer fixation duration.
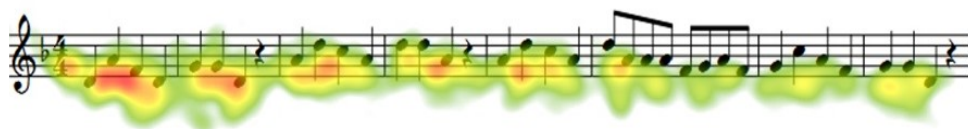
CONCLUSION

With the analysis of reading music notation we could learn more about the reading process in general, as during the silent and loud music reading visual symbols based on conventions are decoded. The level of experience, the prior knowledge, the level of process automation and continuity have major roles during the music reading process. In our research we examined students music reading skills from three different European countries. However they study music with different methodology (Kodály or Dalcrose methods) we can not find significant differences between the gained results; it suggests that there could be 'universal' indicators and factors in music reading development. With the help of heatmaps and recording we discriminate several elements of musical syntax (intervals and rhitmic patterns) that are difficult for students, we also find examples for reading strategies and how music memory works in students . Eye-voice span (3-4 notes) are also observed.

Our further aim is on the base of our results to create an online adaptive measurement that could test musical skills in theirs complexity and which is relevant to the practical needs of modern day music education.

REFERENCES

Barkóczi and Pléh (1982). Music makes a Difference: The Effect of Kodály's Musical Training on the Psychological Development of Elementary School Children. Kecskemét: Kodály Institute.

Ester, D. (2010). Sound Connections: A comprehensive approach to teaching music literacy. Fishers, IN: Educational Exclusives.

Erősné, I.: A zenei alapképesség vizsgálata. In: Czeizel Endre és Batta András (szerk.): *A zenei tehetség gyökerei.* Mahler Marcell Alapítvány – Arktisz Kiadó, Budapest p. 183–206. 1992

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence (pp.231-236). Hillsdale, NJ: Erlbaum

Gromko: Predictors of Music Sight-Reading Ability in High School Wind Players. *Journal of Research in Music Education Spring* 2004, 52 (1), p. 6-15

Lehmann, C. / Ericsson, K. A.: Music performance without preparation: Structure and acquisition of expert sight-reading, *Psychomusicology,* 1996, 15. p. 12–19.

Józsa, K. / Steklács, J.: Content and curriculum aspects of teaching and assessment of Reading, in: Csapó Benő és Csépe Valéria (szerk.): *Framework for diagnostic assessment of reading.* Nemzeti Tankönyvkiadó, Budapest 2012, p. 129–182.

Király, Zs.: *Computer-aided Ear-training.* Budapest: Révai Digitális Kiadó 2012

McPherson, G. E. (1994). Factors and abilities influencing sight-reading skill in music. *Journal of Research in Music Education* 42 (3) p. 2172–31

Pearson and Dole (1987). Explicit comprehension instruction: A review of research and a new conceptualization of instruction. Elementary School Journal, 88, 151-165.

Singer, H. (1983). A critique of Jack Holmes's study: The substrate-factor theory of reading and its history and conceptual relationship to interaction theory. In Reading Research Revisited.

Sloboda, J. A. (1974). The eye-hand span – an approach to the study of sightreading. Psychology of Music, 2, 2. 4–10.

Waters, Townsend és Underwood (1998). Expertise in musical sight reading: A study of pianists. British Journal of Psychology, 89, 1. 123–149.