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ZSUZSA BUZÁS

TESTING THE MUSIC READING SKILLS
OF 10- TO 14-YEAR-OLD STUDENTS

THESES OF PhD-DISSERTATION

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Introduction

Improving music reading skills forms a central part of music education. It includes instrumental, vocal and solfège training. Music education in Hungary is based on the well-known Kodály concept. In order to enhance students' reading skills, Zoltán Kodály composed a series of music reading materials which is currently used in all levels of music education.

The knowledge of musical notation is essential to participate in orchestras or in choral ensembles. According to the research with secondary school instrumental students, active music making (playing on an instrument or singing) supports the development of cognitive, metacognitive and affective skills (Hollenbeck, 2008). Musical activities can play an important role in promoting social skills and cultural development as well and contribute to the improvement of special musical-artistic skills.

Although a great number of music students learn music reading, only a few studies aim to examine its teaching and there are no comprehensive examinations of this issue. It was the research carried out by Erősné (1993), which formed the basis for the definition of the model of basic musical skills. They explored the musical skills of children aged 10, 14 and 16 as well as university students, including music listening skills, communication, music reading and writing. The longitudinal study conducted by Turmezéné & Balogh (2009) was also a milestone in the field of music perception, singing, music reading and writing among 7-10-year-old children. Technology-based assessment is a rapidly developing area, which can be extended to musical skills and provides new possibilities for diagnostic testing. The research of Asztalos and Csapó (2015) was the first attempt to develop an online test to examine music perception skills and their developmental trends among 7- to 12-year-old students. However, we still lack data about the music reading skills of students aged between 10-14. Neither are there tests to assess their music reading skills.

The international scholarly literature explores music reading skills with eye tracking technology. Most eye-movement studies focus on instrumentalists, e.g. pianists, violin or guitar players. Primarily they aim to compare the eye movement patterns of skilled and unskilled performers, generally adults. However, it is of crucial importance to compile proper music reading material. My literature search has indicated that the readability of the music material has not yet been examined.

In the present dissertation, one fundamental component of music literacy, i.e. music reading, has been explored. The theoretical background of music reading skills and research conducted with eye-tracking analysis and on online platform with 10-14 year-old music-school students have also been introduced.

Theoretical background

Music and language skills enabled the emergence of modern human social and individual cognitive flexibility; both music and language can be regarded as subcomponents of the human communicative toolkit (Cross, 1999).

The music related activities indicate numerous psychological processes, including the

perception and rapid processing of audio stimuli, attention and auditory, sensory and visual memory activation. Musical development provides a significant effect on functional and structural brain plasticity. Music making stimulates a strong connection between perception and action mediated by sensory, motor, and multimodal integrative regions distributed throughout the brain (Schlaug et al., 1995). These alterations occur most probably in early childhood and school-age.

Written language is a relatively recent cultural invention which came into existence some 5,000 years ago (Rayner & Pollatsek, 1989, in Csapó & Csépe, 2012), but remained the privilege of only small proportion of the world population until a few hundred years ago. Almost 90% of all children can learn to read alphabetic as well as non-alphabetic scripts and write fluently without obvious problems (Csapó & Csépe, 2012).

Music literacy, or *music reading comprehension* is traditionally defined as an acquired musical knowledge and a skill to translate notation into vocal sound (reading/singing) and sound into notation (notating/ writing). Both reading and notating skills are fundamental prerequisite for comprehensive musicianship. As reading, music reading is a highly complex activity on multiple levels, and the acquisition of reading literacy means to learn, use and perfect a corresponding set of highly interrelated operations, skills, and strategies which can and should be improved until adulthood even in the case of highly skilled students. Music reading skills comprises several closely related subskills and abilities. The most important period of their development is the first years of primary school. The acquisition of music reading is similar to that of reading, i.e. we learn, use and improve those interacting and related activities, skills and strategies that can be improved till adulthood (Schnotz & Molnár, 2012).

The term, functional music literacy, is defined by Jorgensen (1981) and means the minimal level of musical skills which enables students to function with musical materials. Functional reading literacy is generally seen as an enculturation process where literacy practices at school are designed, so that they resemble literacy events, practices, and authentic texts used for specific purposes in real-life contexts, emphasizing social interaction and collaborative construction of meaning (Linnakyla, 2007).

The principal aim of music education is to develop functional musical literacy through solo or group (choir/ chamber/ orchestra) performances. The first step to functional music literacy is the development of an aural/oral vocabulary of tonal and rhythm patterns. Teachers should proceed through the tonal and rhythm lessons in parallel, preparing students for the discrete tonal- and rhythm-reading activities and the eventual synthesis of these patterns during melodic reading (Ester, 2010). However, sight-singing achievement is usually weak, only a few music programs address reading skills beyond the most prefunctory level (Ester, 2001).

In the Hungarian specialized music education system, a prerequisite to instrumental music instruction is a minimum of one year of vocal music training which includes sight singing and the development of aural skills, and also the preparation for music reading. Kodály composed reading and singing exercises for practicing from primary to professional levels, and he claimed that music reading and writing (like the alphabet) can be learnt by anyone.

Even short-term musical trainings can have transfer effects in the field of reading. Studies exploring the relationship of musical and early reading abilities show that the most significant correlation can be found between musical skills and phonological awareness. Pitch perception

positively correlates with phonemic awareness and reading abilities in childhood (Anvari et al., 2002). In melody perception, the discrimination of pitch and melody contour perception are essential for speech acquisition. The difficulty of reading acquisition with a learning disability, i.e. dyslexia, is one of the causes of the deficit of the auditory perception (Forgeard et al. 2008). The sensibility for pitch discrimination is present in fetuses, whereas infants are able to discriminate minor second intervals (Turmezeyn  , 2012).

Music reading is a process of converting special visual symbols – music notation – into sounds. The sounds may be silent, i.e. conceived internally, or they may be produced externally through voice or musical instruments. From this simplistic definition there arises a number of more complex issues to be explored (Hodges, 2011). Music reading involves at least two distinct skills: the reading skill and the mechanical skill (Wolf, 1976).

Er  sn   (1993) created the model of basic musical skills. She separated five musical dimensions (melody, harmony, rhythm, dynamics and tone). She also distinguished four types of information-giving in musical communication (hearing, conveyance, reading and writing). On a higher level of music education, in music schools or conservatories we should complete the model of basic musical skills with tone-conveyance, tone-reading, tone-writing and dynamic-conveyance, dynamic-reading and dynamic-writing that can add a unique artistic value to the composition.

Several researchers use the term sight-reading, while there are many who make a distinction between sight-reading and music reading (Elliott, 1982). Sight-reading is used in a narrower sense than music reading. Music reading with singing can be named sight-singing, whereas instrumentalists prefer the term sight-playing.

From a cognitive perspective, music reading requires several simultaneous processes including coding of visual information, motor responses and visual-motor integration (Gudmundsdottir, 2010). Studies find that music reading achievement at a high level is determined by the speed of information processing and psychomotor speed. This means that the decoding ability and the motor response are important in music reading but the integration of these abilities may be the key to a successful execution. Studies on perception indicate that pitch information and timing information are processed separately and good rhythmic reading abilities have a high positive correlation with music reading (Elliott, 1982).

There are no research studies at all that deal with other elements of a music score, such as dynamic or agogic and how these signs can affect music reading. Research is needed in the field of singing from a music score with text or singing polyphonic compositions.

Lehmann and McArthur (2002) describe music reading as a reconstructive process that involves a number of sub-skills, one of which is the ability to recognize patterns and match them with a previously acquired vocabulary of musical concepts such as tonal and rhythmic patterns, high or low pitch, duple or triple meter, descending or ascending scale, neighboring tones or large leaps. Familiarity with such basic concepts develops a readiness in the learner for decoding music notation (Gordon, 2004; Schleuter, 1997). By the age of seven, children are able to reproduce complex rhythm patterns nearly as well as adult non-musicians (Drake, 1993).

Essential step is the chunking process that allows students to organize and memorize a large number of vocabulary items, which can facilitate the music reading process. The

recommendations from Schleuter (1997), the principle behind Gordon's music learning theory (1993), and the elements of the Kodály concept all support the idea that the building of tonal and rhythm vocabulary can be started with beginners through vocalization. The experience with the tonal and rhythmic vocabulary via singing would provide beginners with conceptual knowledge with which they can associate the symbols of music notation.

Teaching reading strategies is also the task of the music teachers. With their help, students can become successful music readers. In music we can distinguish between music reading comprehension strategies that are also important to many musicians who consider themselves to be skilled readers. Reading comprehension and the richness of the vocabulary are related, which is true in the field of music reading as well. According to Schoonen and Verhellen (1998), the prerequisite for reading comprehension is that the reader knows the meaning of 95% of the words in the text.

Fixations, saccades, pupil deletions and blinks during the reading process can be observed with eye tracking analysis. Eye movement analysis is not only an educational research tool, but it facilitates the development of student learning, as well. Research so far suggests that the individual's musical skills significantly influence the eye movements during music reading. Fixation/ the duration of information gathering can vary and it is between 250-500ms, but there are much shorter and longer fixations as well. If information processing fails, the brain needs newer information and the eyes return to the point which has already been fixated. We call this kind of backward movement *regression* (Steklács, 2013).

According to previous research in connection with eye-tracking, experienced music readers read more units ahead. Their eyes fix on the structurally important functions, such as certain musical chords or phrases, and then they glide towards the less important musical details. Better sight-readers require shorter and fewer fixations to compare or encode music material for execution because they are able to grasp more information in one fixation. Eye-voice span is the equivalent of eye-hand span with pianists (Sloboda, 1974), while during music reading of instrumentalist's eye-hand-pedal and eye-bow spans can also be distinguished.

The most important characteristic related to reading, reading comprehension and eye movement is that the reader proceeds in the text with 7-9-character- long saccades (these do not necessarily coincide with words). Standard deviation is big: 1-20 characters, 200-250 ms-long fixation is necessary for comprehension on average. In normal reading the eye-voice span is usually 5-7 words, in music reading it is 5-7 notes (Sloboda, 1984). It seems that saccadic eye-movements can be altered by the type of the musical text (Van Nuys & Weaver, 1943). Several researchers discuss the relationship between music reading skills and other skills. Boyle (1970) and Elliott (1982) found a strong correlation between reading notes and rhythm. Furthermore, according to Drake and Palmer (2000), rhythmic skills and performing skills correlate as well. Correlations were found between music reading skills and the results of standardized tests on other musical skills (Cooley, 1961). Tonal music memory, (Kanable, 1969), intelligence and reading skills are also related to music reading (Hutton, 1953; Luce, 1965). Eye-movement data show that, with increasing familiarity with the musical structure of elements, fixations become shorter, because part of the information is already known. More experienced musicians can read even seven notes ahead, because they are driven by the structure of the composition, and they read a whole group of notes, rather than notes one by one.

Researchers have aimed to clarify which features of music notation could be the targets of fixations. Music readers do not fixate on all notes, but they fixate on blank areas between the notes. Goolsby (1994) demonstrates that better sight readers' fixations were also directed across phrase boundaries, while less proficient readers tend to focus on individual notes. Fixations appear to target spaces, note stems or note tails and they follow the melodic contour. The eyes usually look for where the highest or lowest notes of the melody are located. According to Truitt et al. (1997), bar lines are scarcely fixated.

Goals and research questions of the empirical research

The aim of the present doctoral dissertation is to analyze students' music reading skills on the basis of Zoltán Kodály's philosophy of music education and to develop and test technology-based assessments to measure music reading skills. The musical tests were developed to measure the disciplinary dimension of music reading among upper graders in public and music schools. In the research, the explicit knowledge of the rhythmic and melodic elements, dynamic and tempo signs and musical forms were examined. I laid emphasis on Kodály's music reading exercises.

Generation Z, unlike the previous student populations, can have different habits, which is the reason why students' music skills were tested with technology-based methods and tools. To my knowledge, in the international literature there are only music tests that measure mainly aural skills, and no complex measurement for music reading skills has been used in Hungary. My research aimed to meet this long-felt need utilizing eye-tracking technology and online assessments. Hungarian, German and Luxembourger students were tested in the eye-tracking studies. Thermographic pictures of the musical example helped to explore the difficulties in the reading exercises.

The data was recorded on the eDia platform. The advantage of an electronic diagnostic system over paper-based measurements is that the tasks can be made more enjoyable and lifelike with images, sounds, animations and varied response forms (selecting, clicking, coloring, moving, rearranging).

The unique feedback system can give information to the students and their teachers about the test results. Our research can help to give more detailed information about the music reading skills of pupils, with the use of an objective measurement tool the quality of music education can be improved.

Research questions

Eye-tracking research of music reading skills

- 1) What is the level of 10-14 year old students' music reading skills?
- 2) How can musical structure influence students' music reading skills?
- 3) How is eye fixation related to music reading skills?
- 4) Do students use strategies during music reading?
- 5) How can different music methods affect music reading skills of students?

6) Is gender a factor in performance for different parts of the music reading test?

Online assessment of music reading skills

- 1) Can online testing of music reading skills be implemented in general school settings?
- 2) How reliably does the online music reading instrument assess music reading skills?
- 3) How can the measured skill structure be characterized?
- 4) What is the relationship between the students' achievement in music reading and the background variables?
- 5) Do visual-spatial skills correlate with music reading skills?
- 6) What are the differences between the results of students in different school type?
- 7) Is gender a factor in the performance of the music reading test?

The methods of the empirical research

Eye tracking research of music reading skills

The participants of the research were music and mainstream school students (N=78) in Germany, Hungary and Luxembourg. The data was collected between 2013 and 2015. Kodály's music reading exercises formed the basis for testing students' reading skills during the eye tracking research. The examples contained sol-fa syllables, stick or letter notations or ABC names.

The apparatus was a *Tobii T120* with a *Tobii Studio 2.2.7. software*, which enabled us to make video and audio recordings. After studying the musical score on the computer screen, students had to sing the music exercises.

Online assessment of music reading skills

In our online research we tested the music reading skills of students who are specialized in music and also those of mainstream school students. Two online music test versions were developed on the eDia platform to measure students' music reading performances. The first pilot test in music schools was in the fall of 2015 (N=107). The online pilot test was followed by large sample measurements in Hungarian music schools in January, 2016 (N=160).

We conducted our pilot studies in two primary schools in Szeged (N=107). Having piloted the online test, a large-scale measurement was conducted in primary schools across Hungary in January 2016. The sample consists of 10-14 year old students (N=651) from eight mainstream schools.

The task structure of two online test versions reflects the components of music education in a varied way. The different areas of music reading skills were covered by the following subtests: rhythm reading (including simple meters, the symmetrically compound meters, and some rhythm values and patterns), melody reading (including different musical notation systems, recognition of melodic patterns, such as intervals, scales, triads or musical signs). Melody and rhythm reading with soundtracks were also integrated. Tasks with timbre

and dynamic reading (signs and concepts), music reading from different notation systems, such as letter notations or hand signs were explored.

Our test designed for music school students contained 55 closed items. A similar assessment form containing 35 items was developed for mainstream school students. Our online test contained an appendix of three map reading tasks exploring students' spatial abilities, because it was hypothesized that visual/ spatial orientation is related to music reading skills.

The participating schools were given a passcode to be able to log into the eDia platform, where the music reading test and the background questionnaire could be accessed. However, during our research we encountered the problem music schools not having computers, so we needed to conduct the survey in person with the use of tablets.

In developing the tasks, we relied on the opportunities offered by computers, such as variety of form, visualization and sound effects. In order to examine students' music reading skills, our musical examples were notated with MuseScore 2.0 free music composition and notation software.

Results

Eye-tracking research of music reading skills

1) Based on the results of eye tracking and the online music tests, it can be concluded that both testing procedures are suitable for the diagnostic testing of music reading skills in school settings. The heat maps show that the ten-year age groups read music note-by-note, as opposed to the older students who read units.

2) Just like languages, music also has different structural elements (sounds, intervals or chords) that are organized in hierarchical sets (Lerdal & Jackendoff, 1983). According to Sloboda (1977), music and language share the common tendency to evoke strong syntactic expectations, or sophisticated guessing and phrase units of a period could be determinants of visual processing in music reading. The rhythmic tasks and Kodály's compositions were divided into specific research areas (AOIs), namely into two four-bar half periods and four two-bar musical motifs. Musical structures are important in reading materials to enhance and facilitate students reading skills. In the first rhythmic exercise it was found that the fixation duration means of all participants were almost twice longer (18.40s) on the first two bars than on the second four bars (10.15s), which have a similar and familiar form, metrical structure and melody. It can also be concluded that the music structure of the exercises by Zoltán Kodály facilitates students' music reading skills.

3) When the same rhythm pattern, e.g. syncopation, reappears in the same reading exercise, the length of fixation duration drops by almost 50% (from 28.5s to 10.35s), which means that the familiarity with the music pattern helps with the music reading process. Familiarity with the music period units determines visual processing during reading. The research results show that the patterns of music and musical text characteristics strongly influence fixation durations. Kodály's eight-bar rhythm exercises were examined and it was found that the number of

fixations was twice as much as on the first four bars than on the next half period, because they were familiar to the students, in form, rhythm and melody.

In the thermal images it can be seen exactly where the eyes fixate the longest; these parts are highlighted in red, and the areas where the students rarely looked at are shown in green. It is important to explore those areas in different music materials where students have difficulties during music reading.

During music processing, the fixation falls in the middle of the bars, while time signatures and bar lines get less attention in Kodály's compositions. A number of conclusions can be drawn in connection with music reading on the basis of the thermal images of the eye movement tool. As hypothesized, the eye fixates the longest on the beginning of the music score, examining the meter and the different key signatures, and also fixates on the more complex rhythms and intervals. In the music score with sol-fa syllables, a progress can be observed: students were becoming better and better at singing and more self-confident as they were getting familiar with the music. They had fewer fixations towards the end of the score. In general, students observed the sol-fa notation rather than the rhythm or stick notation. They needed longer time when the rhythms became more difficult. Students rarely looked at the bar lines, they tended to focus on the middle of the bars.

4) It was revealed that students use music reading strategies. On a higher music skill level they memorize the melody and use it when they sing the verses of an unknown melodic example. On the basis of the number of fixations, we can calculate the means of total fixation durations. The whole musical score of the folksong with text was perceived in 122.52s. The mean of the musical score with the first text was 95.85s, the mean of the first verse was 13.85s, whereas the second verse had the lowest mean (12.39s). The hypothesis that music structure can have an effect on students' music reading skills was supported by the results. Students also tend to read the melody instead of rhythm.

5) Using quantitative and qualitative methods, it was showed that despite different teaching processes and methods (Kodály/ Dalcrose), we got similar results in the different age groups.

6) The thermal images in the eye-movement test reveal that the boys' reading scores are less scattered and more focused than those of the girls.

Online assessment of music reading skills

1) The online platform made data collection accurate, and it proved to be suitable for data recording, processing and was easy-to use for the participating students. On the basis of the results, it can conclude that the online testing of music reading skills can be implemented in general school settings.

2) The reliability of the test battery for music school students was good (Cronbach's alpha=0.832). The test proved to be the most reliable in the fifth grade (Cronbach's alpha=0.865), while it was the least reliable in the sixth grade (Cronbach's alpha=0.807).

The reliability of the online music reading test of the large-scale measurement in primary schools was 0.839. The reliability of the test was the highest (Cronbach's alpha=0.865) in the

seventh grade, while fifth graders had the worst results. Mainly because of the larger sample, the reliability of each subtest proved to be better than in the pilot study.

3) The music reading test matches the skill level of the grades tested in music schools. Music students' achievement was 76.69% with a standard deviation of 12.35. We found that the rhythm reading subtest was easier for the students than the melodic reading subtest. There were no significant differences between the music reading performances of the consecutive grades. However, significant difference was found in the music reading achievement between grade six and grade eight ($F=4.206$, $p=0.007$) Therefore, the students' music reading skills show an improvement between these grades. The findings confirm the results of the eye-tracking research, where a developmental trend in music reading was observed between the ages of 10-14. Moderate and strong correlations were found between the achievements in the music reading test and its subtests which presumably reflect the homogeneity of the measured skill structure.

Primary school students' mean performance on the music reading test was 54.84% with a standard deviation of 18.65. There were no significant differences between the four grades. The results are supported by Asztalos and Csapó's (2015) research, which explored the developmental trends of music perception abilities. They found that early childhood is an especially sensitive period when musical skills develop the most intensively, and then the process of the development slows down. The knowledge of sol-fa hand signs had a high performance (81%). Tasks in connection with timbre (29%) and dynamic reading got the lowest average (34%).

4) The relationship between the music reading skills and the background variables was analyzed. Moderate and strong correlations were found between music reading achievement and most of the academic subjects (Hungarian literature, grammar, mathematics, biology, history and English); however, it does not show any correlations with the grades in music. Therefore, the grades in music do not reflect the components of music reading. There are correlations between some components of functional music literacy (the attitudes towards choir or solo performances) and the music reading achievement.

We found correlations between the students' attitude towards some activities of the solfège lessons and their achievement in rhythm reading ($r=0.286$, $p<0.01$), attitude towards singing ($r=0.237$, $p<0.01$) and between students' achievement and their attitude towards listening activities ($r=0.245$, $p<0.01$). Music reading achievement does not depend on maternal education or on the socio-economic status.

5) Visual/ spatial tasks were not part of the music reading test, but we were interested whether students' spatial skills correlate with their musical skills. As expected, significant correlations were found between the achievements of the students on the music reading test and the map reading subtest ($p<0.001$). Music school students achieved significantly better results on each task of the map reading test, than mainstream school students.

6) Significant differences were found between the results of the common tasks of the two school types ($t=12.147$, $p<0.001$). The results are not surprising, as there is more emphasis on teaching music reading in music schools. The validity of the tests is supported by the better results of music school students in contrast to mainstream school students.

7) In the sample of the music school students, gender differences are not related to the music reading achievement. However, our expectations that the girls' results are significantly

better than those of the boys in each mainstream school grade were justified. There is a difference between the results of girls and boys in favor of the girls.

Summary

Both eye tracking and online tests require the direct application of music reading skills in a realistic context, thereby providing a valid and instructive measurement. The findings of this research can provide information for the educational system about how familiar Hungarian students are with the components of music reading. They can further support the teaching of music reading and reading strategies as a curricular objective and the development of detailed curricula.

Our researches were novel in the field of digital technology. It was demonstrated that the procedure is suitable for a large-scale assessment of music reading skills. Moreover, the online test proved to be a time and cost efficient objective measurement.

The validity of the tests is confirmed by the better results of the music school students. The reading achievement of the upper-graders significantly correlated with the achievement of visual/ spatial test ($p<0.001$). As expected, highly significant correlations were found between the achievements of students on the music reading test, its subtests and the map reading test ($p<0.001$).

In the background questionnaire the cognitive background variables were represented by grade. The music reading test score correlations with school subjects confirm the findings of Hollenbeck (2008) that draw attention to the cognitive, metacognitive and affective transfer effects of active music making.

Further research

The research investigated the music reading skills of students in the upper grades. Further research can involve the online assessment of students' strategy use utilizing the method of eye-tracking. This further research could serve as a basis for developing training programs of music reading comprehension. Further research can also include the investigation of the effect of beliefs and strategy use on reading comprehension, involving the motivational characteristics of students.

A self-developed new EEG device (EEG Mind Reader 1.0) can record brain waves. Combining EEG with Tobii eye tracking device we can answer the question whether the time on fixation point is actively spent on concentration during music reading. In music education the text is the score. Textual-analyses are needed in the field of music on the basis of linguistic researches in order to enhance student's reading skills. Besides the diagnostic evaluation, the online system can provide a great opportunity for the development. We aim to create programs that can provide music reading exercises in an adaptive way.

Extending the online music reading testing across different cities in different countries can increase the generalizability of the results. The online platform makes it possible to bridge distances. The test has a version in German as well which was used to test the music reading skills of primary school students in Luxembourg on the eDia platform.

Assessment is an essential component of music teaching and the learning process. With the help of a valid, reliable, and individualized assessment, students are able to develop important musical skills and move closer to reaching the ultimate goal of music literacy instruction: independent musicianship.

Irodalom

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