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STRUCTURE AND DEVELOPMENT OF MUSICAL PERCEPTION AT THE
AGES OF 5 TO 17 YEARS – ONLINE DIAGNOSTIC MEASUREMENTS IN
KINDERGARTEN AND SCHOOL ENVIRONMENTS

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Introduction

While learning of music had a great importance during the history of human civilization, scientific research of teaching music goes back no later than a century, and the examination of musical abilities by tests has an even shorter history. The measurement of musical skills by traditional paper-pencil tests has numerous limiting factors. This is partly the reason why we have quite a few information about their development despite of their significance. However technology-based testing provides new possibilities for music ability measurement too, which results better test-objectivity and validity and also facilitates the tests' wider dissemination. Successful education systems make a great emphasis on adapting to rapid changes, and on providing ideal conditions for the development of creative, independent, enterprising, flexible and cooperative personalities. Many areas of art education contribute directly to the development of these necessary skills and abilities. Not only the fast changes but also the growing syllabus challenges the schools. Consequently those subjects which have extensive transfer effects, but don't overload students, got an increasingly important role in education (Kokas, 1972). Music is one of them. There is a general view of music subject, that its evaluation is totally subjective (Hannah, 2007), and despite of the scientifically correct measurement tools developed in Hungary during the past years (Erősné, 1993; Turmezeyné, 2007; Janurik 2010) their regular practical application is rare. However the examination of musical knowledge can support its development and the enrichment of evaluating culture can makes the education process more effective.

The dissertation presents one of the basic elements of musical knowledge; music perception; its theoretical background and those online diagnostic tools which we developed, piloted and applied during the doctoral studies.

Objectives

In our research our main purpose was to develop diagnostic measurement tools which are time-and cost-effective but provide reliable information about students' achievement. We aimed to collect detailed information about the developmental level of musical perception, while our tests still relatively short and subjects can solve the tasks at the same time in their own kindergarten or school. After analyzing the literature we did not find any other technology-based musical tool for kindergartens or schools, so we aimed the testing of the innovative online environment and the demonstration of its application. Our further purpose was to help the focused pedagogical work with objective, diagnostic feedback and to contribute to the early recognition of the problematic or especially talented students, also in big class sizes. Measurements carried out in kindergartens, elementary and secondary schools may highlight the necessity of assessment and evaluation at early stages of public education, which allows right-time intervention, faster compensation and also helps to understand the characteristics of ability development from five years to adulthood. Our aim was to collect our data with big sample sizes, to certify the applicability of the tests in different educational environments and to discover the development and structure of musical perception in a great diversion of subsamples.

Theoretical background of the research

As music has different meanings in different cultures, abilities related to music also show differences (Godt, 2005; Cross, 2009; Lehmann, Sloboda & Woody, 2007). Listening to music or active music making generates numerous psychological processes, including perception, concentration, learning and remembering or the rapid processing of auditory information (Koelsch, 2012). Due to this complexity, music ability – in a wider sense – also means special skills related to interpretation, listening, creating music or skills necessary to play an instrument. In a narrower sense musical skills are related to purely musical contents, like rhythm, melody, pitch cognition and their reproduction.

We define cognitive processes carried out with auditive musical information as musical perception, after the terminology of Hungarian music psychology, and we classify it to the category of musical “aptitude” defined by Gardner (1979). In the definition of Koelsch musical perception means the following: “Music perception involves acoustic analysis, auditory memory, auditory scene analysis, processing of interval relations and musical syntax and semantics, and activation of (pre)motor representations of actions.” Furthermore musical perception effects on emotions, thus activates the autonomic nervous system, the hormonal system and the immune system. The basis of musical perception is the decoding of acoustic information (Koelsch, 2014, p.1.).

The framework of our measurement tools are based on the modular model of musical processing. In their cognitive neuro-psychological model Peretz and Coltheart assume that there is a module responsible for musical processing, which also means that there is a mental system of information processing related especially to musical phenomena. The basic cognitive processes of musical memory and perception develop independently from musical studies. For their research Peretz and her colleagues designed a model which determines the structure of musical system, its components, possible interactions and progresses (Peretz and Coltheart, 2003).

Based on the models analyzed in the present dissertation we can get a detailed picture about musical perception and the processes of acoustic stimuli. The detailed presentation of perception processes and their development provides interpretation framework to subtests included in our measurement tools.

Methods

During our research we developed two measurement tools; their finalization was preceded by pilot studies. The first pilot study was realized in May of 2012 in schools of a town in Southern-Hungary (N=653), and it was a basis for a national data collection in 2013 in elementary and secondary schools (N=2961). Our first kindergarten measurement was carried out during the spring of 2014 in kindergartens of a county seat town (N=203), then we applied the improved tool in September of 2015 in first grades of elementary schools (N=195). Based on the results of these two pilot studies we measured musical abilities nationally during the autumn of 2015 (N=5288).

Tests were created by the eDia online measurement system, and subjects solved the tasks in its web interface. PCs and headphones were provided by the schools and students solved the test in their own classrooms. Due to the easier handling in kindergarten measurements we applied tablets. The anonymity of the students was provided by the measurement identification codes of the Information System of Public Education.

In the case of elementary and secondary school testing our main purpose was to collect detailed information about the whole ability construct, so we applied the following subtests for the measurement of musical perception: (1) rhythm, (2) tempo, (3) melody, (4) visual connection, (5) pitch, (6) harmony, (7) dynamics and (8) timbre.

The framework of the childhood test is based on the most reliable task types by the literature and our own research: (1) melody perception, (2) pitch perception and (3) rhythm perception.

Background questionnaires designed to analyze the interrelationships of musical perception with social, cognitive and affective variables.

Due to the characteristics and functions of our examinations our research questions are formulated separately and we assume them below.

Musical perception test – pilot study

- 1) Is the online measurement of musical perception feasible in average school environment?
- 2) Are the tasks of musical perception provide reliable information of the ability?
- 3) What type of developmental and structural characteristics can be observed in different age groups and samples?
- 4) What are the differences between classes with and without special musical curricula?
- 5) What are the main characteristics of the relationship between the test achievement and background variables
- 6) How the redevelopment of the test should be realized?

Musical perception test

- 1) What is the internal consistency value of the test? Is it reliable for the subtests and subsamples?
- 2) What developmental trends can be observed during the 11 grades?
- 3) Is the structure of the measured perception skills consistent with the hypothetic model based on the literature?
- 4) Are there any gender differences in the test and subtests?
- 5) How socio-economical background affects test achievement?
- 6) How musical training affects test achievement?
- 7) How test achievement correlates with cognitive processes behind school marks?

Childhood musical perception test – pilot 1., pilot 2. and national study

- 1) Is the online testing of musical perception realizable in kindergarten environment,
- 2) Are the tasks of the measurement tool provide reliable information about musical perception?
- 3) How the redevelopment of the measurement tool should be realized?
- 4) What are the main characteristics of the measured ability structure?
- 5) What are the characteristics of the musical perception skills in the examined age group?

Results of the studies

Online diagnostic measurement of musical perception skills in 1st, 3rd and 5th grades of elementary schools – pilot study

1) Based on the outcomes of the test we conclude that the online measurement is suitable method for the diagnostic examination of musical perception in average school settings, the tool proved to be easy-to-use and students liked to work with it.

2) The internal consistency of the whole test is suitable (Cronbach $\alpha=0,92$), however subtests' values low reliability suggest that they need revision.

3) Comparative study of different grades shows the rapid development of the examined abilities during the first school years. Results support the statement of *Silvas* and *Haase* (2013) that melodic and rhythmic components of perception develop separately. Almost continuous musical environment surrounding children results the acceleration of the development of temporal abilities, while melodic and harmonic skills do not follow this trend. But Kodály's music pedagogical conception is basically melody centered and its effect can be detected in the better test achievement of students from schools with special musical curricula. The visual connection task measuring the basic ability of musical reading and writing is the only task which shows significant differences between all of the grades and subsamples.

4) Our results support that musical achievement is not related to socio-economical background variables of the families. Furthermore we did not find significant correlation between parents' highest education and test performance. We only find relation between music marks and test scores in musical schools, but with other school subjects' achievement shows moderate correlation.

5) Subtests' reliability problems should be solved by increased item quantity or we have to delete tasks with low internal consistency. We must define the musical background of the excerpts more precisely for comparative analysis.

Online diagnostic measurement of musical perception skills in grades 1st–11th – national study

1) The whole test's reliability is appropriate (Cronbach $\alpha=0,87$). We measured the lowest internal consistency value in Grade 1st grade and the highest in Grade 10th. The most reliable tasks were pitch perception and visual connection.

2) Comparing the achievement of different age groups we found that significant difference be observed between the age groups in every two year, so the developmental trends are proved but the changes are not dynamic. Analysis of subtests reflect on the hypothesis that from the view point of musical development first period of elementary school is highly important.

3) The structure of the examined ability and the validity of the test were analyzed by confirmative factor analysis based on the neuro-cognitive model of musical perception. The measured model was consistent with the hypothetic model. The examined perception skills relate to four latent factor: temporal processing (rhythm, tempo), contour analysis (melody, visual connection), pitch procession (pitch, harmony) and qualitative musical features (dynamics, timbre).

- 4) Gender differences do not show relationship with musical achievement.
- 5) Among variables related to family background the most significant is mother's highest education. This variable shows no explanatory value during the first school years but from Grade 5 it separates well the subsamples and explains test achievement in 6-11%. Correlation analysis supported the hypothesis, that economical background variables have no effect on musical perception.
- 6) We proved that intensive music training effects positively on test scores. Music curricula and instrument learning cause growing differences between the subsamples in higher grades.
- 7) While musical perception shows moderate correlation with most of the school subjects it must be highlighted, that the relationship between marks of music and test score is weak, negligible. Also the years of musical instrument learning ($r=0,102$, $p<0,01$), and the affection of singing ($r=0,081$, $p<0,01$) show low correlation values. Based on this finding we suppose that instead of perception skills, practical music knowledge and attitude there are other components (e.g. music history and theory) which have more determinative role in grading.

Application of online, diagnostic, childhood musical perception test in kindergartens and schools

- 1) Outcomes of the researches showed the technology-based method is effective way of measuring musical perception also in kindergarten and at the beginning of Grade 1. With tablets and earphones the test was an easy-to-use instrument for kindergarten children too.
- 2) The pilot study proved that the difficulty of the test fitted well to the ability level of children; however the internal consistency values and the deeper analysis showed that the measurement tool needs further development. Especially the terms (higher, lower notes) caused reliability problems in visual connection task, thus we considered the cancellation of these items. In contrasts we compensated low Cronbach values of pitch perception by more items.
- 3) After two pilot studies we optimized the measuring tool and we got a more reliable (Cronbach $\alpha=0,82$), time-effective (average test taking time: 15 min) test which has three subtests and 45 items.
- 4) Test and subtest achievements are moderately and strongly correlated, so the construct of the measured ability is homogenous. We found the weakest relationship between rhythmic and melodic processing. Results support the hypothesis that these two modules develop differently.
- 5) As the difficulty of the items was mostly influenced by their similarity or differences, we conclude that musical processing is not as precise yet as in higher age groups but the main tendencies can be observed and reflect the outcomes of our previous studies.

Conclusion

During the past decades ICT-based evaluation tools got increasingly important role. Most of the online measurements are related to the main subjects, like mathematics, reading comprehension and science. However innovative possibilities open new perspectives for art education too. It's especially important in the area of musical tests, because technology-based tools provides more freedom for students; they can answer the question in their own pace and the volume is changeable according to individual needs.

Based on the literature of musical testing we have not found any online measurement tool developed for educational use. There are only a few online musical perception test examining adult population (*Law & Zentner, 2012; Ullén et al., 2014*). The novelty of our research, that we applied our internet-based tests in the wider spectrum of public education. We proved that the method is suitable for large sample data collection; it is a time- and cost-efficient and objective solution to measure and compare musical development. One of the most important advantages of the online test, that whole classes can solve the tasks at the same time and same classroom without disturbing each other's work. For kindergarten children, lower elementary school students and for those who have reading difficulties the narrator voice provide help which can be listened more times. The online system makes easier the testing for children but data collection is also faster and easier there is no need for coding, databases are immediately available after a test subject solved the tasks. Thanks to the feedback function of the eDia teachers can reach their students' scores and they can compare it with other school in local, regional or national level. To assume, technology-based musical testing is more efficient in educational practice than traditional paper-pencil tests, and it also helps to discover problematic or especially talented students.

In the development of our instrument tools pilot studies had fundamental role, based on their outcomes our final tools have good internal consistency values. Validity of the tests was proved by the better performance of musical test subjects. The unified online test environment and the narrator voice contributed to the test objectivity. We examined musical abilities with tasks which required no special musical training or preliminary knowledge. The measured psychological dimension reflects on the ability itself but showed moderated, strongly-moderated relationship with musical studies.

Results proved that modular model of music perception (*Peretz and Coltheart, 2003*) is consistent with the measurement model of the test. We found four latent factors behind the construct: temporal, contour and pitch processing and qualitative musical features. By the confirmative factor analysis we also demonstrated the validity of the test.

The literature of music psychology supports the fact that musical ability development is a slower process but it has significant, long-term effects. Based on our results we conclude, that most of the examined abilities develop faster during the first elementary school years and this highlights the importance and need of the focused, child-friendly, colorful training of musical skills in this period (*Hargreaves, 1986; Kenney, 1997; Loong & Lineburgh, 2000; Sims, 2005; Werner, 2007*). In later school years we found such dynamic developmental trends online in the case of those students who take part in special musical training. Based on the analysis we suppose that the development of most skills slows down in higher elementary grades, but in secondary years they show a more dynamic trend again. This can be observed in the most characteristic way in visual connection, where – in a unique way – biggest difference between developmental levels can be found in secondary school, so the development of this ability presumably continues in adulthood too. The detailed musical parameters of the items provided opportunity for their multidimensional comparison. Their difficulty was in balance with their musical characteristics. Interesting fact that discrimination of rhythmic patterns is more difficult if the changed note is at the end of the excerpt, while in

melody discrimination the first note is the most sensitive. This finding also support that the two skills develop separately and it is also important in music education practice.

Our results confirm the hypothesis that musical training positively effects musical perception (Hargreaves, 1986; Besson et al., 1994; Gaab & Schlaug, 2003; Meister et al., 2005). There were no significant differences between the test scores of musical and non-musical schools in the first period of elementary school, but in later grades curricula have a growing impact on achievement, and indicate growing differences between the subsamples.

In our questionnaire cognitive background variables were displayed by school marks. We found moderate correlation between test achievement and literature, grammar, foreign language, mathematics and diligence marks. In fact we can't reflect on real transfer effect by these results, but the findings are consistent with the literature (Schmithorst & Holland, 2004; Janurik, 2008; Loui, Kroog, Zuk, Winner & Schlaug, 2011; Milovanov, Pietila, Tervaniemi & Esquef, 2010). We suppose that in the evaluation of music subject musical perception skills and practical musical knowledge have no determinative role.

Important finding of the background variable analysis that test achievement correlates with quite a few economic variables and the measured values really weak, negligible. Only the number of books and musical instruments at home show weak-moderate correlation with perception achievement. Parents' highest education is not determinative in lower grades but in later school grades get more important role, in higher elementary grades its explanatory value is 12%. As the critical period of musical development is in the first school years, music education can be an effective compensation tool for students with less ideal socio-economical background (Barkóczy & Pléh, 1977).

Results interpreted in the dissertation reflect on a basic, determinative but really small area of musical knowledge. In contrast to the highly precise psychological measurement tools (EEG, MRI), online, diagnostic tests are designed for big data collection in short time. Because of this in the future the extension of the measuring content is appropriate for example for the productive and reproductive musical skills. Rapidly developing technology-based methods provide more and more innovative possibilities for the realization of this extension. Besides the psychological dimension (musical ability) it would be worth to examine the declarative parts of musical knowledge by an objective measurement tool collecting information about the curricular goals. The online system not only suitable for diagnostic evaluation but also for developmental programs and in the future our main aim, to design a musical training program which provides adaptive, personalized, game-like musical tasks based on previous test achievements.

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