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## The Relationship between Teacher Evaluation of Children's Musical Abilities and Executive Functions Indicators in Children Attending Music Classes

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**Abstract: Introduction.** The purpose of this work was to investigate the correlation between teacher assessment of children's musical abilities and the development of their executive functions. Additionally, as part of the study, an initial approbation was conducted of a questionnaire for assessing the children's musical abilities. The novelty of this research lies, firstly, in the development and practical evaluation of a new tool for assessing children's musical abilities, based on a concept of B. M. Teplov, and secondly, in the demonstration that not only music lessons affect the developmental indicators of executive functions in children, but also some of the executive functions also contribute to children's musical abilities. **Methods.** The study involved 61 children, aged 5 to 6 years, who had attended music classes several times a week at children's art schools in Moscow and Krasnodar. During the evaluation, such indicators of executive functions as cognitive flexibility, working memory and inhibition were studied in the course of several meetings with children. 50 teachers took part in the assessment of the development level of children's musical abilities. They filled out a specially designed questionnaire aimed to identify the level of development of the following parameters of children's musical abilities: pitch perception, sense of rhythm, modal perception and emotional responsiveness. **Results.** As a result, a positive link was established between visual working memory and the assessment of pitch perception in children in music classes. Moreover, as a result of the regression analysis, it was shown that the indicator of children's visual working memory contributes to the assessment of such parameters of musical abilities as pitch perception ( $R^2 = 0.241$ ,  $p=0.008$ ) and emotional responsiveness ( $R^2 = 0.149$ ,  $p = 0.043$ ). **Discussion.** Therefore, the study demonstrates a link between musical abilities and executive functions in children, as well as a contribution of executive functions to the evaluation of their musical abilities, which justifies the value of systematic musical lessons in preschool age.

**Keywords:** executive functions, preschool age, music lessons, musical abilities, children, inhibition, cognitive flexibility, working memory, music, art schools

### Highlights:

- Musical abilities such as pitch perception, sense of rhythm and emotional responsiveness are positively correlated with such indicators of executive functions as visual working memory and inhibition in children aged 5–6 years.
- Such a component of executive functions as visual working memory contributes to the assessment of children's musical abilities such as pitch perception and emotional responsiveness.
- The established link between musical abilities and executive functions in preschool children indicates the possibility of introducing to musical classes specially designed programs aimed to develop children's executive functions.

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## Introduction

### **Research of musical abilities**

Music is a cultural universal, and all people have the potential to develop musical abilities and skills. However, the evaluation of musical abilities have remained problematic for many years. Many authors have developed methods for assessing musical abilities (Correia et al., 2021; Bentley, 1966; Gordon, 1989; Teplov, 1947), which has led to a large number of approaches to understanding what «musical abilities» are and a variety of testing procedures for this phenomenon (Colwell & Abrahams, 1991; Woodford, 1996; Hallam, 2010; Hallam & Papageorgi, 2016). The lack of a unified theoretical concept for musical abilities was not only reflected in a multitude of testing procedures, but also caused extensive criticism of existing tests, for example, their emphasis on auditory perception and the duration of practice (Howe et al., 1995; Woodford, 1996; Demorest, 1995; Hallam, 2010; Ollen, 2006; Mosing et al., 2014). Moreover, critics claim that the existing tests cannot reflect the true nature of musical abilities and their development, since they ignore a number of important abilities, for example, musical communication, music perception, motivation (Murphy, 1999).

The approach currently used to assess musical abilities considers them a social construct that bears different meanings in different cultures, social groups and even individuals (Hallam & Prince, 2003; Butkovic et al., 2015). Understanding musical abilities as a construct, specific to a population of a country, its musicians and music teachers, allows us to take into account cultural characteristics, as well as current social changes. This enables us to cover many facets of the concept of musical abilities in such a way as to reflect the real experience of practicing music (Levitin, 2012; Kragness et al., 2021).

For example, in a study by Haroutounian (2000) which involved 244 music teachers from the USA, it was shown that such indicators as sustained interest and self-discipline scored higher as predictors of musical abilities and giftedness than musical skills in the strict sense. However, among the skills, the highest average score was obtained for pitch and rhythm accuracy, rhythmicity and

technical fluency. With additional clarifications, the experts stressed the importance of music perception, creative interpretation, performance and motivation. O'Neill (2002) investigated beliefs about musical abilities by evaluating children's personal beliefs about this construct. During the interview, 172 children from the United Kingdom aged 6 to 11 were asked about their beliefs about their own musical abilities. The results showed that the beliefs about one's musical abilities are largely based on their personal experience of practicing music: children who did not play any instruments demonstrated a more rigid view of musical abilities, leaving little room for change. In contrast, children with musical experience had more flexible ideas. Furthermore, motivational factors and enthusiasm are important components of musical abilities (Hallam, 2010; Hallam & Prince, 2003). The pleasure derived from music, as well as the internal motivation that develops through musical experience, are often described as important prerequisites for musical activity and intensive practice necessary for musical skills development (Sloboda et al., 1994).

Within the Russian psychology of musical abilities, the most developed and authoritative concept is the one by B. M. Teplov (1947). According to it, when assessing musical abilities, the following components must be taken into account: modal perception (the ability to perceive pitch movement, the direction and the expressive qualities of the melody), pitch perception (the ability to reproduce sounds and melodies by ear) and sense of rhythm (the ability to feel the rhythm and repeat it) (Teplov, 1947). Moreover, this concept suggests that all musical abilities are interconnected and develop through children's musical activity. In this regard, when evaluating musical abilities, it is important not to think in terms of presence or absence of a particular ability, but rather about the interrelation of the abilities.

### ***Executive functions and music lessons in preschool age***

Executive functions are the general cognitive abilities necessary for purposeful behavior, adaptation and problem solving (Miyake et al., 2000; Morosanova et al., 2021). They include several components such as inhibition, cognitive flexibility, and working memory (Miyake et al., 2000; Miyake & Friedman, 2012). Many authors state that executive functions are important predictors of academic success, social success and quality of life (Shanmugan & Satterthwaite, 2016; Diamond, 2013; Denham & Brown, 2010). In this connection, there is a great potential in developing educational strategies for their development, starting from childhood (Bukhalenkova et al., 2020).

One of the possible ways to develop executive functions in children of preschool and primary school age are music lessons (Diamond & Lee, 2011). Meanwhile, it is noted that various types of musical activities (in particular, playing an instrument, participating in an orchestra, choral singing) can increase the indicators of executive functions of preschoolers and younger schoolchildren (Bugos & DeMarie, 2017; Holochwost et al., 2017; Degé et al., 2011; Jaschke et al., 2018; Roden et al., 2014; Frischen et al., 2021). Several empirical studies have investigated the relationship between instrumental music lessons and executive functions in children (Degé et al., 2011; Joret et al., 2017; Zuk et al., 2014; Chen et al. 2021; Fasano et al., 2019). The results of these studies indicate a positive link between music learning and such indicators of executive functions in children as inhibition (Joret et al., 2017; Fasano et al., 2019), working memory (Chen et al. 2021), cognitive flexibility (Dege et al., 2011; Zuk et al., 2014), information processing speed (Zuk et al., 2014) and planning (Dege et al., 2011; Chen et al. 2021).

At the same time, it is worth mentioning that playing a musical instrument requires a high level of various components of executive functions, such as inhibition, selective attention and

cognitive flexibility (Degé & Frischen, 2022; Okada & Slevc, 2018; Holochwost et al., 2017). For example, inhibition skills are required when the key or rhythm changes, and the musician needs to suppress the intention to stay in the previous key or rhythm (Degé & Frischen, 2022). In addition, the musician must read the notation and translate it into sounds, all while listening to the melody and analyzing it for errors, speed and volume, which also certainly requires a sufficient level of development of executive functions (Slevc et al., 2016).

Thus, despite a large number of studies demonstrating the relationship between music lessons and executive functions, it remains unclear whether music classes contribute to the development of executive functions or whether children with more developed executive functions are more likely to attend them (Schellenberg, 2006; Bayanova & Hamatvaleeva, 2022).

Due to the ambiguous results of studies on the influence of executive functions on children's musical abilities, and the lack of modern diagnostic tools for evaluating children's musical abilities, we decided to develop a questionnaire for music teachers and to assess the correlation between executive functions indicators and the results of this questionnaire.

## **Methods**

### **Sample**

61 children participated in the study: 17 boys and 44 girls (M age = 68.72 months, SD age = 6.73) who attended music classes in the institutions of additional education (children's music schools and art schools) in Moscow and Krasnodar. All the children participating in the study were in senior kindergarten groups. Children attended music classes at art schools over a period from 3 to 6 months, from 1 to 3 times a week. These lessons consisted of both practicing a musical instrument and mixed activities where children danced to music, studied in a group, and sang in a choir. 2 meetings lasting 20 to 25 minutes each were held with each child. The order of presentation of tasks in each meeting was the same for all children.

### **Tools**

The level of development of executive functions was measured using a battery of tools that are subtests of the neuropsychological diagnostic complex NEPSY-II (Korkman et al., 2007):

1. The «Sentences Repetition» subtest is aimed at assessing auditory verbal working memory. This technique uses 17 sentences with a gradual complication of the stimulus material (sentences become longer and more complex in structure). For each sentence, the child is awarded 2 points if there are no errors, 1 point – for one or two errors, 0 points – for three or more errors or in case of a failure to repeat the sentence.
2. The «Memory for Designs» subtest is intended to assess visual working memory. With this technique, two aspects of visual memory are measured at once – memory for «images» and for the spatial arrangement of details. For each task, one point is awarded for each correctly selected card («details»), one for each correctly indicated place, according to the model («location»).
3. The «Dimensional Change Card Sort» subtest consists of several tasks for sorting cards by different attributes. This technique is aimed at determining the level of development of cognitive flexibility in a child.
4. The «Inhibition» subtest includes two tests: the first one is for naming geometric shapes, and the second one is for inhibition. The results of the child's performance (the number of mistakes made and the time spent on each take) allow to determine to what level the

processes of switching and inhibition are developed.

### **Questionnaire for teachers**

To evaluate the musical abilities of children attending music classes, a questionnaire «Assessment of children's musical abilities» was developed. When working on a questionnaire for teachers, we chose as a basis the concept of musical abilities of B. M. Teplov (Teplov, 1947), as it was described above. However, due to the need to take into account the actual life context and the importance of the motivational and emotional components of children's development, we have then included another component of musical abilities, which is more associated with enjoying music – emotional responsiveness, which is defined as the ability to emotionally engage in music and to awaken the imagination.

Thus, this questionnaire consists of 20 questions and requires teachers to assess musical abilities of children they are working with. Each of the 4 scales consists of five questions about relevant competencies of the child: the ability to reproduce a melody, perception of melodic motion, distinguishing registers by ear, identifying the rhythm of the melody, and the emotional response to the melody.

- The «Pitch Perception» scale includes the following questions: «The child is able to sing his favorite song with and without accompaniment, intoning the sounds purely»; «The child is able to identify the melodic motion – ascending, descending, repeated»;
- The scale «Modal Perception» consists of the following questions: «The child is able to identify the mode of a chord – major or minor»; «The child is able to determine the melodic motion of chords – ascending, descending, repeated»;
- The questions for the «Sense of Rhythm» scale are as follows: «The child is able to organize sounds into musical forms and ultimately into a whole composition»; «The child feels and understands the character of the rhythm (calm and slow, active and cheerful)»;
- The «Emotional Responsiveness» scale includes the following questions: «The child is able to feel the character of the music (cheerful, sad)»; «Music awakens the child's imagination, evoking a variety of ideas, associations, images».

The approbation of the methodology took place in several stages. At the first stage, the questionnaire was designed, consisting of 16 questions that constituted a single scale. Then a focus group of 7 teachers from 3 music schools was gathered. They were sent the primary version of the methodology. After the final version was approved by experts, the questionnaire was sent to music schoolteachers. In total, the study included 50 teachers, who taught children undergoing the assessment.

## **Results**

Microsoft Excel 2016 and IBM SPSS Statistics 22 programs were used to process the empirical data. As a result of checking the distribution for normality, it was shown that the distribution over the sample is mixed (Kolmogorov – Smirnov criterion), therefore, nonparametric data processing methods were applied for further testing of the hypotheses.

From the analysis of descriptive statistics of the executive functions indicators, it was demonstrated that the indicators of preschool children attending additional music classes are within the norm relative to the indicators of children of the same age who were not attending music classes (Table 1).

**Table 1***Descriptive statistics for executive functions indicators in preschool children*

<b>Executive functions parameters</b>	<b>Average value</b>	<b>Minimum value</b>	<b>Maximum value</b>
Cognitive flexibility	19.36	13	22
Visual working memory	85.66	53	114
Visual verbal working memory	19.52	8	28
Naming time	92.51	49	164
Inhibition time	124.69	80	180
Mistakes	12.87	3	51
Naming mistakes	4.22	0	25
Inhibition mistakes	8.64	2	31
Naming comb.	10.43	1	17
Inhibition comb.	10.18	3	16

**Check of the consistency-reliability for the teachers' questionnaire scales**

To check the consistency reliability for the scales of the questionnaire «Assessment of children's musical abilities», the Kronbach alpha coefficient ( $\alpha = 0.880$ ) was calculated. A sufficiently high coefficient indicates that the scales of the methodology are consistent with each other.

As a result of the correlation analysis of the questionnaire scales (Spearman's  $R_o$ ), it was shown that all scales of the methodology significantly and positively correlate with each other ( $p < 0.01$ ). Similar results also demonstrate the link and consistency of the questionnaire scales with each other (Table 2).

**Table 2***Results of the correlation analysis for the teachers' questionnaire scales*

<b>Indicators of the Russian Federation</b>	<b>Pitch perception</b>	<b>Modal perception</b>	<b>Sense rhythm</b>	<b>Emotional responsiveness</b>
Pitch perception		.714**	.631**	.544**
Modal perception	.714**		.761**	.545**
Sense of rhythm	.631**	.761**		.738**
Emotional responsiveness	.544**	.545**	.738**	

***The relationship between teachers' assessments and the indicators of children's executive functions***

To determine the level of correlation between teachers' assessments of children's musical abilities and executive functions and emotional development of preschoolers, a correlation analysis was carried out (Table 3).

**Table 3**

*Results of the correlation analysis of the executive functions indicators and the teachers' assessment*

<b>Indicators of the Russian Federation</b>	<b>Pitch perception</b>	<b>Modal perception</b>	<b>Sense of rhythm</b>	<b>Emotional responsiveness</b>
Cognitive flexibility	0.064	0.011	0.132	0.240
Visual working memory	0.421**	0.262	0.333*	0.342*
Visual verbal working memory	-0.050	-0.072	0.019	-0.056
Naming time	-0.323*	-0.280	-0.302*	-0.348*
Inhibition time	-0.363*	-0.264	-0.283	-0.234
Mistakes	-0.282	-0.241	-0.173	-0.337*
Naming mistakes	-0.106	-0.186	-0.092	-0.233
Inhibition mistakes	-0.304*	-0.219	-0.164	-0.302*
Naming comb.	0.096	0.066	-0.021	0.106
Inhibition comb.	0.207	0.069	-0.005	0.162

Based on the correlation analysis, significant positive links were found between such indicators as visual working memory and pitch perception ( $r = 0.421$ ;  $p < 0.01$ ). That is, the more developed a child's visual working memory, the higher this child's teacher's evaluation of her or his ability to reproduce a melody and the ability to identify melodic motion. In addition, indicators of visual working memory are positively correlated with teachers' assessments on such indicators as a sense of rhythm ( $r = 0.333$ ;  $p < 0.05$ ) and emotional responsiveness ( $r = 0.342$ ;  $p < 0.05$ ).

Also, several indicators of the techniques for measuring inhibition demonstrated significant negative correlations with such indicators of children's musical abilities as pitch perception, sense of rhythm and emotional responsiveness. That is, the faster the children cope with tasks for inhibition, the higher the teachers evaluate their ability to reproduce the melody, to identify melodic motion, to identify the rhythm of the music, as well as their ability to respond emotionally to music.

To analyze, to what extent the developmental level of the executive functions of children in music classes contribute to the assessment of their musical abilities, a multiple regression analysis was carried out, where the criterion was musical abilities indicators, and the predictors were executive functions listed above.

**Table 4**

Results of the regression analysis for the contribution of the executive functions indicators to the indicators of the «Pitch Perception» variable

	Regression coefficient	R-square	F	Significance	Durbin-Watson Criterion
Constant	8.064				
Visual working memory	0.126	0.241	8.264	0.008	1.596

As a result of the regression analysis, it was shown that the indicator of children's visual working memory contributes by 24.1 % to the teachers' assessment of such a parameter as pitch perception (Table 4).

**Table 5**

Results of the regression analysis for the contribution of the executive functions indicators to the indicators of the Emotional Responsiveness variable

	Regression coefficient	R-square	F	Significance	Durbin-Watson Criterion
Constant	14.026				
Visual working memory	0.081	0.149	4.534	0.043	1.291



As a result of the regression analysis, it was shown that such an indicator of children's executive functions as visual working memory contributes by 14.9 % to the teachers' assessment of such a parameter as emotional responsiveness (Table 5).

Thus, such an indicator of executive functions as visual working memory largely determines teachers' assessments of such indicators of musical abilities in preschoolers as pitch perception and emotional responsiveness.

## Discussion

As a result of the conducted research, we have developed and tested a methodology of teacher evaluation of children's musical abilities.

Verification of the consistency-reliability of this questionnaire showed acceptable results, which indicates the uniformity of the scales and the possibility of its further implementation. At the same time, due to the lack of other diagnostic tools, at the moment we cannot verify the construct validity of this methodology.

Also, as a result of the study, a relationship was revealed between such a parameter of executive functions as visual working memory and such a parameter of teacher evaluation as pitch perception. In other words, children with a more developed ability to retain objects and their location in working memory are more able to recognize sounds of different heights and timbres. Moreover, the results demonstrated that the parameter «visual working memory» contributes more than 20 % to the ability to recognize sounds. In our opinion, these results may be linked to the fact that while learning to play a musical instrument, children primarily learn to read notation and take solfeggio classes, improving their musical hearing and literacy. While developing the ability to correlate notes and sounds, children are possibly also developing their visual working memory. This result is consistent with some studies that also show the effect of music lessons on visual working memory (Frischen et al., 2021; Bayanova et al., 2022). For example, in the work of Frischen and colleagues (2021), the children who participated in the study were taught to play musical instruments, which included learning and reading musical notation. It can be assumed that this specific activity contributes to the development of visual working memory in contrast to mixed musical activities, when children also sing, listen to music, dance to music, play rhythmic games, etc. (Frisen et al., 2021). Moreover, a study by Bayanova and colleagues showed that children who practice music also have a higher level of visual working memory than children who do not (Bayanova et al., 2022). However, in this study, such differences were not significant, which is explained by the fact that the children included in the musical group were not only practicing a musical instrument, but were also engaged in other music-related activities. In addition, this study was a pilot, and many factors that could influence the results were not controlled. Lastly, some authors note that visual working memory develops in children at a later age, which may also influence the contradictory results of the study by Bayanova and colleagues (Tikhomirova et al., 2020).

At the same time, it is important to emphasize that the results of this study do not agree with most studies on this topic. The latter demonstrate the influence of music lessons on the development of auditory verbal working memory to a greater extent than on visual working memory (Ho et al., 2003; Бойко и др., 2019; Chen et al. 2021). In our opinion, this may be due to the limitations of the study. One of these limitations is a small sample, which makes it impossible to sufficiently assess the diagnostic capabilities of the developed questionnaire and its potential

to search for links between the children's executive functions and their teachers' assessment of their musical abilities. Also, the children who took part in this study had attended music classes for no more than 6 months, so their abilities may not have been formed sufficiently yet to produce noticeable differences in both musical abilities and executive functions. In addition, since it was a pilot study, it have not taken into account such factors as teacher-student relationships, teaching style, home music environment, and others.

### **Conclusion**

Therefore, as a result of this research, a questionnaire was developed and tested to assess the musical abilities of children. This questionnaire is valuable for further study of the link between children's musical abilities and both their personal and cognitive development, as well as the specific features of music teaching in children's art schools. Moreover, the results of the study revealed a link between such a component of executive functions as visual working memory and children's musical abilities. Further study of how music lessons are connected to the development of executive functions is important, on the one hand, for designing programs aimed at working on executive functions of preschool children, and on the other hand, for improving children's musical skills through the development of their executive functions.

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**A. G. Dolgikh** made the conceptualization and methodology of the study, developed project administration and made the final approval of the version for publication.

**L. F. Bayanova** made the conceptualization and methodology, final approval of the version for publication.

**A. N. Shatskaya** – prepared the research, made the final approval of the version for publication.

**A. A. Yakushina** made the preparation and editing of the text, statistical analysis, and final approval of the version for publication.

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#### **Conflict of Interest Information**

The authors have no conflicts of interest to declare.