

THE RELATIONSHIP BETWEEN MUSIC CLASSES AND VERBAL FLUENCY IN CHILDREN

LA RELACIÓN ENTRE LAS CLASES DE MÚSICA Y LA FLUIDEZ VERBAL EN NIÑOS

A RELAÇÃO ENTRE AS AULAS DE MÚSICA E A FLUÊNCIA VERBAL EM CRIANÇAS

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ABSTRACT

This study examined whether music education was associated with improved performance on measures of children verbal fluency. The total sample consisted of 343 children: 210 children who attended music classes (M = 104 months, SD = 9.17) and 133 children who did not attend music classes (M = 101 months, SD = 4.08). Each participant was assessed for their level of verbal fluency. Results indicated that children who attend music classes for more than a year have significantly better verbal fluency than children who do not attend music classes. These differences persist when controlling for factors such as gender, age, and duration of music classes attendance. The results obtained allow us to consider the practice of music classes as one of the resources for supporting children's language development.

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RESUMEN

Este estudio examinó si la educación musical estaba asociada con un mejor rendimiento en las medidas de fluidez verbal en niños. La muestra total consistió en 343 niños: 210 niños que asistieron a clases de música (M = 104 meses, DE = 9.17) y 133 niños que no asistieron a clases de música (M = 101 meses, DE = 4.08). Se evaluó a cada participante en cuanto a su nivel de fluidez verbal. Los resultados indicaron que los niños que asisten a clases de música durante más de un año tienen una fluidez verbal significativamente mejor que los niños que no asisten a clases de música. Estas diferencias persisten al controlar factores como género, edad y duración de la asistencia a las clases de música. Los resultados obtenidos nos permiten considerar la práctica de clases de música como uno de los recursos para apoyar el desarrollo del lenguaje en los niños.

RESUMO

Este estudo examinou se a educação musical estava associada a um melhor desempenho nas medidas de fluência verbal em crianças. A amostra total consistiu em 343 crianças: 210 crianças que frequentaram aulas de música (M = 104 meses, DP = 9,17) e 133 crianças que não frequentaram aulas de música (M = 101 meses, DP = 4,08). Cada participante foi avaliado quanto ao seu nível de fluência verbal. Os resultados indicaram que crianças que frequentam aulas de música há mais de um ano têm uma fluência verbal significativamente melhor do que crianças que não frequentam aulas de música. Essas diferenças persistem quando controlados fatores como gênero, idade e duração da frequência às aulas de música. Os resultados obtidos permitem-nos considerar a prática de aulas de música como um dos recursos para apoiar o desenvolvimento da linguagem nas crianças.

Verbal fluency – is the rapid verbal naming according to specified criteria (Cohen et al., 1999). Generating words requires creating a strategy for retrieving them in memory, holding the instruction, inhibiting repetition and automatically surfacing associations and inappropriate words, and flexibly switching between categories (Kovyazina et al., 2021; Villalobos et al., 2022). This explains the association between verbal fluency and cognitive processes. Verbal fluency is mainly associated with executive functions (Aita et al., 2019; Villalobos et al., 2022), attention (Francisco et al., 2019), updating information (Laisney et al., 2009) and processing speed abilities (Elgamal et al., 2011). In addition, verbal fluency has been associated with language performance (Biesbroek et al., 2016; Bragrad et al., 2012), including vocabulary knowledge, lexical access skills and narratives (Shao et al., 2014; Grogan et al., 2009; Hilviu et al., 2023). The cognitive processes listed above are particularly important in childhood because their development contributes to a child's academic and social adjustment (Veraksa, Sidneva, 2024; Korneev et al., 2023; Bondarenko et al., 2022; Stozharova, Mikhailova et al., 2022).

Due to the fact that verbal fluency has strong associations with both executive functions and language ability, it can be developed through similar activities. One such activity could be music classes (Akishina, 2023). There is a great amount of empirical evidence confirming the association between executive functions and extracurricular music classes in children (Bayanova et al., 2022; Chen et al., 2021; Frischen et al., 2019; Jaschke et al., 2018; Sala & Gobet, 2020; Dolgikh et al., 2022). Thus, in a study by Chen and colleagues (Chen et al. 2021), conducted on a sample of 151 children who had been attending musical classes for at least three years, it was shown that Stroop test scores for children involved in music classes were significantly higher for inhibitory control and working memory, compared to children not involved in music (Chen et al. 2021). The results of the longitudinal study by Jaschke and colleagues (Jaschke et al., 2018), conducted on a sample of 147 children aged 6-7 years over a period of 2.5 years, demonstrated significant improvement in cognitive performance in children who regularly attended music classes. The scores on tests of inhibition, planning, and verbal intelligence were significantly higher in musicians compared to non-musicians (Jaschke et al., 2018).

In addition, previous studies have suggested that music classes have an impact on language abilities (Linnavalli et al., 2018; Ozernov-Palchik et al., 2018; Sala & Gobet, 2020; Vidal et al., 2020). In study by Jaschke et al, 2018 it was shown that children who attended music classes for 2.5 years showed higher levels of language abilities compared to children who did not attend such classes (Jaschke et al., 2018). The study of Cohrdes and colleagues emphasizes the strong association between music classes and language learning. There were 3 experimental groups in the study: those who were in music training, those who were in language training, and those who did not have any additional training during the 6 months of the experiment. The

group who were trained in music significantly improved their skills in tonal analysis, rhythm repetition, compared to those who did not receive any additional training. An important result is that the group that received language training also improved their musical skills, indicating that these areas are interrelated. Thus, the children in the language training group benefited as much from the lessons as the children in the music training group (Cohrdes et al., 2019). In addition, a body of research suggests that music lessons and the development of musical abilities predict higher level of literacy and phonemic awareness, which determine the development of language abilities (Corrigall & Trainor, 2011; François et al., 2013). The results of described studies demonstrate the association between music classes and language abilities. This connection can be explained by the fact that music and language involve similar mechanisms of perception and information processing (Vidal et al., 2020) and activate overlapping areas of the brain (Lehrdahl & Jackendoff, 1983).

However, a number of studies do not support the association between music classes and language abilities in children. For example, Sachs et al., 2017 did not find development of vocabulary knowledge in 8–9-year-old children who attended music classes for 2 years (Sachs et al., 2017). We also have not found any studies about the relationship between verbal fluency and music classes in children.

THE PRESENT STUDY

The aim of this study was to investigate the differences in verbal fluency between children who attended music classes and those who did not. The present study was designed to address two research questions: are there differences in verbal fluency between children who attend music classes and those who do not (RQ1); is it related to the duration of music classes attendance (RQ2).

MATERIAL AND METHODS

PARTICIPANTS

A total of 343 children participated in the study: (1) 210 children who attended music classes ($M = 104$ months, $SD = 9.17$, 70% girls) and (2) 133 children who do not attend music classes ($M = 101$ months, $SD = 4.08$, 51.4% girls). These participants came from state music schools in Krasnodar (Russia). The average length of attendance at music schools was 19 months ($median = 12$; $SD = 13$; range = 1 to 48 months).

Participation in the study for participants was organized on a voluntary non-reimbursable basis with the parents' signed written consent for their child to participate in the study. None of the participants had a developmental delay or disability. During the first half of the day, assessment tasks were completed individually in a quiet room in the music classes.

MEASURES

The Verbal Fluency Test (Akhutina, 2016) was used to assess the children's verbal fluency. The subject is given one minute to name as many words as possible: (1) on a free topic (any words); (2) on the topic of actions (verbs). All children's word rows were recorded and subsequently decoded. The overall verbal fluency score (separately for (1) "any words" and (2) "actions" topic) is the number of productive associations, i.e. all the words named without duplicates. The productivity score was calculated according to the following criteria: each new word was given one point, as were all combinations of words. However, if the child suggested combinations with a repeated word, each new combination was given 0.5 points. If the subject produced a so-called "automated sequence" (i.e. a learned and well-established sequence of words, such as January, February, March, etc.), the interviewer awarded one point for the entire sequence.

DATA ANALYTICAL APPROACH

Firstly, verbal fluency subtests ("any words" and "actions") were compared between children who do not attend music classes (*no-music group*) and children who do attend one (*music group*).

Secondly, the length of attendance at music classes was analyzed (what proportion of children attended music classes for less than 12 months (median value), what proportion attended for more than 12 months). Correlation analyses were conducted

to determine the relationship between the length of attendance at music classes (in months) with the level of verbal fluency development (“any words” and “actions” subtests). For further analysis, a group of children who have been attending music classes for more than a year was selected (*music-12 group*). Next, mean values on verbal fluency “any words” and “actions” subtests) were compared between children who do not attend music classes (no-music group) and children who attend music classes for more than 12 months (*music-12 group*).

Thirdly, the contributions of gender and age to the differences in verbal fluency using partial correlations and linear regression modeling.

RESULTS

VERBAL FLUENCY OF MUSIC GROUPS AND NO-MUSIC

In the first stage of the analysis, the test for normality results showed that the data belong to normal distribution (Shapiro-Wilk statistic $W = 0.991$, $p = 0.054$ and $W = 0.992$, $p = 0.074$ for “any words” and “actions” correspondingly). The results of the Levene's test showed compliance with the assumption of equality of variance for “Any words” ($F = 1.56$, $p = 0.213$) and violation of it for “actions” ($F = 5.28$, $p = 0.022$). For this reason, Student's t-test was used for the analysis of "any words" and Welch's t-test was used for the analysis of "actions".

It was shown that no significant differences between both groups were obtained for any of the subtests on verbal fluency: for "any words" $t = 1.44$, $p = 0.150$ (Cohen's $d = 0.171$), for "actions" $t = -1.89$, $p = 0.060$ (Cohen's $d = -0.217$) (see Table 1).

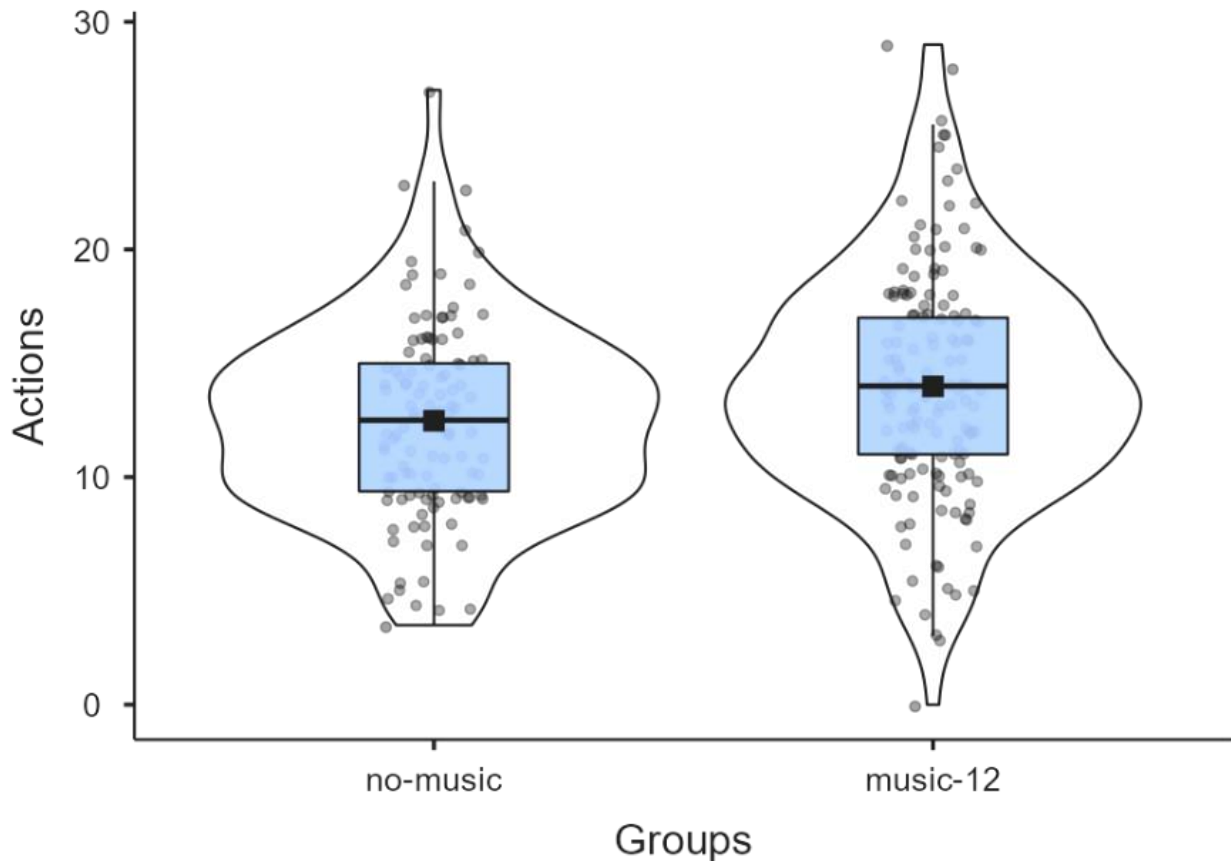
Table 1
 Descriptives statistics for verbal fluency

Groups	Verbal Fluency	
	Any words	Actions
Children who attended music classes	M = 24.3; SD = 7.20	M = 13.5; SD = 7.20
Children who do not attend music classes	M = 25.7; SD = 4.28	M = 12.5; SD = 8.08

VERBAL FLUENCY OF NO-MUSIC AND MUSICAL-12 GROUPS

In the second stage of the analysis, the duration of music classes attendance was assessed. The results showed that 22.9% attended music classes for less than 6 months; 28.6% attended classes from 6 months to 12 months; 44.7% from 12 months to 24 months; 3.8% from 24 months to 48 months (median = 12 months; mean = 19 months, SD = 13 months). Thus, half of the children attend music classes for more than 12 months. Then, the music-group was divided into those who attend music classes for more than 12 months (*music-12 group*) ($n = 162$) and those who attend less.

Verbal fluency was then compared between the music-12 group ($n = 162$) and the no-music group ($n = 133$). Following a series of statistical tests for normality and Levene's tests to assess data normality and equality of variance (Shapiro-Wilk statistic $W = 0.989$, $p = 0.044$ and $W = 0.991$, $p = 0.123$ for “Any words” and “Actions” correspondingly; Levene's tests $F = 0.471$, $p = 0.493$ and $F = 2.318$, $p = 0.129$), it was decided to utilize a Mann–Whitney test for “any words” and Student's t-test for “actions” analysis. The result showed that there are no significant differences on the “any words” subtest ($U = 7901$, $p = 0.279$; effect size = 0.078), and on the “actions” subtest, there are significant differences between the non-music group and the music-12 group ($t = -2.533$, $p = 0.012$; effect size = -0.316). Thus, there are differences in “actions” verbal fluency between children who do not attend music classes at all and those who attend music classes for more than a year (see Picture 1).



Picture 1 Differences in verbal fluency between children who do not attend music classes (non-music group) and those who attend music classes for more than 12 months (music-12 group).

An additional correlation analysis showed that the duration of attendance of music classes was positively associated with the verbal fluency score (Spearman $r = 0.295$, $p < 0.001$ for “any words” and Spearman $r = 0.262$, $p < 0.001$ for “actions”).

CONTROLLING FOR GENDER AND AGE FACTORS

At the third stage, the factors of gender and age were controlled in the correlation between the duration of attendance of music classes (all music group) and verbal fluency. For this purpose, the partial correlation method was used (Table 2).

Table 2

Results of partial correlations for length of attendance of music classes with verbal fluency with control for gender and age

Control factor	Correlations for length of attendance of music classes with verbal fluency	
	Any words	Actions
Without control	0.295 ($p < 0.001$)	0.262 ($p < 0.001$)
Control Sex	0.295 ($p < 0.001$)	0.262 ($p < 0.001$)
Control Age	0.265 ($p < 0.001$)	0.227 ($p < 0.001$)

As a result, for the gender factor, it was shown that gender is not associated with the correlation values. An additional t-test confirmed that there are no significant differences in verbal fluency between boys and girls (for “Any words” $t = -1.166$, $p = 0.244$, for “Actions” $t = -0.602$, $p = 0.548$).

For the age factor, it was shown that when controlling for the age of the participants, the correlation between the duration of music classes attendance and verbal fluency slightly decreases, but remains highly significant (Table 2). An additional correlation analysis of the relationship between age and verbal fluency showed that for the subtest "any words" this relationship is not significant ($r = 0.073$, $p = 0.199$), and for "action" it is weakly significant ($r = 0.135$, $p = 0.018$).

To determine the relationship between verbal fluency and music classes attendance, controlling for sex and age, a linear regression model was constructed. All necessary assumptions were verified (Durbin-Watson statistic = 1.62, $p = 0.014$; VIF for gender = 1.03, for age 1.11, for length of music classes attendance = 1.08; Shapiro-Wilk normality test = 0.989, $p = 0.141$; the residuals of the model are normally distributed). In the first model, the verbal fluency score for the "any words" subtest served as the dependent variable, and in the second model – the score for the "actions" subtest. The following variables served as predictors of the model: sex, age, length of music classes attended. As a result, it turned out that for the first model ($F = 6.27$, $p < 0.001$, $R = 0.297$, $AdR2=0.08$) only the factor of attending music classes was significant ($t = 3.65$, $p < 0.001$), the factors of age ($t = 1.238$, $p = 0.217$) and sex ($m = 0.206$, $n = 0.837$) were insignificant. For the second model ($F = 5.72$, $n < 0.001$, $R = 0.287$, $AdR2=0.07$) similarly only the factor of attending music classes was significant ($t = 3.23$, $p < 0.001$), the factors of age ($t = 1.60$, $p = 0.109$) and sex ($t = 0.064$, $p = 0.949$) were insignificant. Thus, the factor of duration music classes attendance does not reduce its significance when controlling for the factors of age and sex.

DISCUSSION

The results of the present study showed that children who have been attending music classes for more than a year have significantly higher verbal fluency scores (when controlling for gender and age) than children who do not attend music classes. However, these differences are significant only for the "action" subtest, which measures directed associations on a given topic. Thus, children who have been systematically attending music classes for more than a year reproduce a higher number of words compared to those who do not attend such classes. This may be due to the fact that music lessons often start with learning children's songs, which are easier for a child to remember by singing them. Learning new songs encourages the memorisation of words that increase children's vocabulary.

On the other hand, as a large number of studies demonstrate, music classes improve memory, attention and inhibition in children (Jaschke et al., 2018; Sala & Gobet, 2020). These cognitive processes, in turn, are necessary components for successful performance on verbal fluency tests (Villalobos et al., 2022). Thus, music classes may have an indirect effect on improving children's verbal fluency scores by developing the cognitive processes necessary to extract appropriate words from memory.

It is important to note that significant differences were found in the group of children who systematically attended music classes for a year or more. This confirms the fact that in order to improve cognitive indicators, including verbal fluency, it is necessary to regularly attend music classes, including instrument playing, solfeggio, choir, orchestra and other practice.

Finally, a number of important limitations need to be considered. Our study did not consider other extracurricular activities (sports or dance, learning a foreign language), family factors (socioeconomic status, the quality of the home environment), using digital devices. In addition, the conducted study demonstrated only the groups' differences. In order to talk about the impact of music classes on cognitive development, including verbal fluency, it is necessary to carry out a longitudinal study.

CONCLUSION

This study set out to determine the differences in verbal fluency between children who attended music classes and those who did not. The results showed significant differences in verbal fluency for the "action" subtest in children who attend music classes for more than a year compared to those who do not attend such classes. As directions for future research, it is necessary to expand the sample of children of different ages, who attend music classes for a longer time. In addition, a longitudinal study should be conducted to investigate the long-term effect of attending music classes in the development of language abilities.

The findings highlight the importance of regular and systematic music classes for better performance and language development in children. It is important to include music lessons in educational programs for children's cognitive development.

REFERENCIAS

- Aita S.L., Beach J.D., Taylor S.E., Borgogna N.C., Harrell M.N., Hill B.D. (2019). Executive, language, or both? An examination of the construct validity of verbal fluency measures. *Applied Neuropsychology: Adult*, 26 (5), 441–451. <https://doi.org/10.1080/23279095.2018.1439830>
- Akhutina, T.V., Korneev, A.A., Matveeva, E.Yu., etc. (2016). *Metody nejropsiho-logicheskogo obsledovaniya detej 6-9 let [Methods of neuropsychological examination of children 6-9 years]*. Moscow: V. Sekachev. <https://doi.org/10.11621/vsp.2016.01.42>
- Akshina, E.M. (2023). Development of students' musical culture in their perception of Russian music of the 2nd half of the XXth century. *National psychological journal*, 18, 3 (51), 166–173. <https://doi.org/10.11621/npj.2023.0316>
- Bayanova, L., Chichinina, E., Veraksa, A., Almazova, O., Dolgikh, A. (2022). Difference in Executive Functions Development Level between Two Groups: Preschool Children Who Took Extra Music Classes in Art Schools and Children Who Took Only General Music and Dance Classes Offered by Preschools. *Education Sciences*, 12. (2) DOI: 10.3390/educsci12020119
- Biesbroek, J.M., van Zandvoort, M.J., Kappelle, L.J., Velthuis, B.K., Biessels, G.J., Postma A. (2016). Shared and distinct anatomical correlates of semantic and phonemic fluency revealed by lesion-symptom mapping in patients with ischemic stroke. *Brain Struct Funct*, 221(4), 2123-2134. doi: 10.1007/s00429-015-1033-8.
- Bondarenko, I.N., Tsyganov, I.Yu., Morosanova, V.I. (2022). The role of conscious self-regulation in the dynamics of cognitive activity and cognitive engagement of students during the transition from secondary to high school: a longitudinal study. *Moscow University Psychology Bulletin*, 4, 200–223. DOI: 10.11621/vsp.2022.04.09
- Bragrad, A., Schelstraete, M. A., Snyers, P., James, D. G. (2012). Word-finding intervention for children with specific language impairment: a multiple single-case study. *Lang. Speech Hear. Serv. Sch.* 43, 222–234 10.1044/0161-1461(2011/10-0090)
- Chen, J., Scheller, M., Wu, C., Hu, B., Peng, R., Liu, C. (2021). The relationship between early musical training and executive functions: Validation of effects of the sensitive period. *Psychology of Music*, 50(1), 86-99. – DOI: 10.1177/0305735620978690
- Cohen, M.J., Morgan, A.M., Vaughn, M., Riccio, C.A., Hall, J. (1999). Verbal fluency in children: developmental issues and differential validity in distinguishing children with attention-deficit hyperactivity disorder and two subtypes of dyslexia. *Arch Clin Neuropsychol.*, 14(5), 433-43.
- Cohrdes, C., Grolig, L., Schroeder, S. (2019). The development of music competencies in preschool children: Effects of a training program and the role of environmental factors. *Psychology of Music*, 47(3), 358-375. DOI: 10.1177/0305735618756764
- Corrigall, K.A., Trainor, L. J. (2011). Associations between length of music training and reading skills in children music perception. *Music Perception*, 29(2), 147-155. DOI: 10.1525/mp.2011.29.2.147
- Dolgikh, A.G., Bayanova, L.F., Shatskaya, A.N., Yakushina, A.A. (2022). The relationship between the assessment of musical abilities and indicators of regulatory functions of children attending music classes. *Russian Psychological Journal*, 19 (4), 80-93. DOI: 10.21702/rpj.2022.4.5
- Elgamal, S. A., Roy, E. A., Sharratt, M. T. (2011). Age and verbal fluency: the mediating effect of speed of processing. *Can. Geriatr. J.* 14, 66–72. doi: 10.5770/cgj.v14i3.17
- Francisco, H.C., Brigola, A.G., Ottaviani, A.C., Dos Santos-Orlandi, A.A., Orlandi, F.S., Fraga, F.J., Guarisco, L.P.C., Zazzetta, M.S., Pedroso, R.V., Pavarini, S.C.I. (2019). Relationship between cognitive processing, language and verbal fluency among elderly individuals. *Dement Neuropsychol.*, 13(3), 299-304. doi: 10.1590/1980-57642018dn13-030006
- François, C., Chobert, J., Besson, M., Schön, D. (2013). Music training for the development of speech segmentation. *Cerebral Cortex*, 23(9), 2038-2043. DOI:10.1093/cercor/bhs180
- Frischen, U., Schwarzer, G., Degé F. (2019). Comparing the Effects of Rhythm-Based Music Training and Pitch-Based Music Training on Executive Functions in Preschoolers. *Frontiers in Integrative Neuroscience*, 13. DOI: 10.3389/fnint.2019.00041
- Grogan, A., Green, D. W., Ali, N., Crinion, J., Price, C. J. (2009). Structural correlates of semantic and phonemic fluency ability in first and second languages. *Cereb. Cortex* 19, 2690–2698 10.1093/cercor/bhp023

- Hilviu, D., Frau, F., Bosco, F.M. (2023). Can Narrative Skills Improve in Autism Spectrum Disorder? A Preliminary Study with Verbally Fluent Adolescents Receiving the Cognitive Pragmatic Treatment. *J Psycholinguist Res*, 52, 1605–1632 DOI: 10.1007/s10936-023-09945-4
- Jaschke, A. C., Honing, H., Scherder, E. J. A. (2018). Longitudinal Analysis of Music Education on Executive Functions in Primary School Children. *Frontiers in Neuroscience*, 12 DOI: 10.3389/fnins.2018.00103
- Korneev, A. A., Bukinich, A. M., Matveeva, E. Yu., Akhutina, T. V. (2022). Executive Functions and Regulation of Activation Functions in 6–9 Year-Old Children: Confirmatory Factor Analysis of Neuropsychological Data. *New Ideas in Child and Educational Psychology*, 2 (3–4), 21-37. DOI: 10.11621/nicep.2022.0302
- Kovyzina, M., Oschepkova, E., Airapetyan, Z., Ivanova, M., Dedyukina, M., Gavrilova, M. (2021). Executive Functions' Impact on Vocabulary and Verbal Fluency among Mono- and Bilingual Preschool-Aged Children. *Psychology in Russia: State of the Art*, 14(4), 65-77. DOI: 10.11621/pir.2021.0405
- Laisney, M., Matuszewski, V., Mézenge, F., Belliard, S., de la Sayette, V., Eustache, F., et al. (2009). The underlying mechanisms of verbal fluency deficit in frontotemporal dementia and semantic dementia. *J. Neurol.* 256, 1083–1094. DOI: 10.1007/s00415-009-5073-y
- Lehrdahl, F., Jackendoff, R. (1983). An overview of hierarchical structure in music. *Music Perception*, 1, 229-252
- Linnavalli, T., Putkinen, V., Lipsanen, V., Huotilainen, M., & Tervaniemi, M. (2018). Music playschool enhances children's linguistic skills. *Scientific Reports*, 8. DOI:10.1038/s41598-018-27126-5
- Ozernov-Palchik, O., Wolf, M., & Patel, A. D. (2018). Relationships between early literacy and nonlinguistic rhythmic processes in kindergarteners. *Journal of Experimental Child Psychology*, 167, 354-368 DOI:10.1016/j.jecp.2017.11.009
- Sachs, M., Kaplan, J., Der Sarkissian, A., Habibi, A. (2017). Increased engagement of the cognitive control network associated with music training in children during an fMRI Stroop task. *PLoS ONE*, 12(10), e0187254. DOI: 10.1371/journal.pone.0187254
- Sala, G., Gobet, F. (2020). Cognitive and academic benefits of music training with children: A multilevel meta-analysis. *Memory & Cognition*, 48, 1429-1441 DOI: 10.3758/s13421-020-01060-2
- Shao, Z., Janse, E., Visser, K., Meyer, A.S. (2014). What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. *Front Psychol.* 22, 5:772. doi: 10.3389/fpsyg.2014.00772
- Stozharova M.Y., Mikhailova Yu.A. (2022). Development of intellectual abilities of older preschool children through digital educational technologies. *Preschool Education Today*, 5(16), 56–65 DOI: 10.24412/1997-9657-2022-5113-56-65
- Veraksa, A.N., Sidneva, A. N. (2024). Psychological Aspects of Introducing Older Preschoolers to Mathematics. *Lomonosov Pedagogical Education Journal*, 22(1), 130–160. DOI: 10.55959/LPEJ-24-07
- Vidal, M. M., Lousada, M., Vigário, M. (2020). Music effects on phonological awareness development in 3-year-old children. *Applied Psycholinguistics*, 41(2), 299-318. DOI: 10.1017/S0142716419000535
- Villalobos D., Povedano-Montero J., Fernández S., López-Muñoz F., Pacios J., del Río D. (2022). Scientific research on verbal fluency tests: A bibliometric analysis. *Journal of Neurolinguistics*, 63, 101082