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Auditory processing and phonological awareness skills of five-year-old children with and without musical experience

Habilidades de processamento auditivo e consciência fonológica em crianças de cinco anos com e sem experiência musical

ABSTRACT

Purpose: To investigate the relations between musical experience, auditory processing and phonological awareness of groups of 5-year-old children with and without musical experience. **Methods:** Participants were 56 5-year-old subjects of both genders, 26 in the Study Group, consisting of children with musical experience, and 30 in the Control Group, consisting of children without musical experience. All participants were assessed with the Simplified Auditory Processing Assessment and Phonological Awareness Test and the data was statistically analyzed. **Results:** There was a statistically significant difference between the results of the sequential memory test for verbal and non-verbal sounds with four stimuli, phonological awareness tasks of rhyme recognition, phonemic synthesis and phonemic deletion. Analysis of multiple binary logistic regression showed that, with exception of the sequential verbal memory with four syllables, the observed difference in subjects' performance was associated with their musical experience. **Conclusion:** Musical experience improves auditory and metalinguistic abilities of 5-year-old children.

RESUMO

Objetivos: Investigar as relações entre experiência musical, habilidades de processamento auditivo e de consciência fonológica de crianças de 5 anos de idade com e sem experiência musical. **Métodos:** Participaram 56 sujeitos de ambos os gêneros, na faixa etária de 5 anos, sendo 26 do Grupo Estudo, composto por crianças com experiência musical, e 30 do Grupo Controle, composto por crianças sem experiência musical. Todos os participantes foram avaliados por meio da Avaliação Simplificada do Processamento Auditivo e do Teste de Consciência Fonológica, e os dados foram analisados estatisticamente. **Resultados:** Observou-se diferença entre os resultados obtidos nos testes de memória sequencial verbal e memória sequencial não-verbal com quatro instrumentos, tarefas de identificação de rimas, síntese e exclusão fonêmica. A análise de regressão logística múltipla demonstrou que, com exceção do teste de memória sequencial para sons verbais com quatro sílabas, a diferença de desempenho observada nos testes e tarefas teve relação com a experiência musical dos sujeitos. **Conclusão:** A experiência musical promove o aprimoramento de habilidades auditivas e metalinguísticas de crianças de 5 anos.

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INTRODUCTION

Musical development depends on acoustic experiences, including sound discrimination, perception of musical themes, sensitivity to rhythm, texture and timbre and also on the ability to produce or play music⁽¹⁾. Through hearing, the individual acquires knowledge about the physical world around him and learn his first words. The auditory behaviors are one of the favorable conditions for acquisition and development of language⁽²⁾.

Several studies have investigated the neural mechanisms involved in the processing and production of linguistic stimuli, such as speech, and non-linguistic, such as music. A recent study shows that there are differences in neural activity of the auditory association areas of professional musicians, related to the early beginning of their musical training⁽³⁾. There is evidence of overlapping brain areas during the processing of musical and linguistic stimuli⁽⁴⁾. Musical experience seems to influence children's brain structure and reorganization⁽⁵⁾, as well as their cognitive, auditory and linguistic development⁽⁶⁾.

Hearing integrity is relevant for the development of phonological awareness, reading and writing^(7,8). It has been shown that musical experience fosters auditory skills of discrimination of frequency and duration^(9,10), speech recognition in competing acoustic situations with noise in adults⁽¹¹⁾ and auditory pattern recognition of frequencies⁽¹²⁾ and figure-ground⁽¹³⁾ in children. In addition, there is evidence that musical perception, phonological awareness and early reading development are correlated in children of 4 and 5 years of age⁽¹⁴⁾. Similar findings have also shown that children with high musical aptitude had better performance than children with low musical aptitude in phonological awareness verbal tasks⁽¹⁵⁾. In addition, studies with preschoolers showed that children who received four months of music education had superior performance in the development of phonemic segmentation ability when compared to children who did not receive music lessons⁽¹⁶⁾.

At present, musical activity has been widely practiced in preschool education. Some efforts have been made to investigate the influence of musical experience in other cognitive domains, its role on the acquisition of new skills, including auditory and linguistic abilities. Nevertheless, the literature on the investigation of auditory and phonological awareness skills in the same population is still of limited size, especially in children.

Thus, the present study was designed to investigate the relationship between musical experience, auditory processing abilities and phonological awareness skills of 5-year-old children with and without musical experience. Also, we will compare the results of the Simplified Auditory Processing Assessment and the Phonological Awareness Test between groups of 5-year-old children with and without musical experience.

METHODS

The study was approved by the Ethics Committee of the Universidade Federal de Minas Gerais (COEP/UFGM) protocol number 641/07. Parents and caregivers received and were asked to sign a consent form. The study is descriptive-

comparative with a transversal design and non-probabilistic convenience sample, consisting of groups of children with and without musical experience. The study was conducted at specialized music schools and regular schools (with no formal music classes in their daily activities), all situated at Belo Horizonte, Brazil.

The first stage of the study consisted of the application of questionnaires to parents/caregivers in order to select the participants of the study and to characterize the profile of the sample. The following inclusion criteria were considered: to be aged between 5 years and 5 years and 11 months; to present the aropalpebral reflex; no evidence or previous history of neuropsychological, motor, auditory, speech and language related disturbs.

The aropalpebral reflex was tested within the Simplified Auditory Processing Assessment and it is usually referred as an inclusion criterion of participants, given that Rabinovich⁽¹⁷⁾ has reported that the aropalpebral reflex is only shown by children with normal hearing or with moderated hearing losses. In cases of moderated, severe and profound hearing losses, without auditory recruitment, and in cases of liquid in the middle ear, the aropalpebral reflex is not observed. The aropalpebral reflex test was taken into account in combination with complementary auditory data about the hearing of the participants, collected with the questionnaire answered by parents/caregivers of the participants in the sample. None of the children included in the study presented an absent aropalpebral reflex, however, one of the participants whose parents reported hearing impairment was excluded from the sample.

The data obtained from the questionnaires was analyzed using the Chi-Square test in order to compare categorical variables between groups. This analysis showed three significantly different variables between groups, namely: maternal education, age of enrollment in school, habit of listening to classical music, which were included as explanatory variables in the regression analysis along with the variables gender and group. The results of statistical analysis are detailed in the item referring to the results.

In the second stage, we assessed the auditory processing and phonological awareness skills of the participants with the following tests:

1. Phonological Assessment of Children⁽¹⁸⁾: in order to ensure that responses to verbal tests were not to be influenced by any speech and language disorders.
2. Simplified Auditory Processing Assessment: consisting of elicitation of the aropalpebral reflex through instrumental sounds^(17,19), Sound Location Test in five directions, Sequential Verbal Memory Test for sounds with three and four syllables; Sequential Non-verbal Memory Test with three and four instruments. The results were analyzed following the criteria reported in the literature^(20,21).
3. Phonological Awareness Test⁽²²⁾: consisting of syllabic synthesis task, phonemic synthesis task, rhyme recognition task, phonemic segmentation task, and phonemic deletion task. The results of the Phonological Awareness Test were also analyzed following the criteria reported in the literature, with scores from zero to five correct answers, in other

words, the number of correct answers was counted for each participant in each of the tasks of the test.

We assessed 71 children, 56 of which were selected to be analyzed. Losses occurred because of failure to meet the inclusion criteria, such as speech disorders observed with the Phonological Assessment of Children or hearing impairments reported by parents/caregivers in the questionnaire. Children who have been diagnosed with any speech, language or hearing disorder were referred to treatment within the local public health system. The selected participants were distributed into the following groups:

Study Group: 30 participants (20 female e 10 male) enrolled in specialized music schools. Two music schools with long history of formal music education in Belo Horizonte were selected to participate in the study. Both music schools have students in different age ranges (children, adolescents, adults) and their teachers have specific training in Music with Bachelor's degrees of Music. The two music schools provided one music class (musical initiation) per week with duration of one hour and also choral singing and musical instruments as optional classes. The musical content covered in the music classes includes musical parameters of duration, pitch, timbre, intensity, expressive character, initiation to structure and musical notation. The activities are structured to address the musical content in a playful manner, consistent with the age of group of children. Participants in the study group attended regular music classes and had at least four months of musical experience at those classes, although this was not considered as an inclusion criterion.

Control Group: 26 participants (13 female and 13 male) enrolled in regular schools without formal music classes in their daily activities. The regular schools were selected to ensure the similarity of the scenarios studied, with the condition that they should not have formal music classes in their curriculum. Thus, regular schools with a reduced number of students per classroom, about seven and 12 children per class were chosen because of its similarity to the classes at the music schools. This required the choice of five regular schools in order to select the participants in the control group. All regular schools offered recreation during the morning and regular classes in the afternoon. Additional data about the musical profile of the participants in the study was collected with the application of the questionnaire that was used to characterize the sample.

The questionnaire brought up questions about the musical habits of the children, the places where they listen to music more often, the musical genres usually heard, and their enrollment in music classes at regular or specialized schools, their enrollment in music instruments classes as well as the duration of these activities. Data obtained from this questionnaire was analyzed using the Chi-square test and, with respect to the variables of the music profile of the participants, there was a significant difference between the two groups in their habit of listening to classical music, which was included as explanatory variable in the regression analysis.

The results of the Simplified Auditory Processing Assessment and of the Phonological Awareness Test were analyzed using the Mann-Whitney non-parametric test in order to com-

pare the performance between the two groups. To estimate the association between the results of the Simplified Auditory Processing Assessment and of the Phonological Awareness Test and the explanatory variables, procedures of multiple logistic regression were carried out. The dependent variables included in the model were the results of the Simplified Auditory Processing Assessment and of the Phonological Awareness Test and as explanatory variables were those selected in the analysis of the questionnaire (maternal education, age of enrollment in school, habit of listening to classical music, gender and group). The dependent variables were transformed into binary variables according to the number of correct responses in the tests. Data was processed and analyzed using SPSS 13.0, with significance level of 95% ($p \leq 0.05$).

RESULTS

The analysis of the questionnaire showed differences between groups in the following variables: maternal education ($p=0.015$), age of enrollment in school ($p=0.021$) and habit of listening to classical music ($p=0.030$). Due to this difference, these variables were included in the regression analysis as explanatory variables along with the variables gender and group.

All participants presented the auropalpebral reflex and answered correctly to all items of the syllabic synthesis task of the Phonological Awareness Test. Results from the participants in the Control Group and in the Study Group of the Simplified Auditory Processing Assessment and of the Phonological Awareness Test are presented below (Table 1).

The Study Group obtained the highest mean score in the Sequential Verbal and Non-verbal Memory Test with four sound stimuli, rhyme recognition, phonemic synthesis, and phonemic deletion tasks when compared with the Control Group. The association of the results of these tests, enrollment in music classes and the other explanatory variables were tested by the logistic regression model (Table 2).

The results of the Sequential Non-verbal Memory Test with four instruments and of the rhyme recognition, phonemic synthesis and phonemic deletion tasks showed a difference associated only with the musical experience of the participants. This means that the only potential variable considered in this study that provided explanation for the results obtained by the participants in the tests and tasks above mentioned was their musical experience. Furthermore, participants with musical experience had higher chances of getting a superior number of correct answers in those tasks. Participants in the Study Group have chances 9.31 times higher to obtain two or three correct answers at the Sequential Non-verbal Memory Test when compared to participants in the Control Group. Children with musical experience have higher chances to obtain three, four or five correct answers in rhyme recognition task, phonemic synthesis task, and phonemic deletion task (12.46; 30.39 and 7.16 times higher, respectively) when compared to children without musical experience. The only dependent variable that could not be explained solely by the musical experience of the participants was the Sequential Verbal Memory Test.

Table 1. Results of the Simplified Auditory Processing Assessment and Phonological Awareness Test of the Control Group and Study Group

Teste	Control Group		Study Group		p-value
	Mean	SD	Mean	SD	
Sequential verbal memory - 3 syllables	2.84	0.36	2.93	0.25	0.297
Sequential verbal memory - 4 syllables	2.19	0.84	2.66	0.54	0.022*
Sequential non-verbal memory - 3 instruments	2.34	0.48	2.63	0.49	0.066
Sequential non-verbal memory - 4 instruments	0.92	0.74	2.06	0.90	0.000*
Sound location - 5 directions	4.53	0.51	4.40	0.49	0.304
Rhyme recognition	3.15	1.37	4.33	0.84	0.001*
Phonemic synthesis	1.65	1.29	3.36	1.24	0.000*
Phonemic segmentation	0.19	0.56	0.33	1.02	0.808
Phonemic deletion	0.88	1.21	2.66	2.12	0.002*

* Significant values (p<0.05) – Mann-Whitney test

Note: SD = standard deviation

Table 2. Multiple logistic regression for association of the tests sequential verbal memory and sequential non-verbal memory with four sound stimuli, rhyme recognition, phonemic synthesis and phonemic deletion, and explanatory variables

		B	SE	p-value	95% CI - OR		
					Lower	OR	Upper
Sequential verbal memory 4 syllables	Group (Control – Reference)	1.48	1.29	0.254	0.34	4.396	56.08
	Age of enrollment in school	0.13	0.85	0.875	0.21	1.145	6.13
	Habit of listening to classical music	1.06	1.31	0.421	0.21	2.891	38.35
	Maternal education	-0.14	0.52	0.786	0.31	0.868	2.40
	Gender	-0.54	1.09	0.619	0.06	0.580	4.96
Sequential non-verbal memory 4 instruments	Group (Control – Reference)	2.23	0.81	0.006*	1.88	9.31	46.12
	Age of enrollment in school	0.56	0.49	0.250	0.67	1.75	4.59
	Habit of listening to classical music	0.10	0.79	0.893	0.23	1.11	5.31
	Maternal education	0.04	0.44	0.925	0.43	1.04	2.50
	Gender	-1.10	0.80	0.170	0.06	0.33	1.60
Rhyme recognition	Group (Control – Reference)	2.52	1.20	0.037*	1.16	12.46	133.04
	Age of enrollment in school	1.31	0.87	0.134	0.66	3.73	20.84
	Habit of listening to classical music	0.60	1.05	0.567	0.23	1.82	14.42
	Maternal education	-0.42	0.45	0.346	0.26	0.65	1.58
	Gender	0.29	0.89	0.743	0.23	1.34	7.74
Phonemic synthesis	Group (Control – Reference)	3.41	0.94	0.000*	4.80	30.39	192.34
	Age of enrollment in school	-0.40	0.62	0.518	0.19	0.66	2.26
	Habit of listening to classical music	0.29	0.89	0.740	0.23	1.34	7.81
	Maternal education	0.95	0.60	0.115	0.79	2.60	8.55
	Gender	-0.42	0.92	0.650	0.10	0.65	4.02
Phonemic deletion	Group (Control – Reference)	1.96	0.81	0.015*	1.45	7.16	35.25
	Age of enrollment in school	-0.35	0.50	0.474	0.26	0.69	1.86
	Habit of listening to classical music	0.73	0.73	0.320	0.49	2.07	8.78
	Maternal education	-0.19	0.43	0.648	0.35	0.82	1.91
	Gender	0.78	0.71	0.271	0.54	2.19	8.90

* Significant results

Note: B = regression coefficient; SE = standard error; CI = confidence interval; OR = Odds Ratio.

DISCUSSION

The results of this study demonstrated that the performance of both groups was expected at the tests of Sound Localization, Sequential Verbal and Non-verbal Memory with three sound

stimuli as described in the literature⁽²⁰⁾ for 5-year-old children. Children with musical experience had superior performance at the Sequential Verbal and Non-verbal Memory Test with four sound stimuli and in the rhyme recognition, phonemic synthesis and phonemic deletion tasks, with statistical difference.

Regression analysis showed that, with exception to the Sequential Verbal Memory Test with four syllables, this difference was associated only to the musical experience of the participants. Regarding the Sequential Non-verbal Memory Test with four instruments, our findings corroborate results from other Brazilian investigations in which subjects with musical experience had better performance in auditory pattern recognition of frequencies^(9,10,12) when compared to subjects without musical experience.

Participants with musical experience showed higher chances to correctly respond to two or three sequences of four instruments at the Sequential Non-verbal Memory Test when compared to children without musical experience. It is only expected that children respond correctly to two sequences of four sounds in this task when they are 6 years old⁽²⁰⁾. Therefore, in the present study participants in the Study Group had similar performance to 6-year-old children, which was determined by their musical experience.

Regarding the rhyme recognition task, the findings of our study are consistent with researches that suggest the collaboration of educators and music teachers in promoting musical activities in the classroom to stimulate phonological awareness⁽²³⁾. Several tasks of learning how to read music involve to recite verses of songs, identify rhyming words and replace them by others with the same sound patterns⁽²⁴⁾. The mutual influence between musical experience and rhyme recognition skills is a possible explanation for this finding of the present study. Children with musical experience are exposed more often to this kind of stimulus, therefore, they are more likely to recognize rhymes with efficiency.

All participants responded correctly to the five items of the syllabic synthesis task and most of them did not respond correctly to any of the items of phonemic segmentation task. These findings indicate that syllabic awareness is already developed in preschool children and it is independent of formal education as it has been widely reported in previous studies^(25,26).

Previous studies have observed that children's school experience influences the development of their phonological awareness skills and that some of these abilities, such as phonemic awareness, are learned through formal education within the school context^(27,28). The analysis of the questionnaire of the present study demonstrated that participants in the Control Group have a difference of about one more year of school enrollment than the children on the Study Group. Thus, it would be expected that children in the Control Group showed better performance, when compared to participants in the Study Group, at phonemic awareness tasks. However, participants in the Study Group showed superior results both in the phonemic synthesis and phonemic deletion tasks, which were associated with statistical significance to their musical experience. Therefore, musical experience favored the development of phonemic synthesis and phonemic deletion of the children in the study. Notwithstanding, in both groups the mean of correct responses in the phonemic segmentation task was low. This finding is indicative that such a complex skill is not influenced only by the musical experience of the subjects, since it is also strongly correlated with the school experience of the children.

The results of the phonemic synthesis and phonemic deletion tasks corroborate studies that show a significant correlation between musical experience/skills, phonemic awareness and reading development in preschool children^(14-16,29). It can be inferred that the similarity of the skills required for the analysis and organization of musical stimuli is a factor that supports the analysis and organization of speech sounds, and contributes to the execution of phonological awareness tasks.

Moreover, it is known that phonological awareness skills depend, to some extent, on auditory skills^(7,8) and are related to the development of reading^(23,24). Taken together, the results of the Simplified Auditory Processing Assessment and of the Phonological Awareness Test indicate that auditory skills involved in music perception might also be involved in the acquisition and development of phonological awareness skills. In addition, the effect of musical experience may be observed in posterior reading and writing skills.

We can say that musical experience provide subsidies for the manipulation of linguistic and non-linguistic sound stimuli. Thus, it can be used as way of optimize and improve aspects of auditory processing and phonological awareness and should be considered as a protective factor of human communication disorders.

CONCLUSION

The findings of this study represent one of the many possibilities of Music Education and Speech and Language Therapy working together in partnership in order to contribute with the multidisciplinary scientific research. Musical experience was the factor that determined the observed differences related to auditory processing and phonological awareness skills between groups of 5-year-old children with and without musical experience. In the present study, 5-year-old children with musical experience had similar performance to 6-year-old children in the Sequential Non-verbal Memory Test with four instruments. Musical practice, in addition to its cultural role, also promotes improvement of auditory and metalinguistic skills of 5-year-old children.

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