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# The relation between auditory discrimination and phonological disorder

## *A relação entre a discriminação auditiva e o desvio fonológico*

### ABSTRACT

**Purpose:** To determine the most frequent errors of children with phonological disorders in an auditory discrimination test, and to correlate their performance with age, gender and severity of phonological disorder. **Methods:** The sample consisted of 82 children with phonological disorders, of both gender, with ages between 4 years and 7 years and 11 months. All subjects were submitted to the Phonological Assessment of Child (*Avaliação Fonológica da Criança*) in order to establish the severity of phonological disorder, and to the auditory discrimination test. Data were statistically analyzed. **Results:** It was found that 38% of the subjects had poor results on the test, and the most frequent errors were: posteriorization, devoicing of stops, and semivocalization of liquid consonants. Moreover, it was observed that auditory discrimination difficulties were less frequent in older subjects, and more severe according to the severity of the phonological disorder. **Conclusion:** Great part of the children with phonological disorders has difficulties in auditory discrimination. However, these difficulties were less frequent in older subjects and more severe according to the severity of the disorder. Male subjects seem to have more difficulty in discriminating speech sounds.

### RESUMO

**Objetivo:** Verificar os erros mais frequentes cometidos por crianças com desvio fonológico em um teste de discriminação auditiva, e relacionar o desempenho no teste com a idade, o gênero e a gravidade do desvio fonológico. **Métodos:** A amostra constituiu-se por 82 crianças com desvio fonológico, de ambos os gêneros, com idades entre 4 anos e 7 anos e 11 meses. Todos os sujeitos foram submetidos à Avaliação Fonológica da Criança para estabelecer o grau do desvio fonológico, e ao teste de discriminação auditiva. Os resultados foram analisados estatisticamente. **Resultados:** Verificou-se que 38% das crianças apresentaram resultados insatisfatórios no teste, sendo os erros mais frequentes: posteriorização, dessonorização de plosiva, e semivocalização de líquida. Além disso, observou-se que as dificuldades na discriminação auditiva tiveram menor ocorrência em sujeitos mais velhos e foram mais comprometidas de acordo com a gravidade do desvio fonológico. **Conclusão:** Grande parte das crianças com desvio fonológico apresenta dificuldades na discriminação auditiva. Entretanto, tais dificuldades tiveram menor ocorrência em sujeitos mais velhos e foram mais comprometidas conforme a gravidade do desvio fonológico. Os meninos parecem ter maiores dificuldades para discriminar os sons da fala.

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**Conflict of interests:** None

## INTRODUCTION

Auditory discrimination is a fundamental aspect for the correct production of speech sounds<sup>(1-3)</sup>. Children must learn and discriminate some specific sounds so that their speech is considered adequate when compared to the adult pattern of their mother tongue<sup>(2)</sup>. In order to learn speech sounds, the child must present organic conditions to discriminate phonemes<sup>(2)</sup>.

The auditory neurons can be adjusted in a way that the acoustic differences found among sounds are maximized in the brain, facilitating the distinction among sounds<sup>(4)</sup>. Thus, alterations in the ability to discriminate sounds may contribute to speech disorders<sup>(1)</sup>.

According to a study<sup>(5)</sup>, when children are about five years old they should properly use the speech sounds of their mother tongue, in all syllable positions. However, some older children have difficulties during this process, only regarding the phonological component, characterizing a phonological disorder (PD). According to another study, children with PD may not be able to manipulate all the acoustic signals of a phoneme, either due to physiological immaturity or to lack of perception of the acoustic signals of the phoneme<sup>(6)</sup>.

The speech sound disorder or PD is characterized as lack of adaptation, disorganization or abnormality in the children's sounds system, in relation to the adult pattern, without any organic impairment<sup>(7)</sup>. The etiology of the PD is unknown; however, studies have shown that the lack of ability to discriminate sounds by hearing may be a causal or aggravating factor of PD<sup>(2,8)</sup>.

The relevance of the present research is related to the hypothesis that there is a relationship between the auditory discrimination ability and the PD and, if confirmed, it will determine the need to evaluate auditory discrimination in cases of PD. Moreover, it can contribute to the reflection on the need to study the rehabilitation of children with PD. Hence, the purpose of this study was to verify the most frequent errors of children with PD in an auditory discrimination test, and to relate their performance with age, gender and severity of the PD.

## METHODS

This is a cross-sectional quantitative research. It was conducted after the approval of the Research Ethics Committee of the Universidade Federal de Santa Maria (UFSM), under number 23081.006440/2009-60. Subjects' parents or legal guardians signed the Free and Informed Consent authorizing their participation, as well as allowing the display of the results for academic purposes.

The sample consisted of 82 children with PD, male and female, with ages between 4 years and 7 years and 11 months. The diagnosis of PD was established according to study criteria<sup>(9)</sup> that consider: speech intelligibility impairment, age over 4 years, normal hearing, absence of relevant neurological impairment to produce speech, adequate intellectual abilities for oral language development, oral language comprehension compatible with the mental age, and adequate expressive language ability.

All children underwent phonological assessment using the Phonological Assessment of the Child<sup>(10)</sup>. This assessment was recorded, phonetically transcribed and, after that, a contrastive analysis of the speech results was performed. Then, the severity of the PD was classified according to the Percentage of Consonants Correct (PCC)<sup>(11)</sup> as mild disorder (MD) (PCC from 86% to 100%); mild-moderate disorder (MMD) (PCC from 66% to 85%); moderate-severe disorder (MSD) (PCC from 51% to 65%); and severe disorder (SD) (PCC below 50%).

Children were divided into four age groups: group 1, with 16 4-year-old children (from 4 years to 4 years and 11 months); group 2, with 26 5-year-olds (from 5 years to 5 years and 11 months); group 3, with 24 6-year-olds (from 6 years to 6 years and 11 months); and group 4, with 16 7-year-olds (from 7 years to 7 years and 11 months). Moreover, subjects were also divided according to gender (49 male and 33 female) and PD severity<sup>(11)</sup> (30 children with MD; 34 with MMD; 13 with MSD; and five with SD).

For the assessment of auditory discrimination, the Picture Test for Auditory Discrimination, based on The Boston University Speech Sound Discrimination Picture Test was applied. The test consists of word pairs (minimal pairs), and its purpose is to observe the child's discrimination abilities regarding the distinction of point and manner of articulation and voicing of phonemes. The test was individually applied in a silent room, according to a study<sup>(12)</sup>, through the presentation of boards containing pictures of 25 minimal pairs, before children were submitted to speech-language therapy. The correct and incorrect responses were computed always in the child's first attempt. When test percentages were under 80%, they were considered unsatisfactory<sup>(12)</sup>.

The errors that occurred during the Picture Test for Hearing Discrimination were analyzed based on the phonological processes involved with the pairs of pictures (minimal pairs). They were: omission, semivocalization and substitution of liquid phonemes; stop and fricative devoicing; posteriorization and anteriorization.

The percentages were calculated for test performance, as well as for the most frequent errors, which were identified through phonological processes. To verify the correlations and associations among variables, the statistical analysis used the Pearson's correlation test and the Chi-square test, complemented with the analysis of adjusted residuals, considering a significance level of 5% ( $p < 0.05$ ).

## RESULTS

According to the performance in the auditory discrimination test, it was verified that 31 children (38%) presented unsatisfactory results in the test, while 51 children (62%) presented satisfactory results.

Table 1 shows the most frequent errors regarding the phonological processes in the performance on the auditory discrimination test.

It was verified that there was relationship between the variables "process of fricative devoicing" and performance on the test, as well as between "process of substitution of liquid

**Table 1.** Phonological processes for the studied sample

Phonological processes	Present	Suppressed	Total n (%)
	n (%)	n (%)	
Liquid deletion	25 (30.49)	57 (69.51)	82 (100)
Liquid semivocalization	40 (48.78)	42 (51.22)	82 (100)
Liquid substitution	32 (39.02)	50 (60.98)	82 (100)
Plosive devoicing	43 (52.39)	39 (47.56)	82 (100)
Fricative devoicing	31 (37.80)	51 (62.20)	82 (100)
Posteriorization	45 (54.88)	37 (45.12)	82 (100)
Anteriorization	39 (47.56)	43 (52.44)	82 (100)

phonemes” and performance on the test. Such results showed correlation between the presence of these processes and unsatisfactory performance on the test (Table 2).

**Table 2.** Correlation between phonological processes and performance in the auditory discrimination test

Phonological processes	Pearson’s correlation test
Liquid deletion	0.25
Liquid semivocalization	0.45
Liquid substitution	0.74
Plosive devoicing	0.54
Fricative devoicing	0.70
Posteriorization	0.55
Anteriorization	0.46

Significant difference was observed between performance on the test and age. Moreover, the analysis of adjusted residuals revealed positive significant association between the age group with 4 years (4years to 4 years and 11 months) and unsatisfactory result in the test, and positive association between the group with 6 years (6 years to 6 years and 11 months) and satisfactory result in the auditory discrimination test. Such findings revealed that age might be an important factor for auditory discrimination (Table 3).

It was verified that the male gender presented higher

**Table 3.** Performance in the auditory discrimination test according to age

Age group	Performance in the auditory discrimination test		p-value
	Unsatisfactory	Satisfactory	
	n (%)	n (%)	
4y – 4y11m	12 (38.71) <sup>(+)</sup>	4 (7.84) <sup>(-)</sup>	0.005
5y – 5y11m	8 (25.81)	18 (35.29)	
6y – 6y11m	5 (16.13) <sup>(-)</sup>	19 (37.26) <sup>(+)</sup>	
7y – 7y11m	6 (19.35)	10 (19.61)	
Total	31 (100.00)	50 (100.00)	

\* Significant values (p<0.05) – Chi-square association test  
 (+) Analysis of adjusted residues: positive significant association (p<0.05)  
 (-) Analysis of adjusted residues: negative significant association (p<0.05)  
**Note:** y = years; m = months

percentage of unsatisfactory results (64.52%) than the female gender (35.48%), but this difference was not significant (Table 4).

It was observed that children with milder disorders presented higher percentage of satisfactory result in the test when compared with children with more severe disorders. However, this difference was not significant (Table 5).

**Table 4.** Performance in the auditory discrimination test according to gender

Gender	Performance in the auditory discrimination test		p-value
	Unsatisfactory	Satisfactory	
	n (%)	n (%)	
Male	20 (64.52)	29 (56.86)	0.327
Female	11 (35.48)	22 (43.14)	
Total	31 (100.00)	51 (100.00)	

Chi-square association test (p<0.05)

**Table 5.** Performance in the auditory discrimination test according to severity

Severity	Performance in the hearing discrimination tes		p-value
	Unsatisfactory	Satisfactory	
	n (%)	n (%)	
MD	3 (9.68)	2 (3.92)	0.443
MSD	4 (12.90)	9 (17.65)	
MMD	15 (48.39)	19 (37.25)	
SD	9 (29.03)	21 (41.18)	
Total	31 (100.00)	51 (100.00)	

Chi-square association test (p<0.05)

**Note:** MD = mild disorder; MSD = moderate-severe disorder; MMD = mild-moderate disorder; SD = severe disorder

**DISCUSSION**

The findings of this research revealed that 38% of the children with PD presented unsatisfactory results in the auditory discrimination test. Such fact agrees with other study<sup>(1)</sup>, which comments that auditory discrimination is a relevant factor in the normal language acquisition process. Moreover, these findings suggest that children with PD present greater difficulty to discriminate speech sounds<sup>(13)</sup> and that the inability in auditory discrimination, although not applicable to all cases, might be an aggravating factor in cases of PD<sup>(2)</sup>. Also, these findings show the importance of evaluating auditory discrimination in children with PD, contributing to the therapeutic planning of these children.

The most frequent errors found in this study (Table 1) were in the phonological processes of posteriorization, stop devoicing, and semivocalization of liquid phonemes, in this order. These results may indicate that these phonological processes were not overcome in children’s speech, since studies have revealed that perception precedes production<sup>(6,14,15)</sup>. Moreover, these findings suggest that children with PD may present more

difficulties discriminating particular distinctive features such as [anterior] and [voiced].

The devoicing process was one of the most frequent processes found in this study, showing the difficulties of children with PD to discriminate the [voice] feature. This result corroborates recent researches<sup>(6,16,17)</sup> that reveal the devoicing process as one of the disorders with higher frequency and evolutive difficulty in clinical practice. Moreover, in the devoicing process, the discrimination of stops according to the voicing feature was the most difficult. This finding is different from data about the phonological acquisition of Brazilian Portuguese<sup>(18)</sup>, in which the acquisition of stops precedes the acquisition of fricatives. It also disagrees with a study<sup>(6)</sup> that verified that the child with phonological disorders presents more improved perception of the voicing feature in the class of stops than in the class of fricatives.

The least frequent error was related to the process of omission of liquid phonemes. Such result suggests that the omission of a phoneme is frequently discriminated by children with phonological disorders. Some studies<sup>(19,20)</sup> agree with this idea. They refer that omissions or deletions of phonemes in children's speech are less frequent than substitution of phonemes.

The presence of positive strong correlation for the processes of fricative devoicing and substitution of liquid phonemes with unsatisfactory results in the test (Table 2) suggests that children with phonological disorders present difficulties to discriminate the [voice] feature and to distinguish points of articulation<sup>(21)</sup>.

Age is an important factor for auditory discrimination, because the older the child is, the better skills he/she has to distinguish speech sounds. This finding corroborates other studies<sup>(2,22,23)</sup> that indicated that the best performance in auditory discrimination was directly related to advance in chronological age. Another study<sup>(24)</sup> agrees with this statement, showing the importance of auditory discrimination, indicating that this ability increases according to linguistic competences, that is, auditory discrimination is better in subjects with more mature linguistic competences.

However, the fact that 7-year-old children presented lower performance in the auditory discrimination test disagrees with literature<sup>(2,22-24)</sup> (Table 3). This divergence may be attributed to the experience with the performed task<sup>(25)</sup> or, yet, it may be due to the heterogeneous sample distribution, and can also be pointed out as a limitation of the study.

Although there was no significant difference regarding gender, this study verified that male subjects presented higher percentage of unsatisfactory result than the female individuals (Table 4). Similar results were found in another study<sup>(2)</sup>, which suggested better performance in the female group, although also with no significant difference.

Regarding PD severity, the results evidenced that children with milder degree of PD presented better performance in the auditory discrimination test than children with more severe PD. However, there was no significant difference. Such findings agree with another study<sup>(2)</sup>, which verified that the more severe the PD degree, the higher the number of phonemes children have difficulties discriminating. Hence, it is noted that there may be a relationship between severity of PD and auditory

discrimination, with this ability being better in milder disorders, which agrees with the present study.

## CONCLUSION

It is possible to infer that children with phonological disorders frequently present difficulties in auditory discrimination, an ability that may be focused during speech-language therapy. Moreover, the errors related to phonological processes evidence the difficulty presented by children with phonological disorders in discriminating voicing and point of articulation. Finally, the auditory discrimination difficulties were less frequent in older subjects, suggesting that performance improves as chronological age advances.

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