RELATIONSHIP BETWEEN MASKING LEVEL DIFFERENCE TEST AND ACOUSTIC REFLEX FINDINGS IN CHILDREN WITH PHONOLOGICAL DISORDER

Relação entre os achados do teste masking level difference e do reflexo acústico em crianças com transtorno fonológico

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ABSTRACT

Purpose: to investigate the findings of the test Masking Level Difference with the results of acoustic reflex and the composition of the phonological system of children with Phonological Disorder, with the purpose of check if there associations that may assist in understanding the process of acquisition of atypical language **Methods:** quantitative, observational and descriptive study, developed through secondary survey of a database, consisting of speech therapy evaluations of 110 children with Phonological Disorder, ages between 5 and 10 years. For the composition of the corpus used in this study was the requirement to have done tympanometry with present tympanogram of type A (Jerger) and have evaluation of Masking Level Difference. **Results:** data from 110 children, 57 were suited to these requirements, composing the population of this study, 42 male and 15 female. Of the 57 children, 23 (40.3%) had normal results of Masking Level Difference and 34 (59.7%) had altered result. No statistical difference was found in the relationship between the Masking Level Difference with the variables age, sex, degree of speech intelligibility, and the result of contralateral and ipsilateral acoustic reflex. The relationship between phonological acquisition of the phonemes in initial and medial onset, statistical significance was found between the non-acquisition of phonemes /s/ and /ʀ/ early-onset and /s/ and /z/ in medial onset with the test result altered. **Conclusion:** other auditory processing abilities beyond the binaural interaction, should be studied in order to identify its relation with phonological disorder.

KEYWORDS: Child Language; Auditory Perception; Reflex, Acoustic

INTRODUCTION

During the language acquisition process hearing plays a fundamental[1] role, this is because the integrity of the structures involved ensure the quality of the sound information when exposed to speech. If the listening experience does not occur properly, the child's language can be changed, causing an impairment of their speech intelligibility[2].

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The investigation of auditory acuity and auditory processing is therefore important in the diagnosis of language disorder in children. Auditory acuity refers to the degree of hearing sensitivity, which can be assessed through a battery of auditory evaluations. Auditory processing, which is defined as the efficiency and effectiveness with which the central auditory system processes information[3] is evaluated using a battery of behavioural assessments that aim to identify altered aspects of the hearing process.

The path taken by sounds as they enter the ear, from the outer ear to the central auditory cortex involves various structures responsible for the transmission and interpretation of auditory information (Figure 1). At the brain stem, the first structures to receive auditory information are the cochlear nuclei. They are responsible for analysis of the sound by the type of cells stimulated and it´s response, generating temporal information for sound localization by means of the interaural differences in stimulus time between ears[4,5].

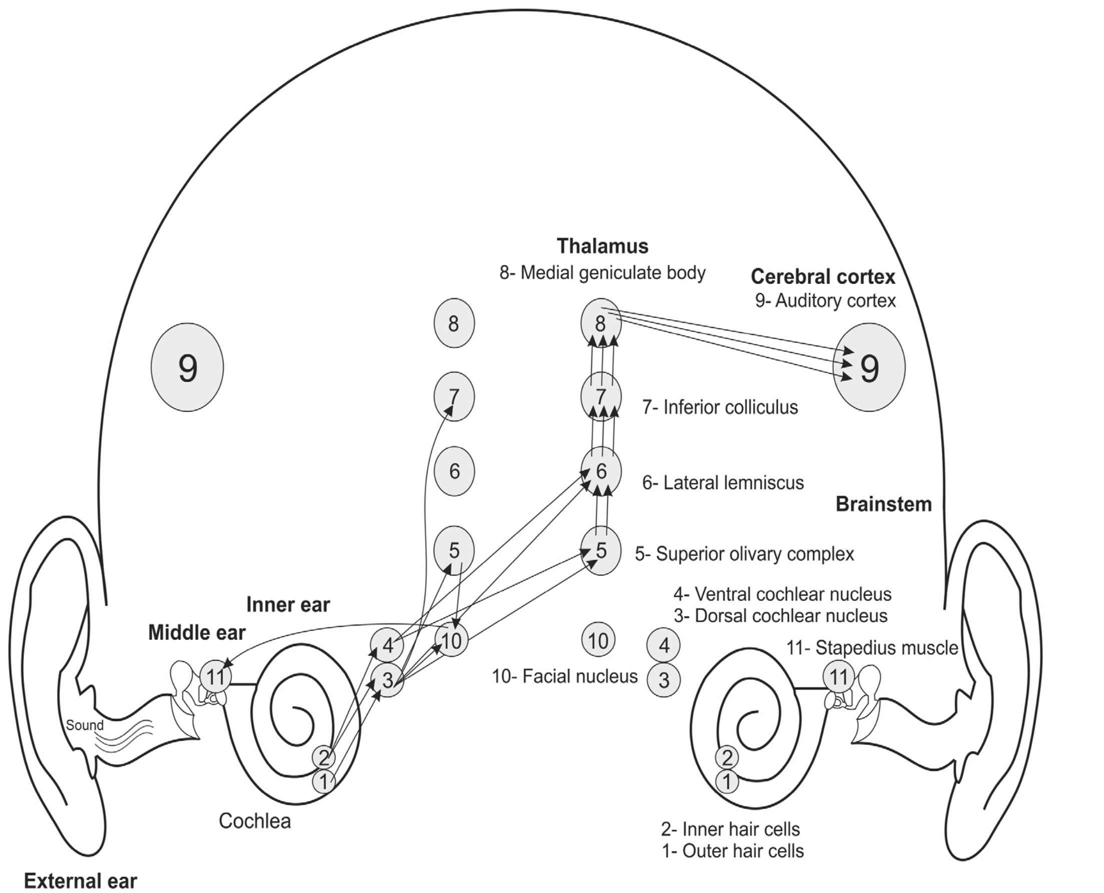

Figure showing the organization of auditory pathways from the outer ear to his arrival to the cerebral cortex. Figure drawn by Diana Weber Bartz.

Figure 1 – Organization of Auditory pathways

The majority of fibres which leave the cochlear nuclei proceed to the superior olivary complex. This structure is characterized as a complex transmission station of auditory information, responsible for processing and interaction of information coming from both ears, since it identifies interaural time differences and intensity that are utilized to determine sound location and lateralization[4,5]. These features aid speech recognition in the presence of competitive auditory information and thus contribute to the language development process, particularly for distinguishing speech sounds that are acoustically similar[6]. Among the behavioural tests that are part of auditory processing evaluation, the Masking Level Difference test is specifically directed towards investigating binaural[3] interaction.

The superior olivary complex is also involved in triggering the contralateral and ipsilateral acoustic reflex, characterized by contraction of the stapedius muscle in response to an acoustic signal. There are studies that associate the absence of the acoustic reflex with the presence of language and auditory processing alterations, associating the reflex with improvement in speech discrimination under high intensities and in the presence of background noise[7,8]. Investigation of this reflex permits the assessment the auditory pathway starting from region of the middle ear to the superior olivary complex[9].

As the superior olivary complex is responsible for binaural interaction, aiding in the identification of speech sounds in competitive[10] situations, analysing acoustic reflex and auditory processing in the presence of language disorders during childhood is important. In children that show mixed speech sound disorders and difficulty in discriminating between phonemes, closer investigation is essential in order to identify how auditory information goes through the structures responsible for hearing. In this group, the process of language development occurs in an atypical way, in terms of both age and the sequence of language acquisition patterns, identifying therefore the origin of the condition known as phonological disorder[11,12].

To establish the diagnosis of phonological disorder, certain characteristics are essential: spontaneous speech with absence or substitution of sounds; children older than four years; auditory thresholds within normal limits; no anatomical or physiological abnormalities in the speech mechanism; adequate intellectual capacity for development of oral language; absence of neurological dysfunction relevant to speech production; understanding of the language according to age; expressive language with adequate vocabulary range extending to appropriate statements and adequate and sufficient exposure to the language and social interaction[13].

In order to investigate associations that can assist in the understanding of atypical language acquisition process, the aim of this study is to analyse the findings of Masking Level Difference test along with the results of the acoustic reflex and the composition of the phonological system of children with phonological disorder.

METHODS

This study was approved by the Committee of Ethics and Research of the Federal University of Health Sciences of Porto Alegre, under registration no. 621.047/2014.

This quantitative, observational and descriptive study was conducted with the use of a secondary database analysis consisting of speech therapy evaluations of 110 children, all monolingual speakers of Brazilian Portuguese diagnosed with phonological disorder, ages 5 - 10 years.

The relationship between Masking Level Difference test results and the variables: age, sex, degree of speech intelligibility, contralateral and ipsilateral acoustic reflex and the phonological acquisition of phonemes in initial and medial onset was analyzed in this study.

The composition of the database used in the study is presented in Table 1.

Table 1 – Database composition

Evaluation	Total
Medical History	110
Child Phonological Assessment (AFC)	110
Degree of Speech Intelligibility (PCC-R)	110
Basic Audiological Assessment	110
Immitanciometry	110
Phonological Awareness: Instrument of Sequential Assessment (CONFIAS)	105
Auditory Processing Screening	104
Orofacial motricity Assessment	102
Medical History Specific to Auditory Processing	75
Pediatric Speech Inteligibility (PSI)	74
Staggered Spondaic Words (SSW)	72
Masking Level Difference (MLD)	71
Random Gap Detection Test (RGDT)	64
Self-Awareness of Speech Deviations (CPDF)	59
Pitch Pattern Sequence (PPS)	52

The inclusion criteria for the sample consisted of subjects who had undergone a tympanometry exam with tympanometric curve type A (Jerger) and Masking Level Difference assessment. Of the 110 children evaluated, all between the ages of 5 and 10 years, 57 fit this criteria, consequently these subject were used to make up the population of the study.

The speech evaluations conducted were obtained from the application of the Child Phonological Assessment protocol[14]. This protocol consists of phonetic inventory, contrastive analysis of the phonological system, the functional analysis of distinctive features and the study of phonological processes; each sound was considered acquired when there was correct production of 80% or more of the same segment[14]. For this study, the data on contrastive analysis of the phonological system was considered.

The degree of speech intelligibility was calculated using the PCC-R[15] formula, its classification is divided into four categories according to the number of correct consonants; severe (PCC-R less than 50%); moderate- severe (PCC-R between 51% and 65%); moderate- mild (PCC-R between 66% and 85%); mild (PCC-R greater than 86%). In this study, this classification was utilized to categorize the sample.

Immittanciometry consists of two evaluations: tympanometry, which identifies the tympanometric curve and the study of acoustic reflexes. The tympanometry can be classified into A, B, C, Ar, and As[16,17], and the type A (Jerger)curve was used to indicate, in most cases, normal middle ear function. The acoustic reflex was held at 500, 1000, 2000 and 4000 hertz[7] and was considered normal when the acoustic reflex was present in all four frequencies tested, and altered when absent in at least one of the frequencies.

The Masking Level Difference test consists of determining the hearing thresholds using a pulsed pure tone of 500Hz in the presence of a masking noise in two different conditions: noise and pure tone in both ears; and pure tone in both ears with noise in inverted phase in one ear. The child is directed to signal every time the pure tone is heard. The result is obtained by subtracting the thresholds obtained between the two conditions. The Masking Level Difference was considered normal when the threshold difference between the signal/noise was greater than or equal to 9dB (value used in normal clinical practice)[18].

After collecting the data, statistical analysis of the results was attained using the Student T-test and chi-square Pearson Independence, establishing a significance level of $p < 0.05$. For this analysis, we used the SPSS software, version 20.

RESULTS

Of the 57 children diagnosed with phonological disorder, the majority had altered results.

The average age of subjects with normal results was 6.91 years, and the average age of subjects with abnormal result was 6.84. Table 2 shows the association between age and the result of the Masking Level Difference. The results indicate no significant relationship between Masking Level Difference results and age.

Table 2 – Association between age and results of the Masking Level Difference test

Idade		5 years	6 years	7 years	8 years	9 years	10 years
Normal MLD		0 (0,0%)	12 (21,0%)	5 (8,7%)	3 (5,2%)	2 (3,5%)	0 (0,0%)
Altered MLD		4 (7,0%)	15 (26,3%)	4 (7,0%)	4 (7,0%)	6 (10,5%)	1 (1,7%)
p-value	*0,933*						

MLD – Masking Level Difference.
Test – T-Student (p < 0,05)

In relation to the gender of the participant subjects, 73.7% (42 subjects) were male and 26.3% (15 subjects) were female. As shown in Table 3, the relationship between these variables and the Masking Level Difference results obtained demonstrated no significant relationship between them.

Table 3 – Association between gender and results of the Masking Level Difference test

Gender	Male		Female	
Normal MLD	17 (29,8%)		6 (10,5%)	
Altered MLD	25 (43,9%)		9 (15,8%)	
p-value		*1,00*		*1,00*

MLD – Masking Level Difference.
Test – Pearson´s Qui-squared Test (p < 0,05)

Table 4 shows the degree of speech intelligibility and the corresponding result of the Masking Level Difference test. The total number of subjects in each group, according to the classification of speech intelligibility, was distributed as follows: 19 children classified as mild; 29, mild-moderate; 5, moderate-severe; 4, classified as severe. Statistical analysis indicated no significant association between these variables.

Table 4 – The relationship between degree of speech intelligibility and results of the Masking Level Difference test

DSI		Mild	Mild-moderate	Moderate-Severe	Severe
Normal MLD		7 (12,2%)	10 (17,5%)	3 (5,2%)	3 (5,2%)
Altered MLD		12 (21,0%)	19 (33,3%)	2 (3,5%)	1 (1,7%)
p-value	*0,199*				

DSI- Degree of Speech Intelligibility ; MLD – Masking Level Difference.
Test – Pearson´s Qui-squared test (p < 0,05)

The relationship between the results of the contralateral and ipsilateral acoustic reflex in both ears with the result of the Masking Level Difference test is presented in Tables 5 and 6. The acoustic reflex results are separated by right and left ear, and described as normal or altered. Statistical analysis of the results found no significant relationship in this association.

Table 5 – Relationship between contralateral acoustic reflex and results of the Masking Level Difference test

Contralateral Acoustic Reflex	Right			Left		
	Normal	Altered		Normal	Altered	
Normal MLD	14 (24,6%)	9 (15,8%)		14 (24,6%)	9 (15,7%)	
Altered MLD	22 (38,6%)	12 (21,0%)		26 (45,7%)	8 (14,0%)	
p-value			*0,787*			*0,247*

MLD – Masking Level Diference.
Test – Pearson´s Qui-squared test (p < 0,05)

Table 6 – Relationship between ipsilateral acoutic reflex and results of the Masking Level Difference test

Ipsilateral Acoustic Reflex	Right			Left		
	Normal	Altered		Normal	Altered	
Normal MLD	16 (28,1%)	7 (12,3%)		15 (26,4%)	8 (14,0%)	
Altered MLD	25 (43,8%)	9 (15,8%)		27 (47,4%)	7 (12,2%)	
p-value			*0,771*			*0,358*

MLD – Masking Level Diference;
Test – Pearson´s Qui-squared test (p < 0,05)

Figure 2 shows all altered acoustic reflexes present in the sample separated by frequency. In the 57 individuals analyzed, the frequency with the greatest number of abnormal results was 4000 Hz in both ears, both ipsilateral and contralateral.

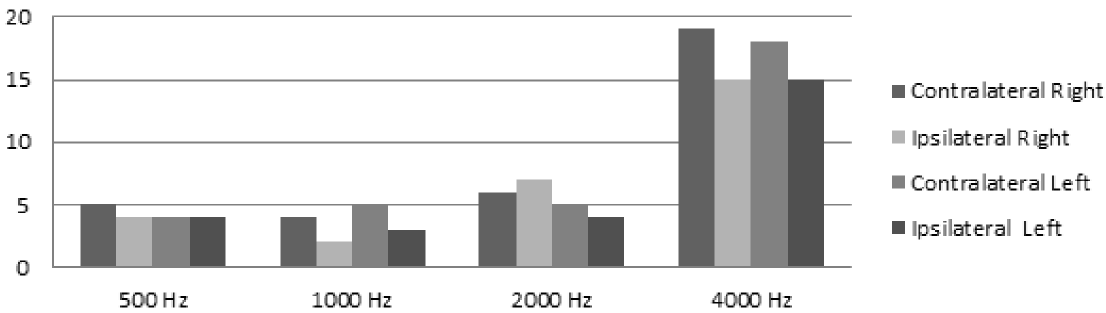

Figure 2 – Total number of acoustic reflexes with alterations in frequency

In regards to the association between phoneme acquisition and Masking Level Difference results (Table 7), subjects with altered Masking Level Difference test results were observed to have a statistically significant association with the absence of phoneme acquisition in both initial (/s/ and /ʀ/) and medial (/s/ and /z/) onset.

Table 7 – Reationship between phoneme acquision in inicial onset and medial onset and results of the Masking Level Difference test

Acquired Phonemes	Inicial Onset	MLD Normal	MLD Altered	*p-value*	*Medial Onset*	MLD Normal	MLD Altered	*p-value*
/p/	56 (98,2%)	22 (39,3%)	34 (60,7%)	*0,404*	54 (94,7%)	22 (40,7%)	32 (59,3%)	*1,000*
/b/	46 (80,7%)	16 (34,8%)	30 (65,2%)	*0,098*	44 (77,1%)	16 (36,3%)	28 (63,7%)	*0,339*
/t/	52 (91,2%)	21 (40,4%)	31 (59,6%)	*1,000*	53 (92,9%)	20 (37,7%)	33 (62,3%)	*0,292*
/d/	41 (71,9%)	15 (36,6%)	26 (63,4%)	*0,383*	42 (73,6%)	14 (33,3%)	28 (66,7%)	*0,124*
/k/	51 (89,4%)	19 (37,2%)	32 (62,8%)	*0,208*	52 (91,2%)	20 (38,4%)	32 (61,6%)	*0,384*
/g/	36 (63,1%)	12 (33,3%)	24 (66,7%)	*0,175*	40 (70,1%)	16 (40,0%)	24 (60,0%)	*1,000*
/f/	51 (89,4%)	20 (39,2%)	31 (60,8%)	*0,677*	52 (91,2%)	19 (36,5%)	33 (63,5%)	*0,146*
/v/	43 (75,4%)	15 (34,9%)	28 (65,1%)	*0,210*	43 (75,4%)	16 (37,2%)	27 (62,8%)	0,532
/s/	46 (80,7%)	14 (30,4%)	32 (69,6%)	*0,004**	47 (82,4%)	15 (31,9%)	32 (68,1%)	0,010*
/z/	39 (68,4%)	14 (35,9%)	25 (64,1%)	*0,388*	40 (70,1%)	12 (30,0%)	28 (70,0%)	0,020*
/ʃ/	31 (54,3%)	13 (41,9%)	18 (58,1%)	*1,000*	30 (52,6%)	11 (36,6%)	19 (63,4%)	0,597
/ʒ/	25 (43,8%)	11 (44,0%)	14 (56,0%)	*0,786*	28 (49,1%)	10 (35,7%)	18 (64,3%)	0,592
/m/	54 (94,7%)	21 (38,9%)	33 (61,1%)	*0,559*	57 (100%)	23 (40,3%)	34 (59,7%)	-
/n/	48 (84,2%)	20 (41,6%)	28 (58,4%)	*0,726*	57 (100%)	23 (40,3%)	34 (59,7%)	-
/ɲ/	-	-	-	-	46 (80,7%)	16 (34,7%)	30 (65,3%)	0,098
/l/	45 (78,9%)	18 (40,0%)	27 (60,0%)	*1,000*	45 (78,9%)	20 (44,4%)	25 (55,6%)	0,325
/ʎ/	-	-	-	-	31 (54,3%)	11 (35,5%)	20 (64,5%)	0,432
/ɾ/	-	-	-	-	16 (28,0%)	5 (31,2%)	11 (68,8%)	0,549
/ʀ/	41 (71,9%)	13 (27,1%)	28 (72,9%)	*0,041**	45 (78,9%)	16 (35,5%)	29 (64,5%)	0,193

MLD – Masking Level Diference.
Test– T-Student (p < 0,05, * indicate statiscal significance).

DISCUSSION

The binaural interaction is responsible for the central auditory system's ability to process incongruent information entering both ears [10], helping perception, organization and processing of auditory information received by peripheral auditory pathways[19]. This ability can be seen in the child's behaviour, from the first months after birth, becoming more evident with time and ensuring the efficient functioning of the structures responsible for localization of a sound´s source[20].

The evaluation of this ability is done through activities that involve the location and lateralization of acoustic stimuli[21], changes in the auditory threshold determined by masking, the detection of the acoustic signal in a noisy environment and binaural fusion[22]. The Masking Level Difference test focuses on evaluating binaural interaction through the perception of acoustic signals in the presence of noise[3], while also indirectly assessing location and lateralization, quickly and efficiently, being a sensitive test to identify changes located in the lower brainstem[21]. This structure is responsible for detecting the differences in time and intensity of the signals received for both ears[4,5], assisting in speech recognition in the presence of competitive auditory information, which contributes to sound detection in noisy environments.

Our sample did not indicate that there was a significant relationship between the ages of the subjects and the result of the Masking Level Difference test. This finding is similar to the result of another study, which showed no significant association between the two variables[23]. These findings can be explained by the fact that the test evaluates the lower brainstem, as this structure has fully matured within the first years of life, it is expected that after five years of age, all subjects are already within the normal range of function, with no response differences after this age.

After a review of the literature concerning the relation between age and sound localization, two surveys were found in which this ability functioned adequately in all children in the study, regardless of age[24,25]. A study of 61 pre-school aged children (4-6 yrs.), found that all children 5-6 years passed in the sound localization test, with 92.5% of the 4 year old children achieving the same result[26]. As the location of a sound source is identified by the brain stem, these findings are in agreement with the results observed in the study sample, since significant correlation was not found between the ages of the subjects and the test that evaluates the lower brainstem.

The prevalence of male children diagnosed with phonological disorder is also present in other studies [9,27,28]. The prevalence of these alterations in male children is explained by the slower maturation of the brain in males compared to that of female children[28]. Regarding gender and the result of the Masking Level Difference, another comparative study also found no significant difference between these two variable[29].

No studies were found relating the degree of speech intelligibility to the result of the Masking Level Difference test. However there is a study that investigated the presence of phonological disorder and alterations in sound localization, comparing this task in children with and without phonological disorder. Lower performance in sound localization activity was identified in children with abnormal language caracteristics[30]. It would be important to conduct studies comparing the entire battery of assessment criteria for auditory processing with the degree of speech intelligibility, taking into account the fact that integrity of the auditory pathway is essential for speech recognition[1].

As for the association between the results of acoustic reflex measurement and sound localization, there is a study that found lowered values between these two variables in children with phonological[27] disorder. This study reaffirms that auditory processing and acoustic reflex play an important role in the process of acquisition of speech sounds. In the research conducted, most subjects showed normal acoustic reflex results. However, if the frequencies of the acoustic reflex are analyzed individually, it is observed that a large number of children presented absence of the acoustic reflex at the frequency of 4000 Hz, in both the ipsilateral and contralateral pathways. This information is consistent with a study that compared the results of acoustic reflex measurement with the results of figure-background testing and temporal ordering, which also found a higher number of altered acoustic reflex results at this frequency[31]. The occurrence of isolated absence of the acoustic reflex at 4000 Hz is high when compared with other frequencies. However, in the literature, there are accounts of the absence of pathology in these situations[17].

In the present study, when phonemic acquisition was compared with the result of the Masking Level Difference test, it was observed that children with altered Masking Level Difference tests had not acquire fricative phonemes /s/ and /z/ (in medial onset), /s/ (early-onset) and /ʀ/ (early-onset). Notably /ʀ/, despite being classified as a liquid consonant, is expressed phonetically as a fricative, which could explain these findings. Moreover, these phonemes are acquired at a later stage in life when compared to the vast majority of phonemes of Brazilian Portuguese[32]. It was also observed that, when comparing voiceless and voiced sounds, there was a tendency for the voiceless phonemes to be present in a larger percentage of the sample subjects. Auditory discrimination is very important to distinguish between sounds, aiding in the distinction and identification of acoustic differences of each phoneme. This ability may be found to be altered in children diagnosed with phonological disorder[27].

There was a high prevalence of altered Masking Level Difference results in the study sample: 34 subjects (59.7%). One explanation for this result may be the high incidence of otitis media during early childhood[33]. A recent study, which investigated the impact of otitis media on speech perception in the presence of a masking noise, confirmed the hypothesis that the presence of a history of otitis media in early childhood, has negative consequences on the mechanisms related to auditory processing, especially the binaural interaction[33,34]. This is due to the partial hearing loss which occurs during the period of infection, causing damage to the auditory canal and processing of auditory information not only for the duration of the infection but also persisting after treatment. As a result of alterations in speech perception in the presence of masking noises[34]; classroom tasks, games and group activities may be potentially compromised because important information is lost.

Another important factor that could be related to altered Masking Level Difference results comprises executive functions. For the Masking Level Difference test, it is essential that the child disregards the masking noise and indicates the presence of pure tones, whereby verifying his/her ability to inhibit the competitive responses[35]. In this manner, mechanisms associated with inhibitory control and within the region of executive functions, may end up influencing the answers. Thus, issues related to the discernment of auditory stimuli in noise require the activation of structures beyond the brain stem.

The results of this study indicated weak correlation between the binaural interaction and phonological disorder, hinting to the possible involvement of other mechanisms and abilities. Studies examining the whole battery of assessments of auditory processing in more homogeneous samples are critical to understanding these cases and to the formulation of new rehabilitation proposals. The need to incorporate auditory processing assessment in hearing evaluations is a present-day priority and is critical to the assessment of a person´s capacity to process auditory information and, consequently, its impact on the daily activities of individuals[25].

CONCLUSION

It was observed that phonological disorder was more prevalent among male children than females in the sample population. In the individual analysis of the acoustic reflex results, the frequency of 4000 Hz had a greater number of altered results in both ears, in both the ipsilateral and contralateral pathways.

From this study we conclude that there is no statistical association between the outcome of Masking Level Difference test and the following variables; age, sex, speech intelligibility degree and results of acoustic reflex testing. A statistically significant relationship was observed between the phonological acquisition of phonemes /s/ and /R/ early-onset and /s/ and /z/ in medial onset with altered Masking Level Difference test results.

These findings indicate that other auditory processing mechanisms, in addition to binaural interaction, should be studied in more homogeneous samples in order to identify its relationship with the phonological disorder.

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RESUMO

Objetivo: investigar os achados do teste *Masking Level Difference* com os resultados do reflexo acústico e a composição do sistema fonológico de crianças com transtorno fonológico, com o propósito de verificar se há associações que possam auxiliar a compreensão do processo de aquisição de linguagem atípica. **Métodos:** estudo quantitativo, observacional e descritivo, desenvolvido por meio de levantamento secundário de um banco de dados, constituído de avaliações fonoaudiológicas de 110 crianças com transtorno fonológico, com idades entre 5 e 10 anos. Para a composição do *corpus* deste estudo o requisito utilizado foi a realização da timpanometria, com curva timpanométrica do tipo A (Jerger) e possuir avaliação do *Masking Level Difference*. **Resultados:** dos dados de 110 crianças, 57 se enquadraram nestes requisitos, compondo a população deste estudo, sendo 42 do sexo masculino e 15 do sexo feminino. Destas 57 crianças, 23 (40,3%) apresentam resultado do *Masking Level Difference* normal e 34 (59,7%) apresentam resultado alterado. Não foi encontrada diferença estatística na relação entre o *Masking Level Difference* com as variáveis idade, sexo, grau de inteligibilidade de fala e o resultado do reflexo acústico contralateral e ipsilateral. Na relação entre a aquisição fonológica dos fonemas em *onset* inicial e medial, foi encontrada significância estatística entre a não aquisição dos fonemas /s/ e /ʀ/ em *onset* inicial e /s/ e /z/ em *onset* medial com o resultado do teste alterado. **Conclusão:** outras habilidades do processamento auditivo, além da interação binaural, devem ser estudadas a fim de identificar a relação deste com o transtorno fonológico.

DESCRITORES: Linguagem Infantil; Percepção Auditiva; Reflexo Acústico

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