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Masking Level Difference in schoolchildren: environmental analysis

Masking Level Difference em escolares: análises ambientais

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Keywords

Hearing Tests
Child
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ABSTRACT

Purpose: To investigate the auditory ability of selective attention in the school population and to identify reference values to the age group from seven to ten years old through the Masking Level Difference Test, and to identify if the parents' schooling, as well as the family income can influence the test results. **Methods:** Thirty-one schoolchildren who match the eligibility criteria attended the study, being 20 female and 11 male. An anamnesis was conducted to question the familiar income and the schooling of the children´s parents; we also performed visual inspection of the External Acoustic Meatus, Pure Tone Audiometry, Speech Audiometry, Acoustic Immittance Measures, Dichotic Digits Test and Masking Level Difference test. **Results:** The mean age of the individuals was 8.67 years. There were no observed differences between genders and between the evaluated ages in the MLD performance. There was no relation between the parents' schooling and the average monthly income with the performance of the children in MLD Test. The MLD mean was 7.65 dB and standard deviation of 2.51 dB. **Conclusion:** The Masking Level Difference in schoolchildren from seven to ten years old is 7.65 dB and is independent of the gender, parents' schooling and the average monthly income of the schoolchild.

Descritores

Testes Auditivos
Criança
Atenção
Audição
Percepção Auditiva

RESUMO

Objetivo: Pesquisar a habilidade auditiva de atenção seletiva na população escolar e identificar valores de referência para a faixa etária de sete a dez anos por meio do teste *Masking Level Difference*, além de identificar se a escolaridade dos pais, bem como a renda familiar, pode influenciar os resultados do teste. **Método:** Participaram do estudo 31 escolares que se encaixaram nos critérios de elegibilidade da pesquisa, sendo 20 do gênero feminino e 11 do gênero masculino. Realizou-se anamnese para questionamento da renda familiar e escolaridade dos pais do escolar, inspeção visual do meato acústico externo, audiometria tonal liminar, logoaudiometria, medidas de imitância acústica, teste Dicótico de Dígitos e teste *Masking Level Difference*. **Resultados:** A idade média dos indivíduos foi de 8,67 anos. Não foi observada diferença entre os gêneros e entre as idades avaliadas, no desempenho do MLD. Não houve relação entre a escolaridade dos pais e a renda mensal média com o desempenho das crianças no MLD. A média do MLD foi de 7,65 dB, com desvio padrão de 2,51 dB. **Conclusão:** O *Masking Level Difference* em escolares de sete a dez anos é de 7,65 dB e independe do gênero, do nível de escolaridade dos pais ou da renda mensal média da família do escolar.

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INTRODUCTION

Listening is not enough to understand the sound message. It is necessary to develop different auditory abilities, which depend on the integrity of the auditory system at birth, as well as on the acoustic experience in the environment, in order to process and understand the content of what is heard[1].

Central Auditory Processing (CAP) refers to all the processes and auditory mechanisms which are responsible for the sound localization and lateralization phenomena, auditory discrimination, recognition of temporal aspects of hearing (resolution, masking, integration and ordering), auditory performance in the face of competitive and degraded acoustic signals. These processes and mechanisms are evaluated through tests that use both verbal and non-verbal stimuli[2].

Individuals with CAP disorder may have difficulty to understand oral language, to follow verbal instructions correctly, to understanding fast or fractional language, and/or identify the source of sound, impairments that worsen in noisy and reverberant environments. On the other hand, problems to learn a foreign language, to follow sequential instructions and disorders related to musical perception can be observed[3].

In the midst of this, attention is a crucial ability that enables the individual to interact effectively with his environment, as well as subsidize the mental processes organization. With attention, the individual is able to select which stimulus will be analyzed in detail and taken into account to guide his behavior. There are three types of attention: selective, sustained and divided[4]. In this study, selective attention will be addressed, which can be evaluated by the Masking Level Difference (MLD) test.

The use of hearing abilities, especially the selective attention, is extremely important in a classroom, for example, where the student should focus the attention on what is said by the teacher and should ignore any other stimulus that might affect negatively the listening orientation: colleagues, dragging chairs, footsteps in the hallway, fan noise, street honking or screaming in the school yard. The schoolchild with good functioning of the Central Auditory Nervous System will understand the teacher easily, while the schoolchild with CAP alteration may have difficulties in understanding what is being said, which may interfere negatively in the learning process[5].

The influence of the socioeconomic level on language development is one of the variables that has gained attention in the studies of the last years and it demonstrates better language performance in children of families with higher income, suggesting that the family income influences the quality of the stimuli provided and, consequently, the child's development[6].

High MLD may occur as a result of increasing age, but only up to about five or six years[6]. For the MLD test, there are studies that provide values of normality for the adult population only, that is, after maturation of the auditory system in which the hearing abilities do not suffer variations anymore[7,8], factor which may not be adequate for the child population.

Thinking about this population, the adequate screening of the hearing abilities development and the importance of the CAP for the learning development, the purpose of this study is to investigate the selective attention auditory ability in the school population and to identify reference values for the age group of seven to ten years through the MLD test. Also, identify whether parents' schooling, as well as family income, can influence the results of the test.

METHODS

The evaluations of this study were carried out at the *Ambulatório de Audiologia do Hospital Universitário de Santa Maria*, from March to July 2016. The study was prospective, quantitative and cross-sectional with convenience sample.

All individuals invited to participate of the research were advised in relation to their free and spontaneous participation. After the acceptance, the parents signed a Free and Informed Consent Form (FICF), which described all the procedures to be accomplished, allowing the child to participate in the research, on a voluntary basis. This study was approved by the Ethics and Research Committee (ERC) in Human Subjects of the University, under the protocol number 25933514.1.0000.5346, and followed the precepts of resolution 466/12.

To compose the sample, students from five public schools in Santa Maria, RS, chosen for convenience, were invited, and 513 invitations were given to the classes from the first to fourth years of elementary school. The students took the invitations home, and the interested parents returned the ticket to the school with contact information. Parents were then contacted to schedule the evaluation of their children.

The eligibility criteria for the sample were: schoolchildren of both genders, aged between seven and ten years and 11 months; with audibility thresholds less than or equal to 15 dBHL in the frequencies from 250 Hz to 8 kHz; absence of middle ear changes and presence of contralateral acoustic reflex; not to present evidence of cognitive, neurological or psychiatric alterations that could prevent the understanding of the tasks requested or that were referred by those responsible; do not present cerumen or foreign body that would prevent the visualization of the external acoustic meatus; do not have diseases that require the use of continuous medications (so as not to interfere the attention and performance in the days of the tests); not having fluency in speaking and understanding of any language other than Portuguese; not have repeated schooling; have manual right preference and present normality in the Dichotic Digit Test (TDD), according to the norms proposed for age[9].

Only the school children, whose parents or guardians agreed to participate in the study, signed the FICF and met the inclusion criteria aforementioned were enrolled in the study.

Initially, 217 students accepted to participate of the study, with only 52 attending on the day of the evaluation. Of these, 21 students were excluded, one of whom presented unilateral hearing loss of the sensorineural type, two presented cognitive

deficiency reported by those responsible after diagnosis of a neurologist, four had TDD alterations, two did not understand the test, five were left-handed and seven had absent contralateral acoustic reflexes. Thus, 31 students who fit the eligibility criteria of the research composed the sample of this study.

To attend to the series, the students were submitted to anamnesis; visual inspection of the external auditory meatus; pure tone audiometry (PTA); logoaudiometry; acoustic immittance measures, TDD as auditory processing triage and evaluation of the selective attention auditory ability through the MLD test, in the version marketed by Auditec St, Louis.

In the anamnesis, questions about auditory complaints or other comorbidities, audiological history, diseases, medication use, family history, noise exposure, use of sound devices, aspects of auditory behavior and complaints related to auditory processing of school children were asked for those responsible. It was also questioned about the educational level of the parents of the school. Thus, they should respond to their schooling, among the options of: Incomplete Elementary Education, Complete Elementary Education, Incomplete Secondary Education, Complete Secondary Education, Technical Education, Incomplete Higher Education, Complete Higher Education or Post-Graduation. For the family's monthly income, they should report what was the average monthly income of the taxpayers of the household where the scholar resided, not being a criterion of inclusion or exclusion of the sample. For the classification as monolingual of the Brazilian Portuguese and the manual preference of the scholar, only the report of the responsible person was considered, without the accomplishment of specific protocols.

For PTA, logoaudiometry, TDD and MLD, the two-channel clinical audiometers Itera II and Fonix Hearing Evaluator, model FA 12, type I and TDH-39P earphones, brand Telephonics, were used. The PTA and CAP tests were conducted in an acoustically treated booth. The tests were performed by means of a CD, reproduced in an ASUS branded notebook attached to the audiometer.

MLD was applied binaural in intensity of 50 dBNS. For the analysis of this test, the children were divided into two groups according to the age group, being a group with schoolchildren between seven and eight years and another with students from nine to ten years and 11 months, in order to observe the existence of differentiated values of MLD in these age groups.

MLD was determined by calculating the difference in the threshold between an antiphasic condition and a homophasic condition. A lower threshold for the antiphasic condition demonstrated increased detectability. The test consists of determining the threshold in the presence of an effective masking noise level when the signal and noise are presented in phase between the ears[8].

The MLD test consists of ten stimuli presented in phase (homophasic-SoNo), which consists of a pulsatile tone of 500 Hz together with a masking noise in the same ear and in both ears in the same phase; 12 stimuli presented out of phase (antiphase - SπNo), in which one of the stimuli undergoes phase reversal and only 11 presentations of noise, without any tone (NT), that serve as capture tests. The protocol progresses from the most favorable to least favorable signal-to-noise ratios with the three conditions (SoNo, SπNo, and NT) randomized in blocks of three, approximately. The MLD is determined with the Spearman-Kärberque equation which is simplified with the Threshold Plane calculation[7].

The calculation to arrive at the MLD value of the scholar according to the aforementioned plan took into account the successes in the SoNo and SπNo phases. The hits of each phase were counted and converted to a new value, using the test response table. Subsequently, the value of the stimuli presented out of phase (SπNo) of those presented in phase (SoNo) was subtracted, what resulted in the value of MLD.

The data were collected by the researchers and registered in a Microsoft Office Excel program (2010), for later analysis of the results. After data collection, they were submitted to the ANOVA test for a comparison of MLD means and average monthly income of the parents and to the Pearson Correlation Test to correlate MLD with parental schooling. Significant results were considered when $p \leq 0.05$ with a 95% confidence interval.

For the analysis of monthly income, a mean of the reported incomes was made and the sample was divided into three groups: up to two minimum wages, three to six minimum wages and seven to ten minimum wages; the second group is the average income of the sample.

RESULTS

To understand the sample, Table 1 presents a complete descriptive for age and MLD. Therein it is possible to observe that the coefficient of variation (CV) is less than 50% in these variables, indicating homogeneity in the sample. The median value close to the mean value also indicates that the sample is symmetric.

In the distribution of the sample in relation to gender, the Equality Test of Two Proportions was used and a larger number of participants of the female gender (64.5%) was observed, with a significant difference (p-value = 0.022).

Table 2 makes a comparison between the genders by age group. It is possible to observe that the MLD values for these two groups did not present difference for the feminine and masculine genera and that the thresholds found in the test did not differ for the age groups of seven to eight years and of nine to ten years.

Tables 3 and 4 show the comparison between the MLD result and the average monthly family income, and the correlation between the parents' schooling and the MLD result, respectively.

Table 3 shows that there is no difference in the MLD average between the family monthly income ranges analyzed, that is, there is no income effect on the MLD result. Regarding Table 4, it can be observed that there is no correlation of MLD with parents' schooling, being statistically independent variables.

Table 1. Distribution of average values for complete descriptive analysis of age and MLD

Descriptive	Age	MLD (dB)
Average	8.67	7.65
Median	9.03	8.00
Standard Deviation	1.04	2.51
VC	12%	33%
Q1	8.03	6.00
Q3	9.55	9.00
Min	7.00	4.00
Max	10.07	14.00
N	31	31
CI	0.37	0.88

Caption: dB - decibel; VC - variation coefficient; Q1 - 1st quartil; Q3 - 3rd quartil; Min - minimum; Max - maximum; N - number of schoolchildren; CI - confidence interval

Table 2. Comparison of the average MLD values between genders per age range

MLD	From 7 to 8 years old		From 9 to 10 years old	
	Female	Male	Female	Male
Average	7.90	6.80	7.20	8.67
Median	8.0	8.0	6.0	9.0
Standard Deviation	2.02	2.68	2.35	3.50
VC	26%	39%	33%	40%
Min	5.0	4.0	4.0	4.0
Max	12.0	10.0	12.0	14.0
N	10	5	10	6
CI	1.25	2.35	1.46	2.80
p-value	0.388		0.330	

ANOVA Test
Caption: VC - variation coefficient; Min - minimum; Max - maximum; N - number of schoolchildren; CI - confidence interval

Table 3. comparison of the MLD average values with monthly Family income

Income	Until 2 salaries	3 to 6 salaries	7 to 10 salaries
Average	7.56	7.75	7.00
Median	8.0	7.0	7.0
Standard Deviation	1.67	2.94	1.41
VC	22%	38%	20%
Min	4.0	4.0	6.0
Max	10.0	14.0	8.0
N	9	20	2
CI	1.09	1.29	1.96
p-value	0.920		

ANOVA Test
Caption: VC - variation coefficient; Min - minimum; Max – maximum; N - number of schoolchildren; CI - confidence interval

Table 4. Correlation of the MLD average values and parents' education

Education and MLD		
	Corr (r)	P-value
Mother	-9.9%	0.594
Father	-5.7%	0.760

Pearson Correlation Test

DISCUSSION

It was evidenced, in the current study's participants, an average MDL of 7.65dB, with a 4 to 14dB variation and regular deviation of 2.61dB on the entire age range of 7 to 10 years old with an average of 8.6 years old (Table 1). Another Brazilian study, which evaluated children from 7 to 8 years old with the same version of MDL[10], found similar threshold to the one found in the current study (6.95dB), in a sample of 21 children. The authors also compared children with and without school difficulties, in which no differentiation to the MDL was shown, which brings us, in this case, a questioning about the reliability of the test in relation to the evaluated variables, considering that such difficulties are often associated to the Hearing Process Disorder. Yet, the authors say that this result may have occurred due to the lack of investigation of the pedagogical difficulty via instruments, since only the teacher's reports were used. However, such MDL values are different from the ones found by another study, which was carried out with 62 Australian children, with an age average of 9.4 years old, in which the MDL average was of 11.21dB[11]. These differences show that maybe the individuals' culture may influence the test result and not the age per se, since the evaluated individuals were normal and had no complaints in the hearing process.

Regarding the gender, there was no significant difference between female and male in the different age ranges, as it is shown in Table 2. Yet, it is possible to observe a predominance of the female gender, with 20 individuals total, which meets another study's findings, which evaluated the selected attention skill in Brazilian children with the MDL, showing a greater number of female individuals and similar test results with no difference between the genders[10].

Nevertheless, the study that evaluated the MDL in Australian kids showed a predominance of males[11] and, although the age average is similar to the one shown in this study (9.4 years old) and had no difference between the genders, the MDL value was superior, as previously referenced (11.21dB). Another study, yet Brazilian, also showed a male prevalence (73.7%) in the sample and did not show difference in the rest result, compared to female, in an age range of 5 to 10 years[12] old. Yet, there was no presentation of an acquired value average, considering that they were distributed into normal and altered in face of a normality used for the test, which was of 9dB.

The abovementioned researchers who used MLD in students with speech-language[12] disorder, found greater occurrence of such disorder on the male gender, and a greater percentage of altered individuals in the test, however, as in the current study, there was no significant difference to the 5 to 10 year old age ranges. The authors explain that this majority result may have occurred due to the great number of children who showed otitis media during childhood, which may have brought consequences to the hearing skills. However, because it was not significant, a weak relation between MLD and the speech-language disorder is shown, considering that there are possibly other skills involved or that may be beyond the brainstem, which is a region that may be assessed by the MLD test. In this case, therefore, the

gender would not be the cause of differences but other altered hearing skills in children who have the speech-language disorder diagnosis.

Another study[13] also evaluated the selective attention in children with and without learning disorders. There was a comparison between 20 children with disorder, of which 80% were males, and 40 children with good school performance (50% of each gender), with an age range of 9 years and 5 months to 11 years and 10 months. In this study, the Pediatric Test of Speech Intelligibility (PSI) was used and no significant difference between the genders in both groups was observed but it was noted that this test was efficient to differentiate the groups.

Based on the previously mentioned studies, it is possible to understand that there is not a gender that presents better outcome in the selective attention skill regarding students with no hearing damage. A greater number of male children with learning alterations in speech or in other skills that complement the normal development is perceived. However, when compared to the female gender with the same characteristics, they tend to present similar results on the selective attention skill, detected by the MLD test. Yet, when observing the studies' results, it is noted that the MLD test may not have the capacity of capturing such alterations as the PSI in the abovementioned study, or, hence, that the test alone is not sufficient to diagnose alterations of the hearing process or of the selective attention, considering that it does not have significantly different results when comparing groups with alterations and/or complaints in learning, in speech or general development. Still, it is important to highlight that the MLD and PSI tests may not assess the same proportion of the auditory pathway.

Regarding the lack of difference in the MLD outcome among the age ranges, it is believed that it may be associated to the end of the auditory pathway maturation until the low brainstem, where the stimulus presented in the test is analyzed[12,14]. This fact meets what the other authors[10,12] reported in their studies with MLD in children, which is that the peripheral hearing processes and of the brainstem responsible for answering to the MLD are ready in the sixth month of life. Therefore, by the age of 7, there is already stability in this pathway and, hence, in the current study, it is possible to perceive the uniformity in answers of the different age ranges, as well as in the abovementioned studies, which evaluated similar age ranges.

However, there is a study that observed lower MLDs in children with an average of 8.6 years of age, when compared to older (average of 11.2 years of age), in spite of having no statistical[15] relevance. The authors evaluated dyslexic children and showed that the lower was the noise intensity, the higher were the MLDs. Such inconsistencies may be once more related to the cultural background of the evaluated children and not to the auditory pathway maturation, once the latter is already complete in the portions that correspond to the test, in younger children.

If the children were compared to young adults, it would be possible to observe similar responses, as the ones described in a study with Brazilian[16] adults with an 18 to 28 age range, with no hearing complaints, that also showed one value for MLD of 7.65 dB in both genders. Nevertheless, it diverges from another study that searched for normality values for adults and is normally used as reference[7], which is 10 dB or more of normality, but it refers to an international study, showing that adults may present different MLD values, also depending on one's culture. This fact must be highlighted, since the values found in the national and international literature are once more visibly different, which requires the development of studies that aim at determining specific results for different populations and pathologies.

The MLD values in the Brazilian population appear to be different from other sites, as it is observed in the previously mentioned studies, but are the same in children as they are in adults in Brazil, with an MLD a little lower than what is referenced in the international literature. Hence, the reference value for the MLD may be the same for 7 years old students to 28 years old adults, according to the abovementioned studies, once there was already maturation and there is still no beginning of degeneration of the structures responsible for the MLD response.

The differences in societies and their respective cultures influence the daily life organization and the activities performed by people. Such facts relate directly to the development of the hearing and learning skills. In children, besides the age, the environment in which they are inserted also affects their development, regarding the motor of the cognitive[17] skills.

In spite of the lack of studies that relate parents' socioeconomic and educational levels to the children's hearing skills development, it is also important to search this relation to indicate which skills may suffer greater influences of such variables. It is believed that a varied repertoire of children activities and the access to different technologies (which require financial resources) may contribute to their development[18] in a positive way, showing the importance of bringing the socioeconomic level into researches.

In the hearing skills scope, a lack of relation between the parents' educational and socioeconomic level and the students' academic outcome was perceived, in the current study, for the selective attention skill, assessed by the MLD, according to the data presented on Tables 3 and 4. However, there is a study[16] that evaluated the hearing skill of temporal resolution, in order to verify the influence of the parents' educational and socioeconomic levels and their children' outcome, which concluded that the socioeconomic level may influence children's temporal resolution outcome. This study also supported another study, which evaluated 51 children with the same age range as the one approached by the current study, with silent and loud sentences and a worse outcome in noise was verified for children with low socioeconomic[19] level.

Another study, that evaluated 30 children with an age range of 5 to 6 years old, identified a dependency relation between the mothers' educational level and the family[20] environment resources, since the fathers' educational level did not present relevant connection in this study. According to the authors, the more educated is the mother, the more directed is the family environment resources to positively influence the educational matters, such as toys and books purchases. This possibly happens

because the mother figure is often more present in children's daily life and is the main mediator of the family environment resources. Hence, it is possible to perceive the association between the students' learning process and outcome and some aspects from the family environment.

This information also validates what was found by other researchers[21] in 23 children with an age range from 10 to 12 years old, which showed a positive correlation between the academic outcome and some items from the family environment profile such as books, magazines, toys and homework monitoring. Yet, another study[22] applied a battery of tests of auditory processing in children and teenagers divided into two groups, one with individuals in situation of social vulnerability and another with no complaints. A statistically worse outcome was verified within the individuals in situation of social vulnerability, in behavioral tests. These data indicate that, when there is stimulation and motivation in the family environment, there are also better chances for the child to have a good academic outcome.

In the literature, there are not many studies that relate the auditory processing skills with the parents' socioeconomic and educational levels, although it is possible to perceive that such matters influence many skills that complement a normal development in children. Therefore, such connection should be better explored in the speech-language therapy field.

In the current study, the lack of influence of the socioeconomic factor may be due to the fact that the majority of children presented a family income of 3 to 6 minimum wages (20 individuals), only two children were in a superior level and nine were under this level, which may have influenced the comparison. Likewise, this might have happened to the different educational levels of the parents, which was not much different in the analyzed individuals. In spite of the absence of this factor's significant influence, the correlation with the mothers' educational level was slightly superior when compared to the fathers'.

Thereby, this study shows that the application of only one test to assess the auditory processing may produce a wrong diagnosis in auditory skills, such as selective attention, among other skills, because, in the MLD case, it is not possible to have the adequate answers, since its values are similar in children with and without complaints. This may lead to a misperception of the child as altered, causing a delay in treatment, which may lead to losses in the child's development and learning processes, for instance.

Yet, it is important to highlight the similarity in answers between children and adults, which may be expected, considering the maturational level required by the MLD test. However, a considerable difference between national and international literatures was observed, once the international studies show superior values, indicating a better outcome in the selective attention skill. Besides, the equivalence of answers on MLD, independent of factors such as gender and socioeconomic levels, may affect the reliability in its results, enabling its application in different populations with no modification in the answers. Therefore, the current study brings great contributions to the scientific community and promotes the development of further researches, aiming at generating specific reference values for different populations and pathologies on the MLD test and at investigating the influence of different variables upon it.

CONCLUSION

It was possible to investigate the selective attention in students with an age range from 7 to 10 years and 11 months old and to identify values of MLD, which were different from the ones found in the international literature, but compatible to the ones found in Brazilian studies.

The Masking Level Difference in students with an age range from 7 to 10 years old is 7.65 dB and does not depend on the individual's gender, nor the parents' educational level, or the average family monthly income.

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Author contributions

QPM and VAF were responsible for collecting and preparing the data as well as for formatting the manuscript; MB was responsible for co-guidance and preparation of the manuscript; DG was responsible for co-orientation of the manuscript and MVG was responsible for the guidance, supervision and overhaul of the manuscript