Original Article

http://dx.doi.org/10.1590/2317-6431-2016-1746

Audiology Communication Research
ISSN 2317-6431

Masking level difference: reference values in adults

Limiar diferencial de mascaramento: valores de referência em adultos

Suzana do Couto Mendes[1], Fátima Cristina Alves Branco-Barreiro[2], Silvana Frota[1]

ABSTRACT

Introduction: The Masking level difference is a behavioral test that evaluates the mechanism of binaural interaction of auditory processing. **Purpose:** Describe the masking level difference in adults, to contribute to the establishment of reference values for the test. **Methods:** 109 women with normal audiometry and without hearing complaints were evaluated. The version of masking level difference used was Auditec of Saint Louis, which consists in the presentation of 33 segments of narrow-band noise in one ear for at least three seconds whether or not in the presence 500 Hz pure tone. Three different conditions were used: pure tone and narrow-band noise in phase in both ears (homophasic signal/noise condition - SoNo), inverted phase pure tone in one of the ears and noise in phase in both ears (signal/noise condition - SπNo) and noise without the presence of pure tone (no tone - NT). The task for the participants was to indicate if they have heard the tone or not. **Results:** The average value in homophasic condition (SoNo) was 12 dB, with a standard error of 0.284, and in antiphasic condition (SπNo) was 22.77 dB, with standard error of 0.510. The average value resulting from the difference between the two conditions, masking level difference, was 10.83 dB with standard error of 0.316. **Conclusion:** The mean masking level difference obtained from 109 normal hearing young female individuals was 10.83 dB.

Keywords: Hearing; Auditory perception; Hearing disorder; Hearing tests

RESUMO

Introdução: O Limiar Diferencial de Mascaramento é um teste comportamental que avalia o mecanismo de interação binaural do processamento auditivo. **Objetivo:** Descrever o Limiar Diferencial de Mascaramento em adultos, a fim de contribuir para o estabelecimento de valores de referência para o teste. **Métodos:** Foram avaliadas 109 mulheres sem queixas auditivas e com audiometria normal. Foi utilizada a versão do Limiar Diferencial de Mascaramento da Auditec of Saint Louis, que consiste na apresentação de 33 segmentos de ruído de banda estreita nas duas orelhas, por pelo menos, três segundos, na presença ou não de tom puro de 500 Hz. Foram utilizadas três condições distintas: tom puro e ruído de banda estreita em fase, nas duas orelhas (condição sinal/ruído homofásica - SoNo); tom puro em fase invertida, em uma das orelhas e o ruído em fase, nas duas orelhas (condição sinal/ruído antifásica - SπNo); ruído sem a presença de tom puro (*no tone* – NT). A tarefa para as participantes foi a de indicarem se ouviram ou não o tom. **Resultados:** O valor médio na condição homofásica (SoNo) foi de 12,00 dB, com erro padrão de 0,284 e, na condição antifásica (SπNo), foi de 22,77 dB, com erro padrão de 0,510. O valor médio resultante da diferença entre as duas condições, Limiar Diferencial de Mascaramento, foi de 10,83 dB, com erro padrão de 0,316. **Conclusão:** O Limiar Diferencial de Mascaramento médio, obtido a partir de 109 adultos jovens, normo-ouvintes, do sexo feminino, foi de 10,83 dB.

Palavras-chave: Audição; Percepção auditiva; Transtornos da audição; Testes auditivos

Study performed at the Laboratory of Complementary Examinations of the Course of Speech and Hearing Therapy, Faculty of Medicine, Universidade Federal do Rio de Janeiro – UFRJ – Rio de Janeiro (RJ), Brazil.
(1) Universidade Federal do Rio de Janeiro – UFRJ – Rio de Janeiro (RJ), Brazil.
(2) Universidade Anhanguera de São Paulo – UNIAN – São Paulo (SP), Brazil.
Conflict of interest: No
Authors' contribution: *SCM* participated in the conception and study design, data collection, analysis and interpretation of the results, and preparation of the manuscript; *FCABB* participated in analysis and interpretation of the results and revision of the manuscript; *SF* supervised the study and participated in the conception and study design, data analysis and final review of the study.
Corresponding author: Suzana do Couto Mendes. E-mail: suzanamendes.fono@gmail.com
Received: 7/22/2016; **Accepted:** 3/28/2017

INTRODUCTION

Binaural interaction tests evaluate the listener's ability to process unequal, non-simultaneous, and complementary auditory information delivered to both ears[1,2]. The brainstem mediates the ability of the central auditory nervous system (CANS) to confer information presented to both ears in a complementary way[3,4,5].

Binaural interaction is one of the most important auditory processes. Because of this, international organizations such as the American Speech-Language-Hearing Association recommend that the behavioral evaluation of central auditory processing includes at least one test to evaluate the mechanism of binaural interaction[6].

Binaural interaction can be evaluated by binaural fusion (BFT) and masking level difference (MLD) tests. There is another test currently in use outside Brazil [the Listening in Spatialized Noise - Continuous Discourse Test (LISN-CD)], but it lacks translation and cultural adaptation. This test produces a virtual three-dimensional auditory environment with the presentation of a target speaker and competitive voices coming from various directions[7].

The MLD was developed by Hirsh in 1959 and is considered in international literature as one of the more reliable behavioral tests for the evaluation of brainstem function. It depends on the masking release, which is a psychoacoustic phenomenon in which the detection or recognition of a signal presented in the mono or binaural conditions is enhanced in the presence of a competitive bilateral noise. This enhancement results from the auditory system's use of a subtle binaural event and the differences in levels of amplitude between signals presented simultaneously or masked signals"[1].

MLD assessment can be performed by means of an audiometer (audiometric MLD) or a compact disc (CD) recording of the version developed by Richard Wilson, commercially available from Auditec of Saint Louis®. This version consists of the presentation of 33 segments of narrow-band noise in both ears for at least three seconds in the presence or absence of a 500 Hz pure tone. Three distinct conditions are used: pure tone and narrow-band noise in phase in both ears (homophasic signal/noise condition; SoNo); out-of-phase pure tone in one ear and homophasic noise in both ears (signal/noise condition; SπNo); and noise without the presence of pure tone (no tone; NT). The task is to indicate whether the tone has been heard or not by raising the hand when it is heard. The test is performed in the binaural condition, and the intensity for presentation is 50 dB HL[1,8]. For each of the conditions, all signals affirming the tone was heard are summed. This summed number is converted to dB using a table available in the test manual. The final result is the difference in dB between the scores under SoNo and SπNo conditions. In individuals with normal brainstem function, the threshold in the antiphasic condition is better than in the homophasic condition. This improvement is considered to be representative of the masking release, which originates at this level of the CANS, where the integration of information coming from both ears first occurs[9,10].

Although it has been used for some time in international clinical practice, in Brazil, MLD has only recently been incorporated into the battery of exams evaluating central auditory processing. The reference ranges available for the MLD refer to international studies or to national pilot studies with a restricted number of participants. Data from international literature indicate values greater than or equal to 10 dB as suggestive of normality[11]. A national pilot study involving 30 male and female adults aged 18–31 years suggested that values equal to or greater than 7 dB were found in normal subjects[12], while another national study involving 29 female participants aged 22–42 years found average MLD values around 10 dB[13]. Both studies used the Auditec of Saint Louis® version of the test.

Although MLD is an important test because it is one of only a few tests that assess binaural interaction, reference ranges have not been reported for the Brazilian population. Therefore, there is a need for a study to establish these reference ranges. The objective of this study was to determine the mean masking level difference in adults from Brazil in order to contribute to the establishment of reference values for this test.

METHODS

A convenience sample underwent initial screening tests described below. The study population consisted of 109 female students aged 20–30 years, recently enrolled in the third and fourth periods of a speech therapy course, with no prior knowledge of Central Auditory Processing (CAP) behavioral tests.

The study was approved by the Research Ethics Committee of the *Hospital Universitário Clementino Fraga Filho*, under number 941.370, on 01/14/2015. Participants signed a Free and Informed Consent Term (FICT) after being apprised of the study procedures and research objectives.

Tests used to select the participants included anamnesis, otoscopy, pure tone audiometry, and the dichotic digit test. The audiometric evaluation and behavioral auditory processing tests were performed with a Madsen Itera II equipment, Otometrics® brand.

The anamnesis consisted of questions to obtain information about the participant's medical background, such as audiological history, general health, use of medications, and exposure to occupational noise. Individuals with a history of complaints regarding external and middle ear abnormalities, recent otological alterations, otologic surgeries, neurological disorders, or exposure to occupational noise/acoustic trauma were excluded from the study.

After the interview, otoscopy was performed; individuals with abnormal assessment were excluded.

For the remaining individuals, pure tone audiometry was performed in an acoustic booth. Participants who presented air conduction pure tone thresholds worse than 20 dB, in the frequencies of 250 Hz to 8000 Hz, and/or the presence of air-bone gap were excluded from the study.

Finally, the dichotic digit test was applied, which is part of the CAP evaluation battery required to perform CAP screening[14,15,16]. Individuals who obtained less than 95% correct answers in both ears were excluded[16].

The women who met the criteria described above continued the evaluation process and were subjected to the masking level difference (MLD) test.

A CD player from Auditec of Saint Louis® containing the MLD test recording was reproduced by a Samsung® CD player, coupled with the audiometer. The test was performed in the binaural condition at 50 dBHL. Participants were asked to signal each time they heard a tone. For each of the conditions all signals affirming the tone was heard were summed, and that number was converted to dB using a table available in the test manual. The final result was the difference in dB between the scores in the SoNo and SπNo conditions (Chart 1).

Chart 1. Threshold values corresponding to the number of correct responses in each condition, according to the test manual

SoNo		SπNo	
Correct answers	Threshold	Correct answers	Threshold
1	0	1	-8
2	-2	2	-10
3	-4	3	-12
4	-6	4	-14
5	-8	5	-16
6	-10	6	-18
7	-12	7	-20
8	-14	8	-22
9	-16	9	-24
10	-18	10	-26
11	-20	11	-28
12	-22	12	-30
13	-24	13	-32

Subtitle: SoNo = homophasic condition; SπNo = antiphasic condition

Statistical analysis of the data, including graph construction, was performed by means of the R statistical software, version 3.1.3.

Assuming the observations for each of the samples (corresponding to the random variables SoNo, SπNo and MLD) were identical and independently distributed, but were derived from an unknown distribution, with mean and standard error, and also considering that sample size was sufficiently large (in this case, n = 109> 30), confidence intervals were constructed for the sample means, applying the central limit theorem. Under these conditions, the shape of the sample distribution was approximately normal. Thus, in this study, reference values were established from the interval estimation.

RESULTS

The descriptive analysis of the results of the thresholds in dB obtained in the conditions SoNo and SπNo and the difference between the conditions (MLD) are presented in Table 1.

Table 1. Descriptive statistics of the results in dB of the thresholds under the homophasic and antiphasic conditions and masking level difference

Measures	Variables		
	SoNo	SπNo	MLD
Minimum	-20.00	-30.00	6.00
First quartile	-14.00	-26.00	8.00
Median	-12.00	-24.00	10.00
Mean	-12.00	-22.77	10.83
Third quartile	-10.00	-22.00	14.00
Standard deviation	2.97	5.326	3.302
Standard error	0.284	0.510	0.316
Maximum	-4.00	22.00	18.00
Sample size	109	109	109

Subtitle: SoNo = homophasic condition; SπNo = antiphasic condition; MLD = masking level difference

The normative values for each of the conditions of the MLD and the end result are shown in Table 2.

Table 2. Normative values for the variables under study: homophasic condition, antiphasic condition, and masking level difference

Variables	Mean	Standard error	95% Confidence interval for mean	
			Lower Limit	Upper Limit
SoNo	-12.00	0.284	-12.99	-11.86
SπNo	-22.77	0.510	-23.78	-21.76
MLD	10.83	0.316	10.20	11.45

Subtitle: SoNo = homophasic condition; SπNo = antiphasic condition; MLD = masking level difference

DISCUSSION

Inclusion of the MLD test in the minimum evaluation of CAP is recommended[6] and aims to evaluate the binaural interaction, an important physiological mechanism due to the ability of the CANS to uniformly process different and complementary information presented between the each ear[17]. In order for binaural interaction to occur properly, the integrity of the auditory pathways of the CANS from the superior olivary complex to higher levels of the central auditory

pathways is required[18,19]. Individuals with impairment in binaural interaction ability may have difficulty discriminating the direction of a sound source and understand speech in the presence of noise[19].

The results found in this study suggest values greater than or equal to 10 dB as reference values of normality for the test in the population studied.

An international study[11] that proposed a similar protocol (Auditec of Saint Louis® version) found 95% of normal hearing adults had MLD values greater than or equal to 10 dB and suggested this value be used as a normal reference for the test.

A national study[13] compared the performance of 29 young female normal hearing adults in the MLD test recorded on CD (500 Hz) and in the audiometric MLD (found in the menu of an audiometer). Mean values for the recorded MLD test (the same test used in this study) were approximately 10 dB and, for the audiometric MLD, approximately 6 dB. The authors used only the mean value (10 dB) to propose a normal value.

In the present study, we obtained a similar mean value to that obtained by two previously cited studies (10.83 dB). However, we took into account the standard error (0.316) to propose the normality values for the test and, therefore, we suggest a normal value of 10 dB.

Another national study[12], conducted with the purpose of determining reference values for the MLD test in young adults, found lower values than those of the present study and the previously mentioned studies. On the basis of the results obtained in 30 adults, the authors suggested that values equal to or greater than 7 dB are found in normal individuals. It is theorized that these different values may be due to differences between genders, since the study involved participants of both genders and, in the present study, the sample consisted only of female participants. However, the study reported no statistically significant difference between men and women[12]. Another international study also suggests a similar performance between genders[20].

An additional factor that could be considered a cause for the discrepancy of results among different studies is education level. Participants in the present study were higher education students, whereas those from the 7 dB study were from a lower educational level. It would be necessary to broaden this research by applying the test to a larger population to attempt to confirm reasons for these potential discrepancies. Education level could be an important variable influencing test performance. No studies were found in the international literature that investigated the effect of education on MLD performance.

Given the disagreement with another study regarding the minimum value of MLD considered normal for the adult population, it is suggested that further research be conducted with larger samples, both genders, and individuals of varying education levels. More comprehensive data regarding variables that may influence performance on this test may be useful for clinical speech-language practice.

CONCLUSION

The mean masking level difference obtained from 109 young female adults with normal hearing was 10.83 dB.

REFERENCES

1. Frota S. Avaliação do processamento auditivo: testes comportamentais. Bevilacqua MS, Martinez MAN, Balen AS, Pupo AC, Reis ACMB, Frota S. Tratado de audiologia. São Paulo: Santos; 2011. p. 293-313.
2. Musiek F, Shinn JB, Jirsa R, Bamiou DE, Baran JA, Zaida E. GIN (Gaps-in-Noise) test performance in subjects with confirmed central auditory nervous system involvement. Ear Hear. 2005;26(6):608-18.
3. Welsh LW, Welsh JJ, Healy MP. Central presbycusis. Laryngoscope. 1985;95(2):128-36. https://doi.org/10.1288/00005537-198502000-00002
4. Tremblay KL, Piskosz M, Souza P. Effects of age and age-related hearing loss on the neural representation of speech cues. Clin Neurophysiol. 2003;114(7):1332-43. https://doi.org/10.1016/S1388-2457(03)00114-7
5. Neves VT, Feitosa MAG. Controvérsias ou complexidade na relação entre processamento temporal auditivo e envelhecimento? Rev Bras Otorrinolaringol. 2003;69(2):1-11. https://doi.org/10.1590/S0034-72992003000200015
6. American Speech-Language-Hearing Association (ASHA). (Central) auditory processing disorders: technical report. 2005 [acesso 16 jul 2015]. Disponível em: http://www.asha.org/policy/TR2005-00043/
7. Cameron S, Dillon H. Development of the listening in spatialized noise-sentences test (LISN-S). Ear Hear. 2007;28(2):196-211. https://doi.org/10.1097/AUD.0b013e318031267f
8. Eddins AD, Barber EL. The influence of stimulus envelope and fine structure on the binaural masking level difference. J Acoust Soc Am. 1998;103(5):2578-89. https://doi.org/10.1121/1.423112
9. Olsen WO, Noffsinger D, Carhart R. Masking level differences encountered in clinical populations. Audiology. 1976;14(4):287-301.
10. Harris RW, Brey RH, Miller RW, Channell RW. Influence of masker bandwidth on binaural masking level differences. Audiology. 1992;31(4):196-204.
11. Wilson RH, Moncrieff DW, Townsend EA, Pillion AL. Development of a 500-Hz masking-level difference protocol for clinic use. J Am Acad Audiol. 2003;14(1):1-8. https://doi.org/10.3766/jaaa.14.1.2
12. Paula PS, Frota S, Felipe L. Masking Threshold Differential (MLD): pilot study. Int Arch Otorhinolaryngol. 2012;16(suppl. 1):102.
13. Beltrame-Santos J, Momensohn-Santos T, Branco-Barreiro F. Limiar Diferencial de mascaramento: comparação de dois instrumentos. In: Anais do 24° Encontro Internacional de Audiologia; 18-21 abr 2009; Bauru, São Paulo. São Paulo: Academia Brasileira de Audiologia; 2009. p. 2125.
14. Gois M, Biaggio EP, Bruckmann M, Pelissari I, Bruno RS, Garcia MV. Habilidade de ordenação temporal e nível de especificidade nos diferentes testes tonais. Audiol Commun Res. 2015;20(4):293-9. https://doi.org/10.1590/2317-6431-2015-1593

15. Musiek FE, Gollegly KM, Kibbe KS, Verkest-lenz SB. Proposed screening test for central auditory disorders: follow-up on the dichotic digists teste. An J Otol. 1991;12(2):109-13.
16. Matos GGO, Frota S. A influência das perdas auditivas sensorioneurais na ordenação temporal. Rev CEFAC. 2013;15(6):1435-40. https://doi.org/10.1590/S1516-18462013005000008
17. Boscariol M, André KD, Feniman MR. Crianças com fissura isolada de palato: desempenho nos testes de processamento auditivo. Braz J Otorhinolaryngol. 2009;75(2):213-20. https://doi.org/10.1590/S0034-72992009000200009
18. Litovsky R, Fligor B, Tramo M. Functional role of the human inferior colliculus in binaural hearing. Hear Res. 2002;165(1-2):177-88. https://doi.org/10.1016/S0378-5955(02)00304-0
19. McCullagh, Bamiour DE. Measures of binaural interaction. In: Musiek FE, Chermakgd GD. Handbook of central auditory processing disorder: auditory neuroscience and diagnosis. San Diego: Plural; 2007. p. 257-86.
20. Burnham MN. Normal masking level difference parameters for use in the clinical evaluation of auditory processing disorders [dissertation]. Provo: Brigham Young University; 2010.