Temporal ordering ability and level of specificity at different pure tone tests

Habilidade de ordenação temporal e nível de especificidade nos diferentes testes tonais

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ABSTRACT

Purpose: Evaluate temporal ordering ability with different tests, verify the specificity of these tests and compare the result with the level of easiness/difficulty reported by the subjects. **Methods:** The subjects carried out basic audiological evaluation and Dichotic Digit Test, for auditory processing screening, and they also underwent Frequency Pattern Test (FPT) and Duration Pattern Test (TPD), in the versions of Taborga-Lizarro, Musiek and Auditec®, in order to evaluate the temporal ordering ability. Afterwards, the Visual Analogue Scale (VAS) was presented, so that the subjects could identify the difficulty of each test. **Results:** A total of 33 subjects were evaluated, being 29 women and four men, aged from 17 to 27 years. There were a higher number of individuals who have reached normal levels in Auditec® test and in Taborga-Lizarro test, for FPT and TPD. In the Musiek test, there were some subjects with normal results very close to the ones observed on subjects with processing disorders. In the distribution of the most difficult test, there was a statistical significance for the Musiek test. In terms of the specificity of the test, Auditec® proved to be better. However, the analysis was performed only on TPD. **Conclusion:** Although the subjects did not present change and auditory processing complaints, we found difference in the results of temporal ordering tests. In relation to the reported difficulty for Musiek test, we verified that there was influence of this factor on the test results. In the analysis for specificity tests, better results for the Auditec® test could be observed.

Keywords: Auditory perception; Hearing; Hearing tests; Adult; Speech, Language and Hearing Sciences

RESUMO

Objetivo: Avaliar a habilidade de ordenação temporal com diferentes testes, verificar a especificidade desses testes e comparar o resultado com o grau de facilidade/dificuldade relatado pelos sujeitos. **Métodos:** Os indivíduos realizaram avaliação audiológica básica e Teste Dicótico de Dígitos, para triagem do processamento auditivo, e foram submetidos ao Teste Padrão de Frequência (TPF) e ao Teste Padrão de Duração (TPD), nas versões de Taborga-Lizarro, Musiek e Auditec®, para avaliar a habilidade de Ordenação Temporal. Após, foi apresentada a Escala Visual Analógica (EVA), para que os sujeitos identificassem a dificuldade de cada teste. **Resultados:** Foram avaliados 33 sujeitos, 29 do gênero feminino e quatro do gênero masculino, com idade entre 17 e 27 anos. Houve maior número de indivíduos que atingiram valores normais no teste Auditec® e de Taborga-Lizarro, para o TPD e TPF. No teste de Musiek, houve um número de sujeitos com resultados normais muito próximos aos de sujeitos com alteração de processamento. Na distribuição do teste mais difícil, houve significância estatística para o teste de Musiek. Quanto à especificidade dos testes, o Auditec® mostrou-se melhor, porém, a análise foi realizada apenas em TPF. **Conclusão:** Embora os indivíduos não tenham apresentado alteração e queixa de processamento auditivo, houve diferença nos resultados dos testes de ordenação temporal. Quanto ao grau de dificuldade relatado para o teste de Musiek, verificou-se que houve influência deste fator nos resultados dos testes. Na análise de especificidade dos testes, pôde-se observar melhores resultados para o teste Auditec®.

Descritores: Percepção auditiva; Audição; Testes auditivos; Adulto; Fonoaudiologia

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INTRODUCTION

According to the American Speech-Language Hearing Association[1], Auditory Processing (AP) corresponds to a number of mechanisms and processes that occur in relation to the time, allowing the subject to perform acoustic and metacognitive analysis of sounds.

AP is responsible for the behavioral phenomena of localization and lateralization of sound, auditory discrimination, auditory pattern recognition, auditory performance with competitive acoustic signals, auditory performance with degraded acoustic signals and temporal aspects of hearing, including resolution, masking, integration and temporal ordering[1].

The auditory ability of temporal ordering is the capacity to correctly discriminate the order of occurrence of an acoustic signal, within a defined time interval[2,3].

The temporal sequencing/ordering is considered one of the most basic and most important functions of the Central Auditory Nervous System (CANS), as speech and language comprehension are dependent on the capacity to work with sound sequencing. In addition, it is essential for the auditory perception of verbal and non-verbal sounds, allowing the listener to extract and to use prosodic aspects of speech such as rhythm, tone, accent, intonation, as well as a sequence of vowels and consonants, according to the standard of the learned language[3].

Among the tests that evaluate temporal ordering ability, we have the Frequency Pattern Test (FPT) and Duration Pattern Test (DPT), proposed by Musiek[4]. FPT consists on the successive presentation of three pure tones, in which one of them differs in frequency in relation to the other two, with six possible sequences (GGA, GAG, GAA, AGG, AGA and AAG).

For FPT, we used 880 Hz (low-pitched) and 1122 Hz (treble), with stimulus duration of 150 ms, interval between tones of 200 ms and interstimulus interval of 7 s. And, for DPT, we used three stimuli with long pure tones (500 ms) and short ones (250 ms), presented in succession , being one of them different in relation to the duration of the stimulus, when considering the other two stimuli. They present intervals of 300 ms between tones, 7 seconds between stimuli, the frequency is kept constant at 1000 Hz and there are six possibilities of sequences (LLC LCL, LCC, CLL, and CLC CCL)[5,6].

In order to perform FPT and DPT, 30 monoaural stimuli, at a level of 50 dB SL, were shown. For the response pattern, the following possibilities can be found: imitating (humming), verbalizing or indicating the sequence in a form of multiple choice. The normal range for FPT, established in Brazil by Corazza[7], are correct answers above 76% and, for DPT, above 83%, both with the presentation of three sounds. The test of Musiek was developed in the United States and it is applied in Brazil, together with the battery of tests translated and adapted by Pereira and Schochat[5].

In 1997, it also started the commercialization of FPT and DPT tests, developed by Auditec®[8], in the United States, in the adult and children versions. The stimulus is the same one used in the test Musiek, but the acoustic features, such as duration and intervals between tones or the stimuli, are not the same.

In FPT, the difference of the version of Musiek is in the stimulus duration (200 ms) and in the interval of tones (150 ms) for the adult version. On the other hand, for the children version, the stimulus duration is 500 ms and the interval between stimuli is 300 ms. The test presents frequencies in 880 Hz (low-pitched) and 1430 Hz (high-pitched) for both children and adult versions. The normal range of FPT for adults are results with more than 76% of correct answers[8].

In DPT, the version of Auditec® differs from the version of Musiek because of the time interval between sequences (7 seconds for the Musiek version and 6 seconds for the Auditec® version). The other features are the same ones found in the Musiek test: 500 ms (long tone), 250 ms (short pitch), 300 ms (the interval between stimuli) and frequency of 1000 z. The normal range of the DPT is over than 67% of correct answers[9].

With the same proposal of identifying alterations in the temporal ordering ability, there are the FPT DPT tests of Taborga-Lizarro[10], which consist of stimuli of musical sounds of flute. FPT has 440 Hz frequency tones for low-pitched and 493 Hz for high-pitched, with fixed duration, applied to 50 dBSL, and it can be presented in ten sequences of three stimuli and ten sequences of four stimuli. The DPT stimuli are made up of long musical tones (2000 ms) and short (500 ms), applied in ten sequences of three stimuli sequences and ten four stimuli with a fixed frequency of 440 Hz and interstimulus interval of 6 ms. The normal range for FPT of three sounds is 70% for correct answers and, for DPT, 100%. In the evaluation with four sounds, the level of normality for FPT is 60% of correct answers and, for DPT is 90%[5].

Based on the differences between the tests, and due to search for better applicability, this work is justified by the importance of the speech therapist recognize the benefits of selecting the most appropriate test to evaluate temporal ordering, so that the conditions of the subject are considered, as well as optimizing the result of the evaluation for this hearing ability.

Then, the aim of this study was to evaluate the temporal ordering ability with different tests, as well as verifying the specificity of these tests and comparing the result with level of easiness/difficulty reported by the subjects in the performance of the tests.

METHODS

This research was approved by the Research Ethics Committee of *Universidade Federal de Santa Maria* (UFSM), under the protocol 25933514.1.0000.5346.

All the subjects who were invited to participate in the survey were asked about their spontaneous and free participation. Afterwards, they were instructed on the procedures

to be performed. After acceptance, they signed the Informed Consent (IC) form, authorizing their voluntary participation in this research, in which also contained all the procedures to be performed.

The study is characterized as a descriptive research, with quantitative and cross-sectional approach, in which a convenience sample was used. The sample consisted of young adults, who have the following eligibility criteria: normal hearing (up to 25 dBHL[11] at all frequencies (250-8000 Hz); absence of middle ear alterations; absence of auditory processing complaints; values within the normal range for the Dichotic Listening Test (DLT) (5); absence of risk history for hearing, neurologic and language alterations; education level higher than nine years.

The sample consisted of 33 subjects, 29 females and 4 males, aged between 17 and 27 years and mean age of 18.09 years.

We performed the following procedures: visual inspection of the external acoustic canal (EAC), pure tone audiometry (PTA), Speech Recognition Threshold (SRT), Percentage Index of Speech Recognition (PISR), Acoustic Immitance Measures (AIM), Dichotic Listening Test (DLT)[5], FPT and DPT of Musiek[4], Auditec®[8] and Taborga-Lizarro[10].

Visual inspection of EAC was carried out with the help of a clinical otoscope -Klinic Welch-Allyn®, to discard any alterations that could influence the audiometric thresholds, or in the acoustic immittance measures.

PTA was carried out in an acoustically treated booth, with the use of supra-aural headphones TDH39 and the Fonix Hearing Evaluator® audiometer, FA 12 model type I. The airway hearing thresholds were researched in the frequencies 250-8000 Hz, in both ears.

The acoustic immittance measurements were performed with the imitanciometer AT235 model, Interacoustics® brand, for research of the tympanometry curve and acoustic stapedial reflexes. The reflexes were investigated in the frequencies 500-4000 Hz, bilaterally, in the contralateral way. For the sample, only individuals with type A tympanometric curve and present acoustic reflex within the normality were included[12].

DLT was used as a screening test for auditory processing evaluation, with the purpose of characterizing the sample, together with the absence of processing complaint. The test was performed in stages of integration and binaural separation and we only accepted individuals with 95% of accuracy in the integration stage and 91% in the separation stage, in both ears[5].

In order to evaluate the temporal ordering, the subjects were submitted to three different versions of DPT and FPT tests, in the following order: melodic DPT and FPT of Taborga-Lizarro, DPT and FPT with pure tones of Musiek and DPT and FPT of Auditec®, also with pure tone. Each subject performed all tests in a single day, with five minutes interval of rest after each test, so that the fatigue would not interfere with the next test responses. All evaluated subjects performed the tests in the same order and the evaluation lasted approximately one hour.

For the three versions of the test, the stimuli were presented binaurally at a level of 50 dB SL. The subjects were asked to answer the heard patterns and the responses were written down by the evaluator in a printed recording sheet. To analyze the results, we calculated the number of accuracy and then we verified the percentage. The inversions were considered errors.

The tests were performed in acoustically treated booth, with the help of a clinical audiometer of two channels, Fonix Hearing Evaluator® brand, FA 12 model Type I and TDH-39P earphones, Telephonics® brand. The audiometer remained connected in a Dell® Inspiron Notebook i15-3542-A30 with Intel Core i5, through an interface cable that connected the output of the headphones with the CD/Tape of the audiometer. Before starting the evaluation, the calibration of the audiometer was performed through the tone of calibration that makes up the test. Each channel was calibrated with the help of the VU-meter of the audiometer and the pure tone was set at zero level.

After the performance of each test, the Visual Analogue Scale (VAS) was presented, to facilitate the identification of the difficulty of each test by the own subject. The scale is numbered from zero (very easy) to 10 (extremely difficult) and it indicates how the person felt after the testing.

Statistical analysis was carried out by using the two--proportion equality test and the chi-square test. We considered the level of statistical significance of (5%), and the results that showed significance were marked by a superscript asterisk (*).

RESULTS

Regarding the number and percentage of subjects with normal or altered result in different Temporal Order tests, it was possible to observe that there was a greater number of subjects who achieved values within the normality in the Test of Auditec® and Taborga-Lizarro, for both DPT and FPT, with a significant difference, when comparing the number of individuals with altered values in these two versions. This did not occur in Musiek test, in which the number of subjects with normal results was very close to the number of subjects with altered results, not allowing the occurrence of statistical significance, neither for DPT, nor to FPT (Table 1).

Figure 1 allows a clearer view of the percentage of individuals classified as normal or altered, in different versions of DPT and FPT tests.

The analysis of the distribution of the most difficult test and easiest test, according to the responses of the subjects regarding the level of difficulty in performing DPT and FPT, is presented in Table 2.

The distribution of the subjects who present alteration in the tests and the comparison of the mentioned level of difficulty with the test results are shown in Table 3.

For statistical calculation of specificity and accuracy, it was not possible to make analysis of the DPT, as the test Auditec® and the Taborga-Lizarro did not present altered response.

Table 1. Distribution of the tests in relation to the results

Tests	Altered		Normal		p-value
	n	%	n	%	
Auditec® – Duration	0	0	33	100	<0.001*
Auditec® – Frequency	3	9.1	30	90.9	<0.001*
Taborga-Lizarro – Duration	0	0	33	100	<0.001*
Taborga-Lizarro - Frequency	12	36.4	21	63.6	0.027*
Musiek – Duration	15	45.5	18	54.5	0.460
Musiek – Frequency	18	54.5	15	45.5	0.460

* Significant values (p≤0.05) – Test of equality of two proportions

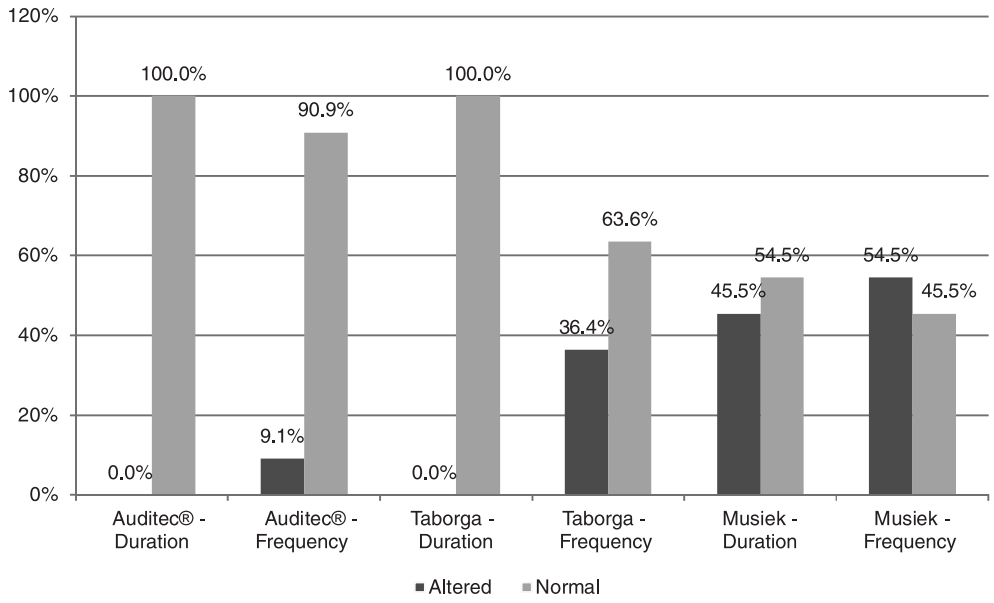

Figure 1. Distribution of the tests regarding the results

Table 2. Distribution regarding the level of difficulty/easiness in the performance of the tests

Most difficult test	n	%	p-value
Taborga-Lizarro	1	3.0	<0.001*
Musiek	32	97.0	
The easiest test	**n**	**%**	**p-value**
Auditec®	16	48.5	0.806
Taborga-Lizarro	17	51.5	

* Significant values (p≤0.05) – Test of equality of two proportions

Table 3. Distribution of alteration for the most difficult test

Most difficult test	Musiek		
	n	%	p-value
Auditec® – Duration	0	0.0	<0.001*
Auditec® – Frequency	3	9.4	<0.001*
Taborga-Lizarro – Duration	0	0.0	<0.001*
Taborga-Lizarro - Frequency	12	37.5	0.133
Musiek – Duration	14	43.8	0.317
Musiek – Frequency	18	56.3	Ref.

* Significant values (p≤0.05) – Test of equality of two proportions
Note: Ref. = reference: the most prevalent test

Therefore, the analysis was performed only in FPT, as it is shown in Table 4.

Table 4. Comparison of specificity for the version of FPT

	Auditec® *versus* Musiek	Auditec® *versus* Taborga-Lizarro	Musiek *versus* Taborga-Lizarro
Accuracy	54.5%	66.7%	81.8%
Specificity	50.0%	66.7%	100.0%
VP +	16.7%	16.7%	100.0%
VP -	100.0%	95.2%	71.4%
p-value	0.097	0.252	<0.001*

* Significant values (p≤0.05) – Chi-square test

DISCUSSION

The application of DPT and FPT Temporal Ordering tests was carried out in young adults with normal hearing, according to the same age group in other studies found in the literature, which evaluated temporal aspects[13-15], because the hearing

tests are dependent on the neural function and they need to be interpreted in "neuro maturational" context. Several studies of behavioral tests of auditory processing describe that there is quantitative improvement in response with increasing age, since the maturation process of the auditory pathway occurs around 8 to 12 years old[16-18].

When analyzing Table 1 and Figure 1, by comparing the test results in different versions, we found that the Musiek test showed greater number of subjects with altered results, when compared with other tests.

Thus, it is possible to think that using Musiek test to evaluate temporal ordering in subject without alteration and complaint of AP may result in a greater number of alterations, if compared with the other DPT and FPT tests. On the other hand, the tests of Auditec® and Taborga-Lizarro were more responsive to the features presented by the evaluated subjects (without complaints of AP and with normal DLT). Other studies have already been performed with the tests of Auditec® and of Taborga-Lizarro and they also found results within the normality[2,6].

In an integrative literature review on FPT and Long Latency Auditory Evoked Potential[19], concerning its applicability to evaluate temporal ordering, we observed that, of the 29 studied papers, FPT was applied in all studies, but in only six of them, we applied DPT for evaluating the temporal ordering[20-25]. It is supposed that over 60% of the evaluators apply FPT and less frequently DPT. It can be inferred, then, that DPT is not so used, because it is considered the easiest and with higher percentage of normality, not being considered, therefore, in choosing to find alterations in the temporal ordering ability.

In our study, for Auditec® as well as for Taborga-Lizarro we obtained 100% of normal in DPT (Table 1), which was expected due to the absence of a complaint, according to what was described above. However, temporal ordering ability for duration must be evaluated together with the ordering of frequency, because the tests can detect certain injuries or brain dysfunctions different among them. Thus, it is assumed that the processes of perception and duration are different from the processes of perception of frequency[5].

Although agreeing to the current study, another study evaluated tune and out-of-tune subjects in vocal quality, all normal hearing, and it verified a greater number of individuals with normality in DPT and FPT tests of Taborga-Lizzaro, when compared with Musiek tests[6].

To reinforce the findings of greater alteration for Musiek Test, the results of the analysis of the most difficult test are shown in Table 2, based on a report of the subjects. It is observed that the Musiek test showed statistical significance as the most difficult test, even for subjects without complaint or alteration of AP. In studies of temporal ordering, in recent years, the most used test was the Musiek test[6,23,26,27].

This result was expected, since one of the hypotheses for Musiek test for being considered the most difficult is the fact that it is constituted of stimuli that present small differences between frequency or duration stimuli, which make it a tough test for the differentiation of the features of tones. This finding is consistent with what is reported in the literature, since, by comparing the DPT of Musiek and Taborga-Lizarro, we observe that the long and short pure tone of Musiek are faster with 500 ms (long) and 250 ms (short) than the tones of Taborga-Lizarro with 2000 ms (long) and 500 ms (short). When comparing FPT between Musiek and Auditec®, we observe less difference between the frequencies used by Musiek, with 880 Hz (low--pitched) and 1122 Hz (high-pitched), than for Auditec®, which is 880 Hz (low-pitched) and 1430 Hz (high-pitched)[5]. These acoustic differences make the Musiek test the most difficult one and, therefore, with greater number of alterations.

Table 3 complements this information, because it shows that, when comparing the most difficult test with the percentage of altered subjects, the FPT of Musiek has a strong relationship of these factors and then the FPT of Musiek and the FPT of Taborga-Lizarro. Some authors mention that FPT is more difficult than DPT[24]. It is believed that the information of the test, or a more difficult version, must be considered in the selection of tests to be applied in order to avoid of false alteration of results.

To make an analysis of the tests on their ability to correctly diagnose normal subjects, the specificity and accuracy were investigated (Table 4). However, it was only possible to perform FPT, since DPT presented 100% of normality in two versions (Auditec® and Taborga-Lizarro). This data shows that, for the research in DPT, both tests are recommended, taking into account the casuistry of this study. Regarding the Musiek test for DPT, there were alterations, which demonstrate, one more time, the excessive difficulty. One study, when using DPT in the version of Musiek and Taborga-Lizarro, found a higher number of subjects with altered results with Musiek test, which is consistent with the above-mentioned, since, in Musiek test, the percentage of alteration is more exacerbated, in comparison with other tests[6].

In relation to FPT, we observed that Musiek and Taborga-Lizarro presented a very high number of alterations (Table 4), significant data. It can be assumed that alterations in Musiek tends to be altered in Taborga-Lizarro and normal in Musiek, tends to be normal in Taborga-Lizarro.

As a result, the Auditec® test demonstrates to be applicable in comparison to the mentioned tests, which would present altered results in a normal population and/or much worse results than they would be in an altered population. One study used a version of Taborga-Lizarro and it found higher percentage of alterations in FPT in a population of children with normal hearing and different levels of school performance, including students with superior academic performance[28]. In another study[29], a percentage of 49.2% of accuracy for FPT and 67.5% in DPT was observed in the version of Musiek, which is considered altered. However, the study was carried out with elderly subjects with normal hearing. With the version of Auditec®,

it was observed, in one study, that the majority of the subjects presented values within the normality, for DPT and FPT[15]. This study was performed by comparing dysphonic teachers and not dysphonic teacher, without hearing complaints. Thus, these findings agree with the above, reinforcing the indication of the Auditec® test for research on temporal ordering.

It was observed that the test of Auditec® showed to be better than the Musiek and Taborga-Lizarro to identify the normal temporal ordering ability for frequency, when compared with other tests.

Given the importance of the theme of this study for clinical practice, we suggested carrying out further research with other populations, since there are no studies with similar methodology and population of this work. As a result, it was difficult to make comparisons with the results which were found and this also limited the discussion of them.

Considering this difficulty, we used studies that showed some affinity with the proposal of the current study, or studies which used the same procedures, even with different populations.

CONCLUSION

Although the evaluated subjects did not presented alteration and complaint of AP, there were differences in the results of temporal ordering tests.

The level of difficulty reported by the subjects, it was verified that there was no influence of this factor on the test results, being worse in the test of Musiek.

In the analysis of the specificity of the tests, we observed better results for the test of Auditec®.

REFERENCES

1. American Speech-Language Hearing Association – ASHA. (Central) Auditory processing disorders: technical report. 2005 [acesso em: 17 mar 2015]. Disponível em: http://www.asha.org/policy/TR2005-00043/
2. Santos JLF, Parreira LMMV, Leite RCD. Habilidades de ordenação e resolução temporal em crianças com desvio fonológico. Rev CEFAC. 2010;12(3):371-6. http://dx.doi.org/10.1590/S1516-18462010005000026
3. Terto SSM, Lemos SMA. Aspectos temporais auditivos: produção de conhecimento em quatro periódicos nacionais. Rev CEFAC. 2011;13(5):926-36. http://dx.doi.org/10.1590/S1516-18462011005000050
4. Musiek F. Frequency (pitch) and duration patterns tests. J Am Acad Audiol. 1994;5(4):265-8.
5. Pereira LD, Schochat E. Testes auditivos comportamentais para avaliação do processamento auditivo central. São Paulo: Pró-Fono; 2011.
6. Santos DG, Bouzada MAC. O processamento auditivo central e a desafinação vocal. Inter Science Place. 2013;1(25):93-111.
7. Corazza MCA. Avaliação do Processamento Auditivo Central em adultos: teste de padrões tonais auditivos de frequência e testes de padrões tonais auditivos de duração [tese]. São Paulo: Universidade Federal de São Paulo; 1998.
8. AUDITEC. Evaluation manual of pitch pattern sequence and duration pattern sequence. St. Louis: Auditec; 1997.
9. Emanuel D. The auditory processing battery: survey of common practices. J Am Acad Audiol. 2002;13(2):93-119.
10. Taborga-Lizarro MB. Processos temporais auditivos em músicos de Petrópolis [monografia]. São Paulo: Universidade Federal de São Paulo; 1999.
11. Lloyd LL, Kaplan H. Audiometric interpretation: a manual o basic audiometry. Baltimore: University Park Press; 1978.
12. Hall III JW, Chandler D. Timpanometria na audiologia clínica. In: Katz J. Tratado de audiologia clínica. 4a ed. São Paulo: Manole; 1999. Cap 20, p. 281-97.
13. Zaidan E, Garcia AP, Tedesco MLF, Baran JA. Desempenho de adultos jovens normais em dois testes de resolução temporal. Pro Fono. 2008;20(1):19-24.
14. Samelli AG, Schochat E. Estudo da vantagem da orelha direita em teste de detecção de gap. Rev Bras Otorrinolarigol. 2008;74(2):235-40. http://dx.doi.org/10.1590/S0034-72992008000200013
15. Buosi MMB, Ferreira LP, Momensohn- Santos TM. Percepção auditiva de professores disfônicos. Audiol Commun Res. 2013;18(2):101-8. http://dx.doi.org/10.1590/S2317-64312013000200008
16. Bellis TJ. Central Auditory Processing Disorders: from science to practice. San Diego: Singular; 1996.
17. Chermak GD, Musiek FE. Central Auditory Processing Disorders: new perspectives. San Diego: Singular; 1997.
18. Schochat E, Rabelo CM, Sanfins MD. Processamento auditivo central: testes tonais de padrão de frequência e de duração em indivíduos normais de 7 a 16 anos de idade. Pro Fono. 2000;12(2):1-7.
19. Mendonça EBS, Muniz LF, Leal MC, Diniz AS. Aplicabilidade do teste padrão de frequência e P300 para avaliação do processamento auditivo. Braz J Otorhinolaryngol. 2013;79(4):512-21. http://dx.doi.org/10.5935/1808-8694.20130091
20. Frederigue-Lopes NB, Bevilacqua MC, Sameshima K, Costa AO. Desempenho de crianças normais em testes temporais auditivos em campo livre. Pro Fono. 2010;22(2):83-8. http://dx.doi.org/10.1590/S0104-56872010000200003
21. Caumo DTM, Ferreira MIDC. Relação entre desvios fonológicos e processamento auditivo. Rev Soc Bras Fonoaudiol. 2009;14(2):234-40. http://dx.doi.org/10.1590/S1516-80342009000200015
22. Murphy CFB, Schochat E. Correlações entre leitura, consciência fonológica e processamento temporal auditivo. Pro Fono. 2009;21(1):13-8.
23. Soares AJC, Sanches SGG, Neves- Lobo IF, Carvallo RMM, Matas CG, Cárnio MS. Potenciais evocados auditivos de longa latência e processamento auditivo central em crianças com alterações de leitura e escrita: dados preliminares. Arq Int Otorrinolaringol. 2011;15(4):486-91. http://dx.doi.org/10.1590/S1809-48722011000400013

24. Onoda RM, Pereira LD, Guilherme A. Temporal processing and dichotic listening in bilingual and non-bilingual descendants. Braz J Otorhinolaryngol. 2006;72(6):737-46. http://dx.doi.org/10.1016/S1808-8694(15)31040-5
25. Camarinha CR, Frota SMMC, Pacheco- Ferreira H, Lima MAMT. Avaliação do processamento auditivo temporal em trabalhadores rurais expostos a agrotóxicos organofosforados. J Soc Bras Fonoaudiol. 2011;23(2):102-6. http://dx.doi.org/10.1590/S2179-64912011000200004
26. Abdo AGR, Murphy CFB, Schochat E. Habilidades auditivas em crianças com dislexia e transtorno do déficit de atenção e hiperatividade. Pro Fono. 2010;22(1):25-30. http://dx.doi.org/10.1590/S0104-56872010000100006
27. Simões MB, Schochat E. Transtorno do processamento auditivo (central) em indivíduos com e sem dislexia. Pro Fono. 2010;22(4):521-24. http://dx.doi.org/10.1590/S0104-56872010000400027
28. Terto SSM, Lemos SM. A. Aspectos temporais auditivos em adolescentes do 6º ano do ensino fundamental. Rev CEFAC. 2013;15(2):271-86. http://dx.doi.org/10.1590/S1516-18462012005000040
29. Parra VM, Iório MCM, Mizahi MM, Baraldi GS. Testes de padrão de frequência e de duração em idosos com sensibilidade auditiva normal. Rev Bras Otorrinolaringol. 2004;70(4):517-23. http://dx.doi.org/10.1590/S0034-72992004000400013