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Original articles

Comparative study of temporal resolution test results in young adults

Estudo comparativo dos resultados de testes de resolução temporal em jovens adultos

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ABSTRACT

Purpose: to compare the performance of adults on tests of temporal resolution, and *Gaps In Noise Random Gap Detection Test.*

Methods: the population studied consisted of 51 students of both genders, aged 18 to 35, with no otologic and/or audiological history, without neurological and learning disorders. The procedures used in the research were Random Gap Detection Test and Gaps In Noise tests, performed at 40 dBSL.

Results: the results showed statistically significant difference when comparing the perception of time intervals of silence Random Gap Detection Test and Gaps In Noise tests for both genders. There was no statistically significant difference regarding the ear in which the Gaps In Noise test was initiated. The detection threshold of the gap of silence at the Gaps In Noise test was lower in miliseconds in relation to thresholds obtained in Random Gap Detection Test.

Conclusion: there is influence of gender on test results Random Gap Detection Test and Gaps In Noise, with best male performance. The ear and gender criteria did not influence the outcome of the Gaps In Noise gap detection test. The comparison between of both tests (Random Gap Detection Test and Gaps In Noise) demonstrated a better performance in Gaps In Noise test, with the perception of gap in smaller time intervals.

Keywords: Hearing; Young Adult; Auditory Perception; Hearing Tests

RESUMO

Objetivo: comparar o desempenho de universitários nos testes de resolução temporal, Gaps In Noise e Randon Gap Detection Test.

Métodos: a população avaliada foi composta por 51 adultos, de ambos os sexos, na faixa etária de 18 a 35 anos, com ausência de histórico otológico e/ou audiológico, sem alterações neurológicas e transtornos de aprendizagem. Os procedimentos utilizados na pesquisa foram os testes Randon Gap Detection Test e Gaps In Noise, realizado a 40 dBNS.

Resultados: os resultados demonstraram diferença estatisticamente significante na comparação entre o tempo de percepção dos intervalos de silêncio nos testes Randon Gap Detection Test e Gaps In Noise, para ambos os sexos. Não houve diferença estatisticamente significante com relação à orelha em que o teste Gaps In Noise foi iniciado. Os limiares de detecção do *gap* de silêncio no teste Gaps In Noise foram menores em milissegundos com relação aos limiares obtidos no Randon Gap Detection Test.

Conclusão: há influência do sexo nos resultados do teste Randon Gap Detection Test, com melhor desempenho do sexo masculino. Para o teste Gaps In Noise, os critérios de sexo e orelha em que o teste foi iniciado, não influenciaram os resultados. A comparação entre os testes Randon Gap Detection Test e Gaps In Noise, para ambos os sexos, demonstrou melhor desempenho para o teste Gaps In Noise, com a percepção do gap em intervalos de tempo menores.

DESCRITORES: Audição; Adulto Jovem; Percepção Auditiva; Testes Auditivos

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INTRODUCTION

The auditory temporal processing consists in the perception of sound changes within a given period of time, or yet, in the ability to perceive or differentiate the stimuli in rapid succession. The temporal auditory processing skills are fundamental for speech perception, for proper decoding of the spoken message. The acoustic cues of frequency, intensity and time are processed through the physiological mechanisms of the auditory system[1,2]. The temporal auditory processing can be divided into four categories, described as: Temporal Ordering or Temporal Sequencing, Temporal Integration or Temporal Summation; Temporal Masking; Resolution and Discrimination or Temporal Acuity [2].

Temporal resolution refers to the individual's ability to detect time intervals between sound stimuli or to detect the minimum time that an individual can discriminate between two audible signals, that is, to perceive short gaps between two stimuli or to perceive that a sound is modulated in some way. The threshold for temporal resolution is known as auditory acuity or minimum temporal integration time. The temporal resolution capacity is responsible for the comprehension of continuous speech and its isolated segments. Disorders of temporal resolution capacity are related to the difficulties of phonological processing and auditory discrimination of temporal cues of speech, resulting in difficulties to identify small acoustic variations of speech, impairing the proper production of its sounds or to interpret the message heard [2,3].

The *Random Gap Detection Test* (RGDT), elaborated by Keith[4], started from the AFT-R revision, called silence interval detection test or gap detection test. It is a test that identifies and qualifies the disorders of the temporal processing and that presents greater sensitivity to identify the disorders of the temporal auditory resolution, which are related to disorders of phonological processing, auditory discrimination problems, receptive language and reading, in order to determine the gap detection threshold. This gap is measured in milliseconds (ms) and obtained by its perception in a series of pairs of stimuli. The interval detection threshold is considered the smallest interval from which the individual happened to identify the occurrence of two stimuli, presenting a normality pattern between 2 and 20 ms[5]. This test evaluates the temporal resolution ability by presenting several pairs of stimuli in binaural condition of a gap, inserted in a pure tone or click, in the frequencies of 500 to 4kHz, with interval of silence between each pair of pure tones - the intervals ranging from 0 to 40 ms. The individual must identify whether the stimulus presented is composed of one or two sound stimuli[6].

The *Gaps In Noise* (GIN) test, created by Musiek[7,8], evaluates the temporal resolution ability, with monaural presentation of several segments of white noise of 6 seconds, which contains 0 to 3 silence intervals (gaps) each. Each noise segment is separated from another by 5 seconds of silence, and the duration of the displayed gaps are 2 to 20 ms. This test has parameters for temporal evaluation using non-verbal material, gaps inserted in white noise and placement of the gaps in a random manner in relation to the occurrence[9]. The test consists of four test tracks, in which gaps are shown in duration and six times per track. Each ear is evaluated separately twice, two test tracks are applied on the right ear and two on the left ear. For each of the test track, two measurements are determined, the gap detection threshold and the percentage of correct hits per test track, being calculated how many gaps were detected in general[10].

Zaidan et all[11], compared the performance of 25 normal young adults of both genders, aged 18-29 years in RGDT and GIN temporal resolution tests and analyzed the differences between these two assessment methods. They found that the male gender presented better performance in both the RGDT test and the GIN test, when compared to the female gender. The authors observed non-significant differences in GIN responses for both ears. The subjects presented better performance in the GIN test, which presented advantages over the RGDT, not only in terms of their validity and sensitivity, but also in relation to their application and correction of the results, being the GIN test a reliable tool to be used in the clinical practice.

Samelli and Schochat[12] researched the existence of differences in response between the right and left ears for a gap detection test in 100 adult subjects, 50 male subjects, ranging from 24 to 72 years old and 50 female subjects in the age range of 23 to 77 years old. According to the results, the responses obtained were similar for both ears, independent of the test starting ear.

The objective of the present study was to compare the performance of university students in temporal resolution tests Gaps In Noise and Random Gap Detection Test.

METHODS

The present research constitutes a line of cross-sectional, contemporary and comparative research, focusing on diagnosis research.

Sixty subjects from both sexes were invited, but 25 subjects of the male gender and 26 female subjects ranging from 18 to 35 years old attended and were included in the study, being young adults, university students. Initially, the subjects were informed about the research purpose and the procedures that would be performed. After clarification and having accepted to participate, they signed a Free and Informed Consent Form.

The criteria of inclusion for the present study were: to present tonal thresholds within the standard of normality up to 25dB HL, according to Northen and Downs criteria[13]; tympanometric curve type A and presence of acoustic reflex (contralateral and ipsilateral) at all frequencies, according to Northen and Gabbard criteria[14]; absence of otologic and/or neurological disorders; absence of learning difficulties and previous history of speech and language development delay, history of middle ear alteration and/or repeated otitis.

Data collection procedures began with audio-logical anamnesis and a self-referenced report with 10 questions in order to collect important data about hearing and general health status of the individuals. Afterwards, the external auditory meatus was inspected. The pure tone audiometry (audiometer model AC 33) aimed to search the hearing thresholds of the subjects (frequencies from 250 Hz to 8000 kHz) for both ears; then the acoustic immitance test was performed, with tympanometric research and acoustic reflexes (middle ear analyzer model AZ 7, *interacoustic*). Subsequently, the subjects who presented the inclusion criteria were submitted to the temporal resolution ability assessment tests, the *Random Gap Detection Test* (RGDT) and the o *Gaps In Noise* (GIN).

For the *Random Gap Detection Test*, available in CD, a radio and CD player (model AZ 1050 Philips) was used coupled to the audiometer to control the evalu-ation parameters. The stimuli were presented at 40 dB HL from the mean tonal thresholds at 500 Hz, 1000, 2000, 3000 and 4000 Hz, for each ear. The presentation was in the binaural condition, of a gap inserted in pairs of pure tones in the frequencies of 500, 1000, 2000 and 4000 Hz, with intervals between the two pure tones that ranged from 0 to 40 ms (RGDT)[15]. The subject was instructed to indicate with his/her fingers the amount of one or two, referring to the number of stimuli detected. Initially, the training track was performed at the frequency of 500 Hz, with the presentation of the stimuli from 0 to 40 ms in ascending order of intervals. If the subject adequately detected the intervals in this range, we began the research of the detection threshold of silent intervals 0-40 ms presented randomly, at 500, 1000, 2000 and 4000 Hz. If a subject did not detect any of the intervals between 0 and 20 ms in the presented frequencies, it was excluded from the research.

The RGDT result was measured from the mean of the smallest gap detection thresholds, that is, the shortest silence interval in which the subject was able to perceive the presence of two stimuli at all frequencies required. The average time to perform this test was 10 minutes.

After completion of the RGDT, the subjects performed the Gaps In Noise Test (GIN), which also evaluates the ability of temporal resolution, with monaural presentation of stimuli[16]. GIN is a test consisting of several segments of white noise of six seconds, which contain 0 to 3 intervals of silence (gaps) each. Each noise segment is separated from another by 5 seconds of silence, and the duration of the displayed gaps range from 2 to 20 ms [17]. For the GIN test, also available on CD, the same radio recorder and CD player was used, coupled to the audiometer. The test consists of a training track and four test tracks, however, in the present research, only two test tracks were applied, one for each ear, according to research described in the literature[17-19]. The GIN test was also performed at 40 dB HL from the mean tonal thresholds of 500 Hz to 4000 Hz. Each of the test strips consists of the presentation of ten gaps (2, 3, 4, 5, 6, 8, 10, 12, 15 and 20 ms) with different durations, being presented six times each, for a total of 60 gaps. The subjects were told they would hear noises and, within these noises, there would be silence intervals (gaps), being up to 3 intervals of silence at the same noise and also noise without interval of silence. The subjects were asked to raise their hands when they realized the interval of silence. If the subject raised his/her hand twice during the presentation without there being an interval of silence, the answer would be considered false-positive[19]. For calculating the threshold of detection we used the procedure described by Samelli and Schochat[19], that is, the identification of the threshold from the smallest gap detected for each test track and the number and percentage of hits, from the number of gaps detected.

The GIN test was performed in 13 male subjects beginning in the left ear and 12 individuals started with the right ear. Whitin the female gender, 14 individuals started the test by the right ear and 12 by the left ear. The GIN test results were recorded in a protocol adapted from Samelli and Schochat[19]; Liporaci [20], and the RGDT ones, in the protocol that comes with the test.

This research was approved by the Research Ethics Committee (REC) of the Institution where it was developed, under the opinion nº 0032/11.

We performed an analysis of the results to characterize the sample by gender in the RGDT test, and in the GIN test by gender and starting ear of the test according to the gap detection threshold, comparing these variables among the groups that were divided by gender (MG and FG). The results were submitted to statistical treatment using the Mann-Whitney, Anderson-Darling Normality and ANOVA tests, with p = 0.05.

RESULTS

Initially, Table 1 shows the characterization of the sample referring to the description of the partial and total number of subjects, mean age and mean auditory tone thresholds for the right ear (RE) and left ear (LE) in both groups (MG and FG). The sample was subdivided according to gender in two groups with great similarity in relation to the numerical quantity of subjects. Regarding the mean ages and auditory thresholds, similar values were also observed, with no differences that could compromise the application of the evaluation procedures.

Table 1. Characterization of the sample according to the number of subjects, average age and auditory thresholds of MG and FG

Group	Number of subjects	Average Age (years)	Average auditory threshold RE (dB HL)	Average auditory threshold LE (dB HL)
MG	25	23,17	7,00	7,00
FG	26	24,38	6,15	5,57
TOTAL	51	23,77	6,57	6,28

Subtitle: MG = male gender; FG = female gender; dB HL = decibel Hearing Level; RE = right ear; LE = left ear

Table 2 shows the results of mean gap detection thresholds for the male and female RGDT test. In the comparison of the mean gap detection thresholds, according to the gender criterion, a better performance was observed for the male gender, with a statistically significant difference in relation to the female gender, according to the Mann-Whitney and Anderson Darling Normality tests.

Table 2. Comparison of thresholds gap detection means for the RGDT test, according to gender criterion

	MG (ms)	FG (ms)
Mean	9,95	13,06
Median	9,00	14,00
Standard deviation	4,66	5,00
p-value	0,0296*	

Subtitle: MG = male gender; FG = female gender; RGDT = Random Gap; ms = milliseconds.
Detection Test; * presence of significant response
Mann Whitney Test e Anderson Darling Normality. p-value = 0,05

Table 3 shows the results of the mean gap detection thresholds for the GIN test, according to the gender and ear in which the test was initiated (right or left) criteria. The comparison of the gaps averages for detecting the silent intervals for the GIN test showed that there was no significant difference according to gender and ear criteria according to the Mann-Whitney and Anderson Darling Normality tests.

Table 3. Comparison of the means of gaps results in the GIN test, for both genders and ear in which the test was started

	RE		LE	
	MG (ms)	FG (ms)	MG (ms)	FG (ms)
Mean	4,04	3,84	3,88	3,96
Median	4,00	4,00	4,00	4,00
Standard deviation	0,73	1,56	0,78	1,21
p-value	0,1631		0,8128	

Subtitle: MG = male gender; FG = female gender; RE = right ear; LE = left ear; GIN = Gaps In Noise; ms = milliseconds.
Mann Whitney Test e Anderson Darling Normality. p-value = 0,05

In Table 4 are the results of the percentage of correct gap hits by test track in the GIN test, according to the ear and gender criteria. In the GIN test, the results of the percentage of correct right and left ear gap hits were compared for both genders using the Mann-Whitney and Anderson Darling Normality tests, in which no significant difference was observed for both criteria (gender and ear).

Table 4. Comparison of the percentage of correct gap hits for the GIN test, for both genders and ears

	RE		LE	
	MG (%)	FG (%)	MG (%)	FG (%)
Mean	74,86	76,09	77,12	73,26
Median	76,70	76,70	78,30	75,85
Standard deviation	7,30	11,25	7,63	12,42
p-value	0,4564		0,3043	

Subtitle: MG = male gender; FG = female gender; RE = right ear; LE = left ear;
Mann Withney Test e Anderson Darling Normality. p-value = 0,05

Table 5 presents the results of the RGDT and GIN tests, according to the ear criterion, for both genders, in order to observe whether there is a similarity between the means found for each test, even if in each test different stimuli are used, which activate different neural pathways for the response. It is observed a numerical difference of the means of the gap detection thresholds between the tests, regardless of the ear or gender criterion. However, these results did not undergo statistical treatment, since they reflect responses of different auditory patterns (monoaural = GIN, binaural = RGDT).

Table 5. Presentation of the means of gap detection thresholds, between the RGDT and GIN tests, for male and female gender, according to the ear criterion

	RGDT (ms)	GIN (RE) (ms)	GIN (LE) (ms)
MG	9,95	4,04	3,88
FG	13,06	3,84	3,96

Subtitle: MG = male gender; FG = female gender; RE = right ear; LE = left ear; ms = milliseconds.

DISCUSSION

The RGDT test results described in Table 2 showed that, for the gender criterion, the mean of the male gap detection threshold was statistically better (9.96 ms) than the female gender performance (13.01 ms). It can be observed that the gender and ear criteria do not determine some type of advantage in the mean gaps detection thresholds and the percentage of correct gap hits in the GIN test, as described in Table 3. These results corroborate with those of the literature[21], which leads us to conclude that criterion such as gender and ear tested are not a determining factor for the performance of auditory processing when it is evaluated through behavioral tests[22,23].

Monotic tests are useful for detecting alterations in the auditory pathways, however they do not localize them, since there is involvement of the ipsi and contralateral pathways, resulting in a similar performance for both ears. There was no advantage of one ear over the other, agreeing with some researches described in the literature[8,12,21] which do not report perceptual asymmetry between the ears in gaps detection tests. In recent study by Shinn et alli.[23], the results obtained suggest that the maturation of the auditory system in relation to the temporal resolution ability occurs similarly in both ears.

In the GIN test results analysis in relation to the percentage of correct answers by test track for both genders, as described in Table 4, no statistical difference was observed between the genders, however, it was observed that the performance of the female gender was better in the right ear (76.09%), while in the male the performance was better in the left ear (77.12%). Although there are few studies related to the percentage of correct answers in the gaps detection test for the gender variable, these findings agree with the research performed in Brazilian adults[12].

When comparing the results of the RGDT and GIN tests, as described in Table 5, it was observed that, in both male and female subjects, the subjects had a better numerical performance in the GIN test. The gap detection test thresholds in the GIN test were better than the thresholds obtained in the RGDT. The GIN test presented advantages over RGDT in its application and perception by the subjects. These findings agree with the results of Zaidan et alli[11], who conducted a comparative study of the performance of normal young adults in temporal resolution tests. In this study the subjects had better performance in the GIN test, when compared to the RGDT, in both genders. The findings of another study [24] evidenced the difference between the types of stimuli used in the respective tests (pure tone in the RGDT test and white noise in the GIN test) and the type of response obtained in the tests (push a button or manually indicate each time the gap is perceived in the GIN test and inform how many sounds were perceived in the RGDT).

The type of response in each test can lead to confusion during its application, as in RGDT, counting stimuli numbers or respond verbally require higher cognitive skills. The GIN test evaluates the right and left auditory pathways separately, which is important in the assessment of children and elderly people, since there may be a difference between the ears in subjects with central auditory pathway disorders[25]. For this reason, the protocol was proposed with differentiated applications for both ears.

Time is one of the key components for the acoustic signal, which should be considered in the interpretation of information transmitted aurally[25]. The auditory ability of temporal processing is important for speech perception, it contributes to the identification of small phonetic elements in speech and changes in this hearing ability may suggest interference in the perception of normal speech and the recognition of phonemes[26].

It can be evidenced in this study that there is influence of gender in the results of the temporal resolution tests, since the male group presented a better performance in relation to the female, both in the

RGDT and in the GIN test. The ear criterion does not influence the result of gap detection in the GIN test.

In the presentation of the performance of subjects for each test (RGDT and GIN) there is a numerical difference between the means, with better performance of the subjects of both groups in the GIN test. This fact leads us to consider that each test can activate more or less areas of the central auditory nervous system (CANS) that respond by the physiological mechanism of temporal resolution ability.

CONCLUSION

Comparing the performance of university students in temporal resolution tests, Gaps In Noise e Random Gap Detection Test, there was a statistically significant difference regarding gender in relation to RGDT test results. This statistical difference, however, was not found in the GIN test, in which the gender and ear in which the test was started criteria did not influence the results. The comparison between the RGDT and GIN tests, for both genders, showed better performance for the GIN test, with gap perception in smaller time intervals.

Thus, studies that identify the physiological mechanisms of the CANS areas that act on the temporal resolution ability response in each test (GIN and RGDT) need to be performed to clarify such difference.

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