THE INFLUENCE OF SENSORYNEURAL HEARING LOSS ON TEMPORAL ORDERING

A influência das perdas auditivas sensorioneurais na ordenação temporal

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ABSTRACT

Purpose: to evaluate the temporal ordering ability in adults with mild to moderate sensoryneural hearing loss, through the Duration Pattern Test, in order to determine whether these losses affect the performance of the aforesaid test. **Method:** 57 adults from 20 to 59 years of age were evaluated, being 30 male and 27 female. All of them underwent a screening test consisting of medical history, ENT examination, basic audiological testing and hearing process screening with the Dichotic Digit Test. After this process, the participants were allocated into three groups, namely: G1 (normal hearing for the averages of 0.5 / 1 / 2 and 3/4/6 KHz), G2 (mild hearing loss in at least one of the averages) and G3 (moderate loss in at least one of the averages). The results were analyzed through comparison between normal hearing and the presence of hearing loss (G2 + G3) and among the three groups described. The normality index used was 70% of successes. For statistical analysis, the tests used were Nonparametric Mann-Whitney, Kruskal-Wallis ANOVA, "One-way" Analysis of Variance, student's *t* and chi-square. The determining criterion of significance adopted was level 5%. **Results:** there was a significant presence of men with hearing loss in the group. The percentage of correct answers in the overall sample was 62.3%, revealing no statistically significant difference among groups. **Conclusion:** the temporal ordering ability evaluated by the Duration Pattern Test is not influenced by mild to moderate sensoryneural hearing loss.

KEYWORDS: Hearing Loss; Auditory Perception; Auditory Perception Disorders; Psychoacoustics; Acoustic Stimulation; Hearing Tests

INTRODUCTION

The human ear functions as a power transducer in the various stages through which the peripheral auditory system follows until it stimulates the central auditory pathway and finally the cortex. For a proper perception of speech sounds, there is a need of hearing integrity, so that the stimuli can reach the central nervous system.

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This study was undertaken as part of the dissertation for the Professional Master's Course in Speech Pathology at the University Veiga de Almeida (UVA). Data were collected at the Municipal Health Center (CMS) Waldyr Franco, a member of the Municipal Health Office in Rio de Janeiro.

Conflict of interest: non-existent

It is believed that hearing disorder involves two aspects, one is hearing loss, which impairs the ability to detect sound energy, and the other is the auditory processing disorder, which refers to a hearing disorder in which there is impairment in the ability to analyze and/or interpret sound patterns. An auditory processing disorder is a deficiency in one or more of the mechanisms and processes of the auditory system that are responsible for the behavioral phenomena of localization and lateralization of sound; auditory discrimination; auditory pattern recognition; auditory temporal aspects, including resolution, masking, integration and temporal ordering; auditory performance with degraded and competitive acoustic signals.[1]

Temporal processing refers to the perception of the characteristics of a sound and its changes within a time interval[2], wherein the temporal ordering refers to the processing of multiple auditory stimuli

in their order of occurrence[3]. As the processing time is closely related to speech intelligibility[4, 5], which is a complex acoustic signal, rich both in spectral and temporal characteristics[6], and the hearing impaired complain about not understanding speech, it was possible to hypothesize that this ability could be harmed in the hearing impairment, which has not been confirmed in a recent study[7], despite the variability of responses which was also observed in most studies [7-9].

The aim of this study is to evaluate the temporal ordering ability in adults with mild to moderate sensorineural hearing loss, using the Duration Pattern Test (DP) in order to check whether those losses influence the performance of this test.

METHOD

This is a prospective cross-sectional study, which at the end of the selection process, included 57 individuals of both sexes, among which 22 had normal hearing (38.6%), 17 had mild hearing loss (29 , 8%) and 18, moderate hearing loss (31.6%). The average age was 45.4 (± 9.6) years, ranging from 20 to 59, with 30 (52.6%) men and 27 (47.4%) women. Each participant was informed about the purpose of the study, and it was initiated after the establishment of inclusion criteria, agreement and signing the informed consent form. The selection of the group with normal hearing was paired with the selection of the two groups of individuals with hearing loss. On the other hand, the selection of individuals with hearing loss was made according to convenience due to the difficulty of gathering this sample.

Data was collected at the Municipal Health Center Waldyr Franco, a center of medium complexity in the Program for Hearing Health Care, member of the Municipal Health Office of Rio de Janeiro, from February to August 2010.

The following devices were used: Audiometer DANPLEX DA 65, Emissions meter AT 235h, CD Player Potenza coupled to the audiometer; CD of Dichotic digits and Duration Pattern tests. All patients went through a selection process that included: Anamnesis, otorhinolaryngological evaluation, basic audiological evaluation and assessment of central auditory processing.

To reach the final sample, the following individuals were excluded using anamnesis: Individuals outside the age range described, illiterate people, individuals with systematic musical practice, individuals with associated neurological disease or disorder, with psychotropic drug use in the 12 months prior to the survey and with a history of ear disease or otological surgery. Starting from the otorhinolaryngological evaluation, we excluded individuals with problems in the outer and middle ear and / or mastoid. From the basic hearing evaluation, the individuals with conductive and mixed hearing losses, with differences between the thresholds of right and left ears at each frequency, greater than 20 dB HL, with three-tone average higher than 55dBHL, with percentage index of speech recognition (PISR) lower than 92% in normal hearers and inferior to 80% in mild and moderate hearing loss[10]; with tympanometry curve type B or C, with absence of contralateral acoustic reflex in at least two out of the four frequencies tested. Starting from the assessment of central auditory processing by means of a screening performed with the dichotic digits test, the individuals who presented a percentage of right answers in the test inferior to 95% in each ear were excluded[11].

To define the degree of normality or degree of hearing loss, we used three-tone averages (TTA) of 500/1000/2000 and 3000/4000/6000 500/1000/2000 Hz and 12 Hz in aerial thresholds. In the case of different three-tone averages in the same ear, the degree of loss was defined by the higher average. To define the degree of hearing loss in the individual with a difference between the degree of loss of the right ear and the degree of loss of the left ear, we used a similar criterion to the criterion aforementioned, i.e. the degree was defined by the worst ear.

The three groups of research procedure (application of the duration pattern test), according to their degree of hearing, are described in Fig. 1

Groups 2 (mild loss) and 3 (moderate loss) were analyzed together (G2 + G3 = loss group) and separately, when compared to the control group. The objective was to check if the presence of loss alone would be enough to compromise the performance of the test and if the aggravation of the loss would influence it.

The DP test was applied with a binaural presentation condition, at 50 dBSL above the three-tone average of 500/1000/2000 Hz of the worse ear. The three initial sequences for training and the subsequent 45 were used for data gathering[13].The type of response used was nomination. The stimuli were nominated as long (L) and short (S). The correct and ordered nomination of the three tones of the sequence was considered correct, being considered as the standard range of 70% of correct answers[14], but in diotic presentation.[13]

This study was approved by the Research Ethics Committee of the Municipal Health and Civil Defense Office of Rio de Janeiro (RJ-SMSDC CEP) under Protocol 204/09.

groups	no	Degree of Hearing Loss	
G1	22	Normal	Both TTA< or = 25 dB HL
G2	17	Mild loss	At least a mild loss of TTA between 26 – 40 dBHL
G3	18	Moderate loss	At least a moderate loss of TTA between 41 – 55 dBHL
G2+G3	35	Group with loss	**********

Figure 1 – Selected groups for research procedures

For statistical analysis we used the Mann-Whitney, Kruskall-Wallis ANOVA, Student's *t*, analysis of variance "one way" and chi-square tests. We applied nonparametric tests because the variables did not present a normal distribution (Gaussian) due to scattering of data, to the lack of symmetry in the distribution, to the rejection of the hypothesis of normality, according to the Kolmogorov-Smirnov test and/or to the small size of the sample in some groups. The criterion for determining significance was set at 5%. The statistical analysis was performed by the software SAS 6.11 (SAS Institute Inc., Cary, North Carolina)

RESULTS

There were no statistically significant differences between the average ages of the groups with normal hearing and hearing loss (43.5 and 46.6 years-old respectively, *p* value = 0.23), ascertained by Student's *t* test for independent samples, nor between the groups with normal hearing, mild and moderate hearing loss (43.5, 45.9 and 47.3 years-old respectively, *p* value = 0.45), analyzed by ANOVA of "one way" variance. According to the χ 2 test, the group with loss (G2 + G3) showed a proportion of men (p = 0.051) significantly higher than the group with normal hearing. According to the same test, there is no significant difference (p = 0.078) in the proportion of men among G1 (36.4%), G2 (52.9%) and G3 (72.2%).

Out of the 57 patients, 34 (59.6%) presented a modified Duration Pattern.

Table 1 provides the measures of central tendency of the Duration Pattern Test according to the overall sample and the following groups: G1 *versus* G2 + G3; G1 *versus* G2 *versus* G3; and the corresponding descriptive levels (*p* value) of the statistical tests. According to the χ 2 test, there is no significant difference (*p* = 0.11) in the proportion of alteration in the duration pattern among groups G1 (72.7%) and G2 + G3 (51.4%) and (*p* = 0.27) among groups G1 (72.7%), G2 (52.9%) and G3 (50.0%)

Tabela 1 – Measures of percentage of correct answers of SD in the overall sample; in the groups with normal hearing and with hearing loss; and in the groups with normal hearing, mild and moderate loss

Variable	Group	n	average	±	SD	med	minimum	maximum	*p*-value
SD	OS	57	62.3	±	24.6	60	15.5	97.7	---
	G1	22	58.4	±	23.8	60	15.5	97.7	0.38 [a]
	G2+G3	35	64.7	±	25.2	62.2	17.7	97.7	
	G1	22	58.4	±	23.8	60	15.5	97.7	
	G2	17	66.2	±	25.7	62.2	17.7	97.7	0.62 [b]
	G3	18	63.2	±	25.3	67.8	20	97.7	

OS: Overall sample; n: number of individuals ; SD: standard deviation; med: medium.
[a] Mann-Whitney Test
[b] Kruskal-Wallis ANOVA

DISCUSSION

This study stems from an analysis of 641 evaluation forms of patients assisted in Program for Hearing Health Care, at the Municipal Health Center (CMS) Waldyr Franco.

It was very difficult to collect the sample. The small number of patients in the groups of mild and moderate loss, was due to the restrictions of the inclusion criteria, such as the absence of asymmetries between the ears, the presence of acoustic reflex in at least two of the four frequencies tested and especially by the screening of auditory processing with Dichotic Digits test[11].

66 patients were selected, after anamnesis, basic otorhinolaryngological and audiological assessment; yet, from those, nine were excluded in the dichotic digits test. Even being aware that the completion of the dichotic digits test does not evaluate the Central Auditory Nervous System as a whole, and that it evaluates only the dichotic listening with binaural integration[15], this test was chosen as a hearing screening because it is widely used and prescribed for this purpose[16,17]. Changes in the central auditory processing in dichotic listening interfere with the performance of temporal processing, more specifically in the temporal resolution[18, 19].

The lack of statistical significance between the average age among groups allowed the elimination of the bias of aging, which could impair the analysis of the sample.

Regarding the gender factor, the overall sample was homogeneous. A significantly greater proportion of men with hearing loss in the group can be attributed to two factors, namely: This study was conducted with adults in the job market, where there is a higher incidence of male individuals with Hearing loss induced by high sound pressure level (HLIHSPL) [20], and the participation of military men complaining of HLIHSPL, who reported not using proper protection activities when in shooting activities [21].

In the duration pattern test, in the overall sample, the average found (62.3%) is below the normal rate proposed, which can be assigned to these two facts: More than half the sample has changed DP (34 individuals - 59.6%) and the occurrence of a great variability of responses with a high range of standard deviation (24.6%, ranging from 15.5% to 97.7%).

The average of 62.3% was close to the one found in a control group of young adults [9] with normal hearing (64.6%), with the record of a high variability of responses. It was also close to the average found for elderly people [8] with normal hearing (67.5%) and for elderly people [7] with hearing loss (63.1%) but lower than the average found in young adults [22] with normal hearing (83%). Comparing the studies that showed similar averages, it was observed that the average age of the present one (45.4 years) is an intermediary between the one held with young adults (29.7 years) and the ones held with elderly people with normal hearing (67.44 years) and elderly people with hearing loss (67.3 years). The studies with the elderly refer to possible losses associated with aging in the results [7, 8], however, the study with the youngest sample maintained a similar average of results. The variability of responses was common in the aforementioned studies, with the largest standard deviation present in the study of the control group of young adults [9]. As the hearing loss did not affect the performance of the test [7, 14], and the age factor raises questions, for the younger population showed a performance similar to the elders[9], it is possible to hypothesize that factors other than those related to aging, can influence the outcome of the test, such as memory [23, 24], attention, interhemispheric transfer, type of response ranging between nomination or humming [22] and educational level. In the present study, illiteracy was regarded as an exclusion criterion, but in a previous research, all the individuals evaluated were either graduated or taking undergraduate courses.[22]

Comparing the group with normal hearing (G1) with the hearing loss group (G1 + G2), it was possible to observe that the group with normal hearing showed worse performance on the DP test (average of 58.4% of correct answers) than the group with hearing loss (64.7%) without statistical significance ($p = 0.38$). This fact can be justified by the number of individuals with DP changes, with a record of changes in 72.7% of individuals in G1 and 51.4% of individuals in the hearing loss group ($p = 0.11$), subtly interfering in the average score of the groups. Regarding the influence of hearing loss in test performance, it can be stated that the temporal ordering ability evaluated by DP test did not appear to be influenced by the variable of cochlear hearing loss, corroborating other studies [7, 14], as it would be expected that the hearing loss group showed worse performance.

In intergroup comparison, it was possible to observe, as in the comparison between normal hearing and hearing loss, that there was no significant difference between the averages of correct answers of the groups (p = 0.62). Between G2 and G3, there was a greater number of individuals with DP changes in the group with mild hearing loss (G2), with 52.9% changes in comparison to G3, which showed 50% of the changes. The worst performance was in G1, followed by G3 and finally, the G2. The temporal ordering ability assessed by the duration pattern test did not prove to be influenced by the varying degrees of hearing loss, corroborating the studies once more. [7, 14]

CONCLUSION

It was ascertained that the temporal ordering evaluated by the Duration Pattern Test is not influenced by mild to moderate sensorineural hearing loss.

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RESUMO

Objetivo: avaliar a ordenação temporal em adultos com perdas auditivas sensorioneurais de graus leve e moderado, por meio do teste Padrão de Duração, a fim de verificar se essas perdas influenciam no desempenho do teste. **Método:** foram avaliados 57 pacientes, com idades entre 20 a 59 anos, sendo 30 homens e 27 mulheres. Todos responderam a anamnese, passaram por avaliação otorrinolaringológica, avaliação audiológica básica e triagem do processamento auditivo, com o teste Dicótico de Dígitos. *Os participantes foram alocados em* 3 grupos: G1 (audição normal para as médias de 0,5/1/2 KHz e de 3/4/6 KHz), G2 (perda auditiva de grau leve em pelo menos uma das médias) e G3 (perda de grau moderado em pelo menos uma das médias). A comparação foi realizada entre a audição normal e a presença da perda auditiva (G2+G3) e entre os três grupos descritos. O índice de normalidade utilizado foi de 70% de acertos. Para a análise estatística foram utilizados os testes não-paramétricos de Mann-Whitney, ANOVA de Kruskal-Wallis, Análise de Variância "one-way", *t* de Student, Qui-quadrado. O critério de determinação de significância adotado foi o nível de 5%. **Resultados:** observou-se presença significante de homens no grupo com perda auditiva. A porcentagem de acertos da amostra geral foi de 62,3% e não ocorreu diferença estatisticamente significante entre os grupos. **Conclusão:** a habilidade de ordenação temporal avaliada pelo teste Padrão de Duração não sofre influência da perda auditiva sensorioneural de grau leve e moderado.

DESCRITORES: Perda Auditiva; Percepção Auditiva; Transtornos da Percepção Auditiva; Psicoacústica; Estimulação Acústica; Testes Auditivos

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