ASSESSING INDIVIDUALS WITH BILATERAL HEARING LOSS USERS AND NON-USERS OF HEARING AIDS BY THE SSW TEST

Aplicação do teste SSW em indivíduos com perda auditiva neurossensorial usuários e não usuários de aparelho de amplificação sonora individual

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ABSTRACT

Purpose: to compare the performance of patients who are users and non-users of hearing aids, through the assessment by the SSW test and reinforce the importance of auditory stimulation through the use of hearing aids in individuals with hearing loss. **Method**: the study was conducted on 13 individuals aged between 55 and 85 year old, with bilateral hearing loss, 6 users of bilateral hearing aids and 7 non-users of hearing aids. The applied test was the SSW test. Before applying the SSW test, these people underwent anamnesis, audiologic and otorhorynolaringologic evaluation. A statistical analysis was performed using the *Bootstrap* technique *and* Kolmogorov-Smirnov hypothesis test. **Results**: the users group showed better performance in the studied conditions then the non-users group, especially under competitive conditions. **Conclusion**: the use of hearing aids contributes to the improvement in speech recognition, through the auditory stimulation.

KEYWORDS: Auditory Perception; Aged; Hearing; Hearing Aids

■ INTRODUCTION

The aging process causes degeneration of the auditory system, denominated Presbycusis, in both its peripheral and central portions. In general, the hearing loss is of the bilateral symmetrical sensorineural type and is more acute in the high frequency ranges[1]. Presbycusis is accompanied by decreased ability to discriminate among the various speech sounds, a decline in central auditory function manifested by means of alteration in figure-ground, auditory fusion, attention and auditory judgment skills and reduction in auditory closing and synthesis speed[2]. As a result the elderly become candidates for the use of hearing aids with the goal of not only improving these auditory skills inherent to good communicative performance, but to amplifying environmental sounds, warning and danger signals (doorbells, fire alarms, telephones), and sounds that enhance the individual's quality of life (music, bird song and others)[3].

With the purpose of re-establishing the communicative function of those with hearing loss, technologies developed for improving the performance of auditory prostheses envisage new technological resources for improving speech reception[4].

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Persons with bilateral sensorineural hearing loss who do not use hearing aids suffer from the phenomenon called "late-onset auditory privation". This manifests as a statistically significant reduction in the rates of speech recognition, associated with reduced availability of acoustic information, since this is not observed in individuals who use bilateral auditory prostheses[3].

The elderly have difficulty with auditory processing of the received speech signal, which results in failure in central fusion in the presence of incomplete auditory information and binaural interaction[5]. These skills are related to the organization and perception of environmental sounds, abilities that depend on the simultaneous use of both ears, neural interaction that occurs with the signals received by the two, and how the auditory information is processed. These interactions facilitate sound localization in space and in encountering/discriminating figure-ground relationships.

The literature has revealed that there is improvement in speech recognition over the course of time, as the individual learns to use the new speech paths available with the use of amplification. This type of training has been denominated "perceptual acclimatization". Acclimatization does not occur immediately, but only after exposure to the acoustic environment[6]. The brain requires some time to use the new acoustic information generated by the auditory prosthesis[3-7]. The main complaint by those with hearing loss refers to the difficulty in oral communication, and this complaint is persistent in new auditory prosthesis users who, even after amplification, find difficulty in recognizing sounds. Thus, acclimatization becomes the phonoaudiologist's and patient's great ally in the process of adaptation to auditory prostheses[8].

Auditory processing refers to the process involved in the detection and interpretation of sound events[9,10]. It involves the detection of acoustic events, capacity of discrimination with regard to location, spectrum, amplitude, time and ability to group components of the acoustic signal in figure-ground relationships. According to the literature, these processes occur in the peripheral auditory system (middle, inner and outer ear and auditory nerve) and in the central auditory system (brain stem, subcortical and cortical pathways), and may involve non auditory cortical areas[11].

The SSW test is a procedure that was proposed as a manner of evaluation auditory processing and the integrity of the central auditory system and has characteristics that make it one of the most frequently used tests in the evaluation of central auditory function: It does not suffer interferences of peripheral losses; is simple and easy to apply, which allows it to be used in patients of various ages and with different pathologies; it is a reliable, valid test that is quick to perform[12,13]. Starting with the presupposition that the chief complaint reported by the elderly (hearing, but not understanding) is not only due to peripheral hearing loss, but also to loss of capacity to perform sound processing. In addition, it is considered that there is improvement in speech over the course of time, as the individual learns to use the new speech pathways available with the use of amplification[3]. This study proposed to compare the performance of hearing aid user and non user patients by means of the SSW test, reinforcing the importance of auditory stimulation obtained with the use of hearing aids in those with sensorineural hearing loss.

■ METHOD

The study was conducted in 13 subjects in the age-range between 55 and 85 years (mean age of users = 70.8 and non users = 73.1), with bilateral hearing loss, being 6 users of bilateral digital auditory prostheses, and 7 non users. Data collection was performed at the "Instituto São Lucas", in the city of Uberlândia- MG, Brazil. All subjects evaluated in the research were referred for audiological evaluation by the otorhynolaryngologist. This was performed by means of anamnesis, inspection of the external acoustic meatus, threshold tonal audiometry, speech perception threshold and percentage index of speech recognition.

The equipment used in data collection were as follows: Hinne brand otoscope, audiometer with two channels, *Interacoustics* brand (AC 40), audiometric cabin, TDH 39 phones, computer coupled to the audiometer, CD volume–attached volume 2, Band number 6, of the CD forming part of the book: "Processamento Auditivo Central: Manual de Avaliação e seu protocolo de avaliação". (Central Auditory Processing: Evaluation Manual and its evaluation protocol). Subjects considered apt for the research were those with bilateral symmetrical sensorineural hearing loss of a light to moderate degree, according to the criteria of Silmam and Silvermann (1997), which take into consideration the mean tonal thresholds obtained at the sound frequencies of 500, 1000 and 2000 Hz.

The auditory processing test applied was the alternate disyllable recognition test in a dichotic task (SSW). The auditory prosthesis-user subjects evaluated showed a time of use of between 4 months and 6 years (mean= 23.6 months) (2). The test was performed at 50 dBNS considering the mean frequencies of 500, 1000 and 2000 Hz, or the most comfortable intensity, ranging from 55 dBNA to 75 dBNA. Before beginning application of the SSW

test, the patient was informed about the sequence of the words heard, which would be presented in each ear separately, and simultaneously in the right and left ears. The patient was asked to repeat the words spoken, obeying the order of their presentation. Training was provided with 4 sequences of 4 words each so that the patient would better understand the task to be performed. The presentation consisted of 40 items of words (paroxytonic disyllables), beginning with 20 in the right and 20 in the left ear. Each item was composed of the following conditions: RNC (Right non-competitive), the word was presented in the right ear without a competitive message; RC (right competitive): The word was presented in the right ear with simultaneous competition in the left ear; LC (left competitive): The word was presented in the left ear with simultaneous competition in the right ear; LNC (left non-competitive): The word was presented in the left ear without competition in the right ear. Every word that was not correctly repeated was crossed out with a line, and above it, was written the word the patient used in reply. The errors considered were: omission, substitution and distortion.

Before data collection, the participants signed the Term of Free and Informed Consent, approved by the Research Ethics Committee of the University of Ribeirão Preto, Registration Number 170/07.

After data collection, statistical analysis was performed using the Bootstrap technique, based on a re-sampling process that selects samples randomly from the original sampling space, generating new sets of samples differing from the original ones, however, maintaining their statistical characteristics in order to relate the performance of both groups in the mentioned test [15]. In this study 800 (n=800) new samples were used, based on the number of correct responses for each set of events. The boxplot was a data plotting analysis tool used in the study. By means of it the median values and data distribution in quartiles can be obtained. The median is represented by the red line; the top quartile shows the values above the median, and the bottom quartile shows the values below the median. Each quartile within the box represents 25% of the data distribution and the other 25% are distributed on the black lines called whiskers, with the sum of the top and bottom quartiles resulting in 100%. The outliers are data with values that exceed the values of the whiskers. To compare the performance of groups among them, under each studied condition, the Kolmogorov-Smirnov test was also used in order to determine whether two subjacent distributions of probability differ from one another, or whether one of the subjacent distributions of probability differs from the hypothetical distribution, in any of the cases based on finite samples.

■ RESULTS

The results obtained in the audiometric evaluation are represented in Figure 1, which was used in order to better characterize the hearing loss of the two groups of participants by means of the Boxplot statistical tool. The figure presents the data obtained in the right ear and left ear for hearing aid user and non user subjects.

a) OD sem AASI
b) OE sem AASI
c) OD com AASI
d) OE com AASI
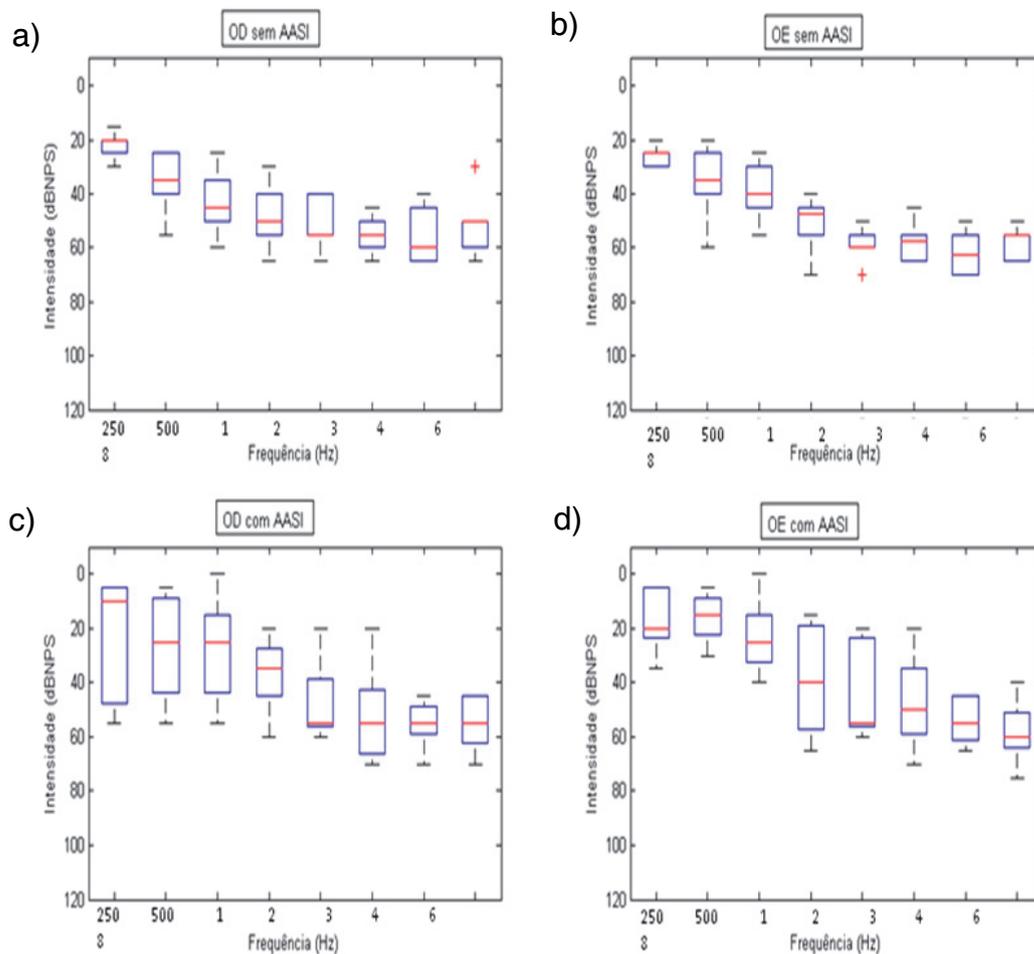
Legend: a) box plot of RE without hearing aid; b) box plot of LE without hearing aid ; c) box plot of RE with hearing aid ; d) box plot of LE with hearing aid.

Figure 1 – Box plot of hearing loss in hearing aid user and non user patients

In the non user group, in the RE the thresholds ranged from approximately 15 dB to 60 dB, and in the LE from 20 dB to 65 dB. In the user group, the audiometric thresholds in the RE ranged from 5 dB to 65 dB and in the LE from 5 to 70 dB. It could be concluded that the best thresholds were concentrated in the low frequencies and the worst in the high frequencies, characterizing a similar and descending degree and configuration of hearing loss in both ears and groups of participants.

Afterwards the result of the comparative study between the two groups for the SSW test was presented in Table 1, as regards the number of correct answers represented by the mean ($\overline{X}$), standard deviation (σ_x) and re-sampled by the bootstrap technique, for each studied condition.

Under the non competitive conditions, the following mean ($\overline{X}$) results were obtained: right non–competitive column A (RNC (A)) = 17.14 and 16.87, right non–competitive column H (RNC(H)) = 15.73 and 15.75 and left non–competitive column D (LNC

(D)) = 17.33, 17.88 and left non-competitive column E (LNC (E)) = 17.16 and 17.2 respectively for non users and users of hearing aids.

Under competitive conditions, the following results were obtained: right competitive column B (DC (B)) = 12.83 and 16.87 and right competitive column G (DC (G)) = 11.33 and 12.11 and left competitive column C (EC (C)) = 11.69 and 14.69 and left competitive column F(EC (F)) = 10.61 and 13.9 respectively for non users and users.

The standard deviation values (σ_x) under non competitive conditions were: RNC (A) = 1.35 and 1.00, RNC(H) = 1.31 and 1.77 and LNC (D) = 1.14 and 0.56 and LNC (E) = 1.47 and 1.46 respectively for non users and users of hearing aids. The standard deviation values (σ_x) under competitive conditions were: RC (B) = 1.95 and 1.00 and RC (G) = 2.11 and 2.54 and LC (C) = 1.85 and 0.66 and LC (F) = 2.49 and 1.65 respectively for non users and users.

Table 1 – Mean number of right answers ($\overline{X}$) and standard deviation σ_x of hearing aid user and non user patients, per column under the studied conditions

	Non Users		Users	
	$\overline{X}$	σ_x	$\overline{X}$	σ_x
RNC (A)	17.14	1.35	16.87	1.00
RC (B)	12.83	1.95	16.87	1.00
LC (C)	11.69	1.85	14.79	0.66
LNC (D)	17.33	1.14	17.88	0.56
LNC (E)	17.16	1.47	17.2	1.46
LC (F)	10.61	2.49	13.9	1.65
RC (G)	11.33	2.11	12.11	2.54
RNC (H)	15.73	1.31	15.75	1.77
Total RNC	32.84	2.83	32.56	2.06
Total RC	23.47	4.04	24.85	3.81
Total LC	22.36	4.28	29.03	2.00
Total LNC	34.43	2.58	34.99	1.64

Legend: RNC = Right non competitive; RC = Right competitive; LC = Left competitive; LNC = Left non competitive.

Thus it may be observed that the performance of the hearing aid user group was better than that of the non user group under the studied conditions. The competitive conditions were those under which the highest number of right answer was presented in the hearing aid user group, based on the mean value of right answers and standard deviation.

Table 2 shows the distribution of the values of right answers for both groups according to the Kolmogorov-Smirnov hypothesis test/kstest2. It can be affirmed that the only distribution in which the hypothesis is null (H=0) could be confirmed; that is to say, the distribution in which the values are not different is ENC-E; the other are considered distributions that differ among them (H=1). This means to say that under the left non competitive condition (E), the two groups had statistically similar values of right answers.

Table 2 – Distribution of numbers of right answers of both user and non user groups

	H	P	K
RCN-A	1	2.47E-31	0.3150
RC-B	1	7.49E-11	0.2025
LC-C	1	2.50E-237	0.8275
LNC-D	1	1.27E-50	0.3925
LNC-E	0	1.92E-01	0.0538
LC-F	1	7.56E-103	0.5500
RC-G	1	1.13E-10	0.2013
RNC-H	1	4.45E-01	0.1150
Total RNC	1	3.79E-10	0.1975
Total RC	1	2.16E-11	0.2063
Total LC	1	8.82E-210	0.7788
Total LNC	1	3.79E-10	0.1975

Legend: KOLMOGOROV-SMIRNOV HYPOTHESIS TEST/KSTEST2.

This shows the distribution of the total values of right answers in the SSW test separated into condition and re-sampling by means of the bootstrap technique for each studied group**.**

Under the RNC condition (Total) the values for number of right answers ranged from approximately 25 to 39 in the non user group, and from 28 to 39 in the hearing aid user group. That is to say, the performance of the two groups was similar, and both had few errors under this condition.

In Figure 2, which corresponds to condition RC (Total) the values of the number of right answers in the non user group ranged between 12 and 34; and in the hearing aid user group, the number of right answers ranged from 15 to 38. It was observed that under this condition, the variation in the number of right answers was higher, which shows that both groups had greater difficulty in performing the test, and that in spite of this the hearing aid user group achieved a better performance (the number of right answers ranging from approximately 15 to 38).

In Figure 3, corresponding to condition LC (Total), the values for the non user group ranged from approximately 6 to 35 right answers and in the other group, the variation in the number of right answers was approximately from 24 to 34. Under this condition it was observed that the hearing aid user group presented a better performance, due to the larger number of right answers and lower variation among these values.

Under the LNC condition (Total) the number of right answers ranged from 25 to 40 in the non user group, and from 30 to 38 in the hearing aid user group. Under this condition, both groups had a good performance. However, there was a variation in the number of right answers between the groups, with the hearing aid user group showing less variation, therefore, better performance.
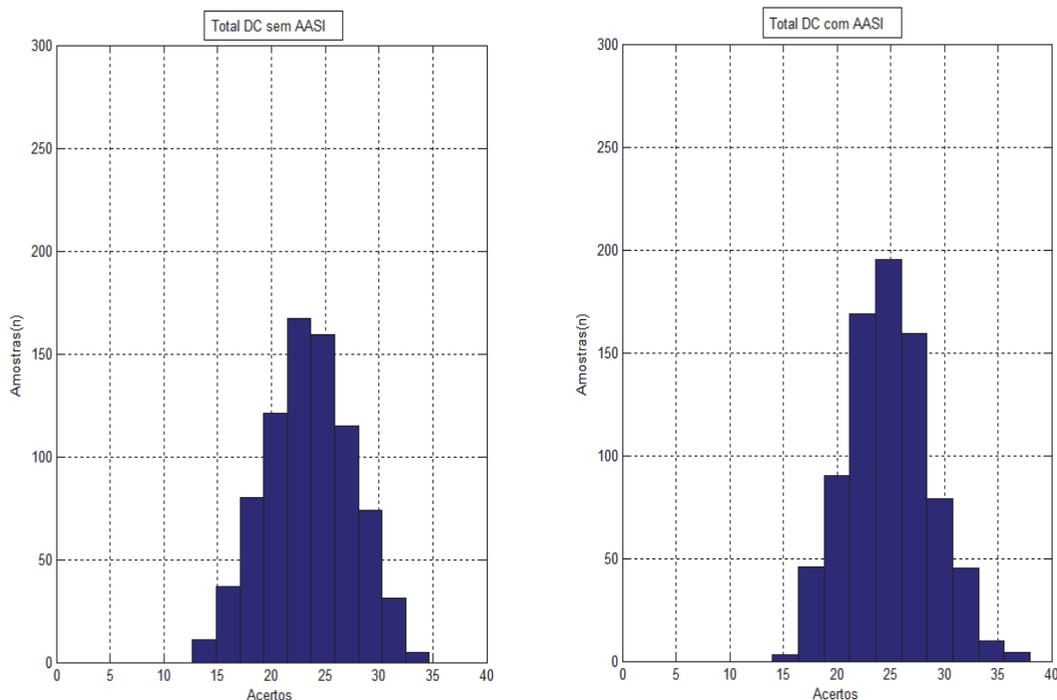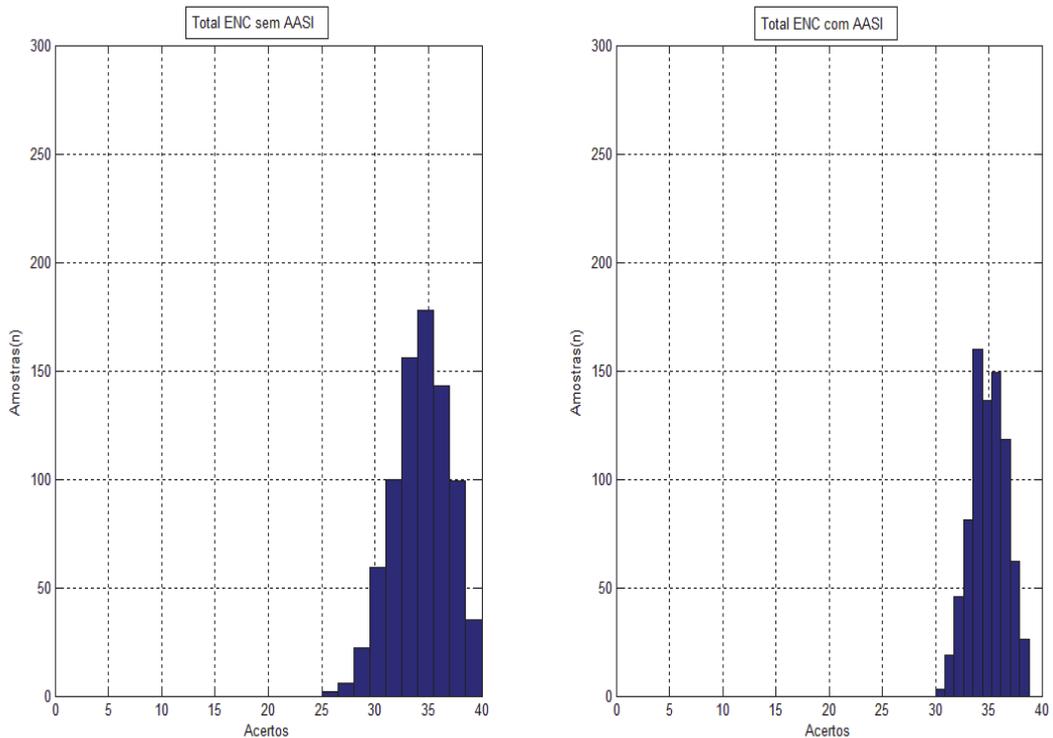

Legend: Without hearing aids = non users of individual sound amplification appliances; with hearing aids = users of individual sound amplification appliances.

Figure 2 – distribution of number of right answers under the right competitive condition – total (RC-TOTAL) of both user and non user groups, separated by columns
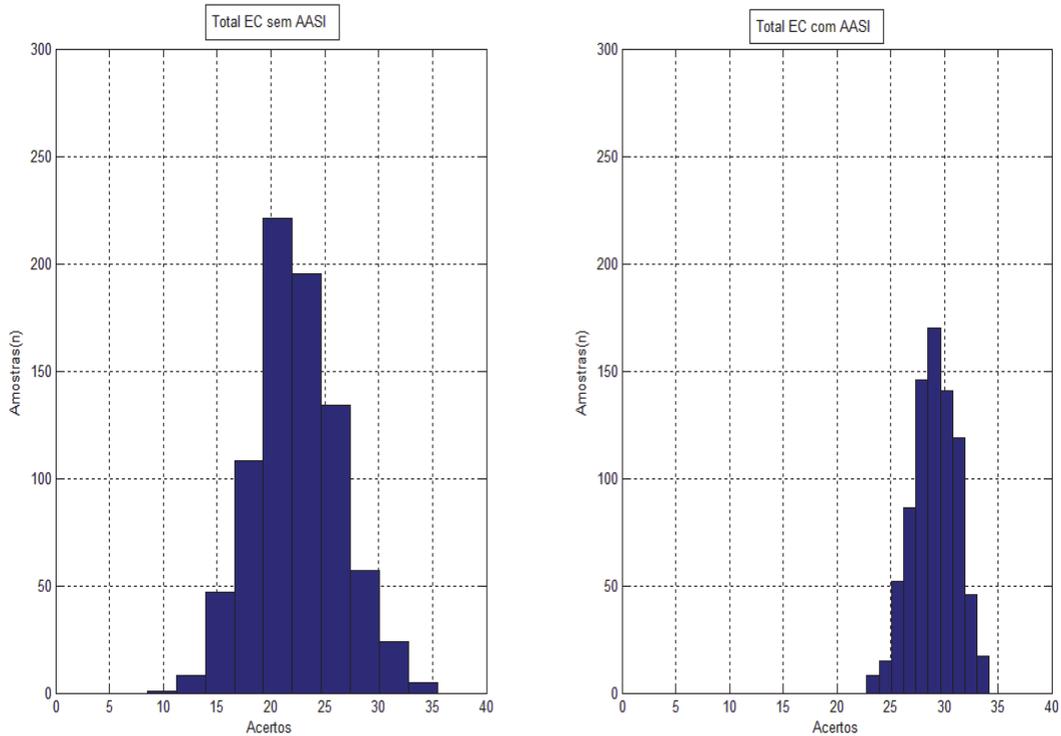
Legend: Without hearing aids = non users of individual sound amplification appliances; with hearing aids = users of individual sound amplification appliances.

Figure 3 – distribution of number of right answers under the left competitive condition – total (LC-TOTAL) of both user and non user groups, separated by columns

Legend: Without hearing aids = non users of individual sound amplification appliances; with hearing aids = users of individual sound amplification appliances.

Figure 4 – distribution of number of right answers under the left non competitive condition – total (LNC-TOTAL) of both user and non user groups, separated by columns

◼ DISCUSSION

When hearing loss in the two groups was analyzed, it was observed that the degree of loss ranged from light to moderate, and the occurrence of symmetry between the right and left ears, and the best thresholds were concentrated in the low frequencies and the worst in the high frequencies. According to the authors[1] descending sensorineural hearing loss is an aggravation of alteration in auditory processing, but not a determinant factor.

In the analysis of the SSW test, the conditions that presented the most right answers were non competitive RNC and LNC, whereas under competitive RC and LF conditions, there was higher variation in the number of right answers between the two groups, however, with a lower number of right answers. These are conditions that involve competition of speech, and are in agreement with the complaint of the elderly of not understanding speech in noisy and/or competitive environments.

The group of hearing aid users presented better performance under both RC and LF conditions. This may be related to auditory stimulation resulting from the use of hearing aids, which corroborates recent studies[14]. These authors verified that when auditory prosthesis users were compared with non users, thy presented better performance in tasks of speech discrimination and sensation of intensity, attributing this improvement to functional plasticity. Significant changes with regard to improvement in speech discrimination of hearing aid users have been observed over the course of months, and the most significant results occurred between the first and sixth month of use[15].

In the SSW test it could be observed that under the RC condition, the performance of the two groups was similar, whereas under the LC condition, the hearing aid user group showed better performance than the non user group.

Age-related changes may occur in all the structures of the central auditory nervous system. The CANS undergoing the process of aging shows reduced efficiency in processing difficult stimuli[16]. The researches mentioned by the authors point out that the differences in performance of the ears in dichotic listening tests may increase with age. The progressive age-related deterioration is directly related to the functioning of the corpus callosum, which results in a systematic decline in the efficiency of interhemispheric communication[16,17].

When mentioning the theory of dichotic listening, the author[18] affirmed that under these listening conditions the ipsilateral pathway is suppressed by the contralateral pathway that has a larger number of fibers, and therefore, as the left hemisphere is dominant, the right ear is at an advantage in these cases. Under competitive conditions, the left hear needs greater participation of the corpus callosum formation in order to be efficient, however, it is important to emphasize that in the elderly population, this process is undergoing natural deterioration due to aging, therefore the performance of LC may be inferior to that of RC, as observed in the results of the present study.

Interaural differences increase with age and may be justified by the structural and cognitive models. The two models seek to explain the advantage of the right ear and consequent disadvantage of the left ear in dichotic tests. This asymmetry occurs, partly because of a decline in cognitive abilities, and partly because of a decline in the efficiency of inter-hemispheric information transfer[19-25].

According to the literature, the structural model justifies perceptual asymmetry: the information presented in the right ear travels directly to the left hemisphere. During dichotic stimulation, the ipsilateral auditory pathways are suppressed, favoring the contralateral pathways that have a larger number of fibers. The disadvantage of the left ear results from the longer time of it takes for transmission of verbal information presented in this ear, since it has to be transported to the right hemisphere for its processing in the left hemisphere through the corpus callosum. Therefore, the left ear requires greater participation of the corpus callosum in order to be efficient in processing linguistic information. In the elderly, this central nervous system structure is undergoing natural age-related deterioration and its performance becomes less efficient, thus generating asymmetry of the ears[20,21]. The cognitive model emphasizes the importance of attention, working memory and information processing speed in dichotic listening tasks. Due to left hemispheric dominance in speech processing, the majority of persons pay better attention to stimuli heard on the right, which allows them to make predominant use of more automatic, bottom up acoustic processing of stimuli. In listening on the left (dichotic task), the stimuli are naturally suppressed by right ear stimuli. In order to meet the need for direction listening to the left, greater activation and involvement of cognitive (top-down) functions are required. As these functions deteriorate with age, asymmetry of the ears may be observed during dichotic tests applied in elderly persons[22,25-29]. These models alone are unable to justify the effect of aging on asymmetry of the ears, therefore there may be an association of both in dichotic listening situations.

In this study, the absence of auditory privation in the hearing aid user group is emphasized, due to the sound amplification and possible retardation

of generation of this system, confirmed by the high rate of right answers under competitive conditions on the right – RC.

The literature mentions that acclimatization can only occur due to the plasticity induced by the reintroduction of auditory stimulation, therefore, the use of auditory prostheses guaranteed sound stimulation and induced neurophysiological mechanisms of plasticity that perfected the functioning of the auditory system[27,28,30].

Acclimatization therefore, refers to the period that follows adaptation to sound amplifiers, when progressive improvement occurs in auditory abilities and speech recognition resulting from the new speech pathways available to users of amplification[23,30].

■ CONCLUSION

Through this study it was possible to observe that the group of persons who used hearing aids had a better performance in the SSW test when compared with the group of persons who did not use them. Non competitive conditions were those that presented less variation in right answers than the LC (left competitive) condition, which was the one that presented the best performance in the hearing aid user group when compared with the non user group.

Thus, it was concluded that the use of hearing aids contributed to improving speech recognition by means of auditory stimulation, enabled by the acclimatization that occurs months after introduction of the prostheses.

It is possible that the use of hearing aids, and therefore, the absence of auditory privation may have retarded this process of CANS (central auditory nervous system) degeneration commonly found in the elderly. Therefore, once again the results obtained in this research point out the efficacy of the use of hearing aids in improving understanding of speech in the studied population, not only by compensating peripheral hearing loss, but also by interfering in the aging process of the CANS (central auditory nervous system).

RESUMO

Objetivo: comparar o desempenho de pacientes usuários e não usuários de AASI, por meio do teste SSW. **Método**: o estudo foi realizado em 13 sujeitos com idade entre 55 e 85 anos, com perda auditiva bilateral, sendo seis usuários de prótese auditiva bilateral e sete não usuários de prótese auditiva. O teste de processamento auditivo aplicado foi o teste de reconhecimento de dissílabos em tarefa dicótica SSW. Foi realizado um tratamento estatístico feito por meio da técnica *Bootstrap* e do Teste de Hipótese Kolmogorov-Smirnov. **Resultados:** o grupo de usuários apresentou melhor desempenho nas condições estudadas do que o grupo de não usuários, principalmente nas condições competitivas. **Conclusão:** os resultados obtidos nessa pesquisa apontam para a eficácia do uso do AASI na melhora da compreensão de fala da população estudada, não somente pela compensação da perda auditiva periférica, mas também pela interferência no processo de envelhecimento do sistema nervoso auditivo central.

DESCRITORES: Percepção Auditiva; Idoso; Audição; Auxiliares de Audição

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