Original Article

Artigo Original

Auditory rehabilitation effects on the temporal ordering ability in elderly hearing aids users

Efeitos da reabilitação auditiva na habilidade de ordenação temporal em idosos usuários de próteses auditivas

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ABSTRACT

Purpose: To analyze the effects of an auditory rehabilitation program for the temporal ordering ability, of duration and pitch patterns of sounds, in elderly hearing aids users. **Methods:** Participants were 17 elderly people, with ages between 60 and 84 years, divided into Control Group (CG), which only used hearing aids, and Study Group (SG), which were submitted to an auditory rehabilitation program that included auditory counseling and training. All subjects were assessed at the beginning and at the end of the study, through the Duration Pattern Sequence and Pitch Pattern Sequence tests. The period between assessments was seven weeks. **Results:** In the Duration Pattern Sequence test, CG subjects showed mean values of accuracy in the murmured condition of 48.64 and 54.43%, for initial and final assessments, respectively; SG subjects, presented 60.39 and 76.28%. In the named condition, CG presented 51.93 and 52.43%, and SG, 63.94 and 77.44% for initial and final assessments, respectively. In the Pitch Pattern Sequence test, CG subjects showed mean values of accuracy in the murmured condition of 80.62 and 79.94%, and SG subjects, of 79.78 and 90.39%, for initial and final assessments, respectively. In the named the condition, CG presented 82.64 and 84.21%, and SG, 82.94 and 85.89%, for initial and final assessments. There was a difference only for SG subjects in the murmured and named conditions of the Duration Pattern Sequence test, in the named condition of the Pitch Pattern Sequence test, indicating higher mean values in the final assessment. **Conclusion:** The auditory rehabilitation program to elderly hearing aid users provide satisfactory improvement in recognition, temporal ordering, and naming of duration and pitch patterns of sounds.

Descritores

Auxiliares de audição
Idoso
Perda auditiva/reabilitação
Sistema único de saúde
Testes auditivos

RESUMO

Objetivo: Analisar os efeitos de um programa de reabilitação auditiva para a habilidade de ordenação temporal, dos padrões de duração e frequência dos sons, em idosos usuários de próteses auditivas. **Métodos:** O estudo foi realizado com 17 idosos, com idade entre 60 e 84 anos, distribuídos em Grupo Controle (GC), que somente fez uso das próteses auditivas, e Grupo Estudo (GE), submetido a um programa de reabilitação auditiva, que abrangeu o aconselhamento e treinamento auditivos. Todos os indivíduos foram submetidos a avaliações no momento inicial e final do estudo, por meio dos testes Padrões Sequenciais de Duração e Padrões Sequenciais de Frequência. O período entre as duas avaliações compreendeu sete semanas. **Resultados:** No teste Padrões Sequenciais de Duração, os sujeitos do GC apresentaram valores médios de acerto nas avaliações inicial e final, na condição murmurado, de 48,64 e 54,43%, e os sujeitos do GE, 60,39 e 76,28%. Na condição nomeado, o GC apresentou 51,93 e 52,43%, e o GE, 63,94 e 77,44%, nas avaliações inicial e final, respectivamente. No teste Padrões Sequenciais de Frequência, os sujeitos do GC apresentaram valores médios de acerto, na condição murmurado, de 80,62 e 79,94%, e os sujeitos do GE, 79,78 e 90,39%. Na condição nomeado, o GC apresentou 82,64 e 84,21%, e o GE, 82,94 e 85,89%, na avaliação inicial e final, respectivamente. Houve diferença apenas para os sujeitos do GE nas condições murmurado e nomeado do teste Padrões Sequenciais de Duração e nomeado do teste Padrões Sequencias de Frequência, indicando valores médios superiores na avaliação final. **Conclusão:** O programa de reabilitação auditiva a idosos usuários de próteses auditivas proporciona evolução satisfatória no reconhecimento, ordenação temporal, e nomeação dos padrões de duração e de frequência dos sons.

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INTRODUCTION

Aging can cause degenerative changes at every level of the auditory system. Although presbycusis is usually considered a cochlear phenomenon, age-related deteriorations are found in the brainstem, as well as in the cortical structures[1].

The technology of hearing aids, which are a means of rehabilitation of individuals with hearing loss because of their age, has evolved considerably in the past years, especially with the introduction of digital prostheses, which allow customized adjustments and different schedules for different environments. However, some elderly people do not present good use of amplification and they are not well satisfied with the hearing aids, preferring to not use it or to use unilateral adaptation, even when they have symmetrical bilateral hearing loss[2,3].

The lack of satisfaction of the elderly is due to the fact that hearing aids do not provide auditory skills or the understanding that are essential for communication. The prostheses are made to provide the largest possible amount of acoustical information, but alone they do not modify directly the brain or the behavior of the user[4]. In this way, an auditory training that is carried out after fitting of hearing aids, having the new amplified signal and the new processing standard, may help the user to interpret the recently introduced acoustic information and maximize the benefits of the hearing aids[5].

The central auditory processing (CAP) refers to the efficiency and effectiveness with which the central auditory system uses the auditory information. The CAP is related to the auditory mechanisms that involve the abilities of: sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal aspects of hearing (including temporal resolution, temporal masking, temporal integration, and temporal ordering), auditory performance in the presence of competitive signals, and auditory performance with degraded acoustic signals[6].

The evaluation of the CAP can help to better understand the underlying causes of some difficulties, mainly in elderly people who often report specific complaints about the understanding of the spoken language, particularly in the presence of competing stimuli. In most cases, these complaints are not consistent with the audiometric thresholds, and the ones who complain about hearing may submit inefficiency of central auditory function[7].

Among the CAP assessments, it is important to incorporate the analysis of temporal processes, considering that all the acoustic information is somehow influenced by time. The ability of temporal sequencing refers to the processing of two or more auditory stimuli in its order of occurrence within a period of time, including the perception of temporal characteristics of a sound or its changes within a specific time interval[8]. In speech perception, this ability is used to discriminate subtle clues like sound, phoneme recognition by using its distinctive features, and discrimination of similar words[9].

The areas that are involved in perception of these sequential stimuli are located in the temporal lobes of the brain, mainly in the Heschl's gyri. The recognition of the curve of the pattern occurs in the right hemisphere and the information is transferred through the corpus callosum to the left hemisphere, where the linguistic naming is associated to the sign. The ability to properly recognize, identify, and sequence auditory patterns involves many perceptual and cognitive processes, and short--term memory[10].

The most frequent complaint that elderly people have is about speech understanding, especially in noisy environments, which cannot be explained only by the presence of peripheral hearing loss[11-13]. Studies have suggested that an age-related decline in temporal auditory processing may contribute to the difficulty of speech perception[11,14-17].

In this context, the aim of this study was to analyze the effects of an auditory rehabilitation program in the ability of temporal patterns for duration and frequency of sounds in elderly hearing aid users.

METHODS

This study can be classified as quantitative, longitudinal, descriptive and experimental. This research was carried out at the Center for Selection and Fitting of Hearing Aids (NUSEAPA), of the Service of Speech, Hearing and Language Care (SAF) of the Universidade Federal de Santa Maria (UFSM), during the period between March and December 2010. The study was approved by the Research Ethics Committee of UFSM, under process number 0138.0.243.000-06.

For sample selection, we analyzed the medical records of patients who were waiting for the provision of hearing aids in NUSEAPA through the streaming Program of Provision of Hearing Aids of the Secretary of Health Assistance of the Ministry of Health, which covers the Midwest State of Rio Grande do Sul, Brazil. The subjects signed a free and informed consent form.

The elderly participants were divided into two groups: Control Group (CG), consisting of eight subjects, three female and five male, with ages between 66 and 81 years; and Study Group (SG), consisting of nine subjects, three female and six male, with ages between 60 and 84 years. There were no gender ($p=1.0$) and age ($p=0.827$) differences in the comparison between CG and SG.

The inclusion criteria were:

- to be 60 years old or more;
- to have mild to moderately severe symmetrical bilateral sensorineural hearing loss[18];
- to have acquired hearing loss in the post-lingual phase;
- to present percentage of Speech Recognition Index (SRI) equal to or over 72%;
- to be a new hearing aids user, without previous experience;
- to have indication of binaural fitting of hearing aids;
- to present complaints about speech understanding in noise;
- to have acquired a hearing aid in NUSEAPA, SAF through the streaming Program of Provision of Hearing Aids of the Secretary of Health Assistance of the Ministry of Health;
- to be committed to attend seven follow-up sessions (exclusively for subjects who were treated with the process of auditory counseling and training).

Exclusion criteria were:

- to present alterations and deficiencies that could impair the

performance in the procedures (neurological, psychological, mental or cognitive) and/or evident speech disorders;
- to present music education;
- to present results not compatible with the normality on the Mini-Mental State Examination – MMSE, according to the years of education[19]. This is a triage used to identify possible alterations in specific cognitive functions, such as temporal and spatial orientation, memory, attention, language, and visual constructive capacity, extensively used in hospitals and clinics[20].

As part of this research, a study of implementation feasibility was conducted, especially considering the need that subjects actually attended the Service for nine consecutive weeks (seven for the hearing rehabilitation sessions and two for initial and final assessments); hence, patients who lived in the city of Santa Maria were put, preferably, in the Study Group (SG). Patients from nearby counties composed the Control Group (CG). However, auditory rehabilitation was also provided for subjects in the CG, though it was held after the final assessment.

Thus, the study had the contribution of two distinct groups, CG and SG, who started the research procedures after partial discharge from the Program of Provision of Hearing Aids; discharge happens when the patient do not present complaints anymore and return to Service by his own initiative. All subjects in the study were considered non-active elderly people, who did not attend third age groups and, as for physical activities or others, when taken, were quite irregular and limited.

The CG used the hearing aids for seven weeks, without any advice or auditory training. On the other hand, the SG was submitted to an auditory rehabilitation program structured in seven 15-minute weekly sessions, with the presence and supervision of the responsible researcher.

All subjects underwent initial and final assessments through the Duration Pattern Sequence (DPS) and Pitch Pattern Sequence (PPS) tests, with an interval of seven weeks between assessments. The SG was assessed before and after the hearing rehabilitation program, and the CG, which was not subjected to auditory training, was also evaluated within the same interval of time between initial and final assessments.

The DPS test is the presentation of sequences of three 1 kHz tones, presented in monotic mode and with an intensity of 50 dB SL, which differentiate into two lengths: 500 ms (Long – L) and 250 ms (Short – S). Sixty sequences are presented in each ear, and 30 must be answered in the form of murmur and 30 in the form of naming. Sequences vary as LLS, LSL, LSS, SSL, SLS and SLL. The test evaluates the recognition, temporal ordering and naming patterns of duration patterns.

The PPS test is the presentation of sequences of three tones with duration of 500 ms, presented in monotic mode and with an intensity of 50 dB SL, which differ in frequency: 1430 Hz (High – H) and 880 Hz (Low – L). Again, 60 sequences are presented in each ear, and 30 must be answered in the form of murmur and 30 in the form of naming. Sequences vary as HHL, HLL, HLH, LHH, LHL e LLH. The test evaluates the recognition, temporal ordering and naming patterns of frequency.

To carry out the assessments, the equipment was properly calibrated using the pure tone available on the first track of the Compact Disc (CD) used, and the VU meter was set on 0 (zero). Stimuli were presented, in average, at 30 dB SL, although it is indicated that the assessments are carried out at 50 dB SL. This was necessary because it was considered the acoustic comfort referred by the subject in each evaluation. It is important to mention that it was used the same intensity in both tests, at initial and final assessments.

Measurements were obtained in an acoustically treated booth, using a two-channel digital Fonix® audiometer, FA-12 model, type I, and TDH 39-P Telephonics® earphones. Stimuli were presented through a Compact Disc Player Digital Toshiba®, 4149 model, coupled to the audiometer. For the application of the DPS and PPS tests, it was used a record of the CD AUDITEC[21].

The auditory rehabilitation program included counseling to participants and auditory training itself. With regard to counseling for hearing loss, the objectives of the tasks and its application in daily communication situations were discussed at each meeting. Besides, it also provided communication strategies and reinforced the practical aspects of hearing aid fitting that were considered in this study. Items on practical issues in hearing aid fitting that were considered in this study were related to: the placement and removal of the ear hearing aids, use of kits (including ear mold or thin tube and olive, in cases of adaptation of the open fit type) batteries, volume control and/or program button; cleaning the ear molds or thin tube and olive, and use the dryer and telephone with hearing aids.

The training itself was conducted through Musical and Auditory Training (M and AT) (TAM)[22], consisting of seven Digital Video Discs (DVDs), which include the auditory temporal processing skills (resolution and temporal ordering) and selective attention through exercises of auditory training of figure-background aspects of instrumental sounds, frequency and duration of sounds, directional hearing, rhythm and auditory closure. In addition to the mentioned listening skills, in each year there is an involvement of attention and working memory, and also the interaction between auditory and visual systems for the implementation of activities presented on the DVD media. Results of auditory training were recorded in specific protocols suggested for each DVD and that are together with the material[22].

The presentation of the referred material was performed in a silent room, through a computer with a DVD player, in which were coupled two speakers with subwoofer Mini 2.1, Clone® brand, 11128 model and 5W power (RMS). The boxes were placed one meter away from the patient, one on the right side and the other on the left side of the computer, resulting in a 45° azimuth position in relation to the subject.

In addition, individuals were encouraged to report weekly differences, perceived difficulties and facilities during auditory training with the use of hearing aids. In contrast, it was intended to strengthen the positive performance of the patient, challenging him/her to overcome his/her difficulties in the next session. This procedure had the aim to optimize speech understanding, maintaining the quality of dialogue and developing confidence of the user to interact in society.

Before starting the auditory training sessions, hearing aids were checked for operation and thus had the audibility of sounds guaranteed. New batteries were used in all sessions.

Thus, data collection lasted nine weeks for each individual participant, not considering absences and holidays. The first and last sessions were booked for initial and final assessments, respectively. The other sessions corresponded to the rehabilitation program.

The timing of the research was structured as it is described:

- Session 1: initial assessment;
- Session 2: verification and guidance about the aspects of placement and removal of hearing aids (including ear mold or thin tube and olive, in cases of open fit), and use of kits, and application of the DVD Figure-Background for instrumental sounds;
- Session 3: verification and guidance on issues related to the volume control and/or program button and the application of the DVD Figure-Background for sequential sounds;
- Session 4: verification and guidance on issues related to hearing aid battery and application of the DVD Sound Duration;
- Session 5: verification and guidance on issues related to the cleaning of ear molds or thin tube and olive, and application of the DVD Sound Frequency;
- Session 6: verification and guidance on issues related to telephone use with hearing aids (adjustments and exploring resources available for this purpose) and application of the DVD Rhythm – Temporal Structuring;
- Session 7: checking and guidance on issues related to the use of the dehumidifier and application of the DVD Auditory Closure;
- Session 8: This session was designed to solve the doubts about the practicalities, re-orient the elderly people regarding items in which it was observed a necessity, and the application of the DVD Directed Listening;
- Session 9: final assessment.

If the patient had a complaint or particular difficulty in any of the sessions, this aspect was valued and treated. So, the schedule of the hearing rehabilitation program was modified according to the items of practical issues.

CG and SG subjects were characterized by gender, age, education, time and degree of hearing loss, brand, model and technology of hearing aids (Charts 1 and 2).

To analyze the variables' behavior, the Liliefors test was applied. For variables with normal distribution, parametric tests were used: Student's t test for two dependent samples (when analyzing the performance of each group at initial and final assessments) and Student's t test for independent samples (when analyzing the performance of both groups at each moment of the evaluation, initial and final).

For variables that did not follow normal distribution, nonparametric tests were used: Wilcoxon test and Mann Whitney U test. To analyze the composition of the groups regarding gender, it was used the Fisher's Exact test. It was adopted a significance level of 5% ($p \leq 0.05$).

Initially, the results obtained in each ear in initial and final assessments were considered. However, as there were no differences regarding this variable for any moment of evaluation, the results obtained in both ears were combined and the analysis was performed according to the new composition of each group.

RESULTS

The performance of the SG presented an improvement in the DPS test for pattern of response, murmured and named, when considering the results obtained before and after the auditory training. The same was observed in the CG (Table 1).

In comparison to the performance of both groups in the PPS test, before and after the auditory training, it was observed that the SG showed an improvement for the named task, while the CG showed no improvement for any pattern of response (Table 2).

Considering the two moments of evaluation in the DPS test, it was observed that the performances of subjects in both groups were similar in the initial assessment, and different in the final assessment (Table 3). The SG presented an improvement, which

Chart 1. General characteristics of the Control Group subjects

Subject (n = 8)	Gender	Age	Schooling	Time of HL (years)	HL level	Brand/model/tecnology* of the hearing aids
S1	M	77	Complet elementary school	Not known	RE: mild LE: moderate	Siemens/Music Pro BTE/B
S2	M	66	Incomplet elementary school	±10	BE: moderate	Starkey/Rhapsody 200 BTE/B
S3	M	80	Incomplet elementary school	±20	RE: moderate LE: mild	Starkey/ Rhapsody 200 ITC/B
S4	F	67	Incomplet elementary school	±10	BE: moderate severe	Siemens/Music Pro BTE/B
S5	F	79	Incomplet elementary school	±6	BE: moderate	Siemens/Music Pro BTE/B
S6	M	66	Incomplet elementary school	±3	BE: moderate	GnResound/RP 70 BTE/B
S7	F	71	Incomplet elementary school	±8	BE: moderate severe	Starkey/Rhapsody 400 BTE/B
S8	M	81	Incomplet elementary school	±20	RE: moderate LE: moderate severe	Starkey/Rhapsody 400 BTE/B

Note: F = female; M = male; HL = hearing hoss; RE = right ear; LE = left ear; BE = both ears; BTE = behind the ear (retroauricular); ITC = intracanal; Tecnologia* = classification according to the unified health system (A, B and C)

shows better performance of these subjects on the discrimination of duration patterns of sounds after the auditory training.

In the test PPS, in the murmured task, it was found that the performance of subjects in both groups was similar in the initial assessment, and different in the final assessment (when the SG presented a more satisfactory improvement) (Table 4).

Chart 2. General characteristics of the Study Group subjects

Subject (n = 9)	Gender	Age	Schooling	Time of HL (anos)	HL level	Brand/model/tecnology* of the hearing aids
S1	M	79	Incomplet high school	±10	RE: moderate severe LE: moderate	Starkey/Rhapsody 200 BTE/B
S2	M	77	Complet elementary school	Not known	RE: moderate severe LE: moderate	Siemens/Music Pro BTE/B
S3	M	84	Incomplet elementary school	±1	RE: mild LE: normal with injury after 2 kHz	Interton/Evo BigNano VC BTE/C
S4	F	60	incomplet high school	±5	BE: moderate	Siemens/Music Pro ITC/B
S5	F	71	Incomplet elementary school	±6	BE: moderate	Starkey/Rhapsody 200 BTE/B
S6	M	64	Incomplet elementary school	±5	RE: mild LE: moderate	Starkey/Rhapsody 200 BTE/B
S7	F	74	Incomplet elementary school	±7	BE: mild	Starkey/Rhapsody 400 BTE/B
S8	M	80	Incomplet elementary school	±3	BE: mild	Oticon/Go Pro BTE/B
S9	M	64	Incomplet elementary school	±4	BE: mild	Oticon/Go Pro BTE/B

Note: F = female; M = male; HL = hearing hoss; RE = right ear; LE = left ear; BE = both ears; BTE = behind the ear (retroauricular); ITC = intracanal; Tecnologia* = classification according to the unified health system (A, B and C)

Table 1. Performance of the Control Group and the Study Group in the Sequential Patterns of Duration task during the initial and final assessments

Test	Group	Assessment	n	Min	Max	Mean	Median	SD	p-value
DPS MURM (% tasks)	CG	Ass 1	14	7	93	48.64	53.5	24.50	0.275*
		Ass 2	14	0	100	54.43	47	29.43	
	SG	Ass 1	18	13	100	60.39	50	32.40	0.03**#
		Ass 2	18	0	100	76.28	100	33.95	
DPS NOM (% tasks)	CG	Ass 1	14	0	100	51.93	60	31.85	0.906*
		Ass 2	14	0	100	52.43	56.5	33.25	
	SG	Ass 1	18	13	100	63.94	63	34.32	0.018**#
		Ass 2	18	7	100	77.44	100	33.80	

* Student's t test for two dependent samples or ** Wilcoxon Test, according to the distribution of the variables

Significant values (p≤0.05)

Note: Ass 1 = initial assessment; Ass 2 = final assessment; CG = control group; SG = study group; DPS MURM = Test of Sequential Patterns of Duration for the answer of the murmured kind; DPS NOM = Test of Sequential Patterns of Duration for the answer of the named kind; SD = standard deviation

Table 2. Performance of the Control Group and the Study Group in the test of Sequential Patterns of Frequency during the initial and final assessments

Test	Group	Assessment	n	Min	Max	Mean	Median	SD	p-value
DPS MURM (% tasks)	CG	Ass 1	16	20	100	80.62	88.5	25.25	0.783
		Ass 2	16	27	100	79.94	80	21.26	
	SG	Ass 1	18	7	100	79.78	100	33.21	0.092
		Ass 2	18	27	100	90.39	100	21.78	
DPS NOM (% tasks)	CG	Ass 1	14	33	100	82.64	87	19.81	0.400
		Ass 2	14	47	100	84.21	93	19.80	
	SG	Ass 1	18	0	100	82.94	93	31.20	0.049*
		Ass 2	18	0	100	85.89	100	32.17	

* Significant values (p≤0.05) – Wilcoxon test

Note: Ass 1 = initial assessment; Ass 2 = final assessment; CG = control group; SG = study group; DPS MURM = Test of Sequential Patterns of Duration for the answer of the murmured kind; DPS NOM = Test of Sequential Patterns of Duration for the answer of the named kind; SD = standard deviation

Table 3. Performance of the Control Group and the Study Group in the test of Sequential Patterns of Duration during the initial and final assessments

Values	DPS MURM Ass 1		DPS MURM Ass 2		DPS NOM Ass 1		DPS NOM Ass 2	
	CG	SG	CG	SG	CG	SG	CG	SG
Mean	48.64	60.39	54.43	76.28	51.93	63.94	52.43	77.44
Median	53.5	50	47	100	60	63	56.5	100
SD	24.50	32.40	29.43	33.95	31.85	34.31	33.25	33.80
p-value	0.268*		0.034**#		0.318*		0.019**#	

* Student's t test for two independent samples or ** Mann-Whitney U test, according to the distribution of the variables
# Significant values (p≤0.05)
Values are expressed in tasks percentage
Note: Ass 1 = initial assessment; Ass 2 = final assessment; CG = control group; SG = study group; DPS MURM = Test of Sequential Patterns of Duration for the answer of the murmured kind; DPS NOM = Test of Sequential Patterns of Duration for the answer of the named kind; SD = standard deviation

Table 4. Performance of the Control Group and the Study Group in the test of Sequential Patterns of Frequency during the initial and final assessments

Values	PPS MURM Ass 1		PPS MURM Ass 2		PPS NOM Ass 1		PPS NOM Ass 2	
	CG	SG	CG	SG	CG	SG	CG	SG
Mean	80.62	79.78	79.94	90.39	82.64	82.94	84.21	85.89
Median	88.5	100	80	100	87	93	93	100
SD	25.25	33.21	21.26	21.78	19.81	31.20	19.80	32.17
p-value	0.512		0.019*		0.346		0.158	

* Significant values (p≤0.05) – Mann-Whitney U test
Values are expressed in tasks percentage
Note: Ass 1 = initial assessment; Ass 2 = final assessment; CG = control group; SG = study group; DPS MURM = Test of Sequential Patterns of Duration for the answer of the murmured kind; DPS NOM = Test of Sequential Patterns of Duration for the answer of the named kind; PPS MURM = Test of Sequential Patterns of Frequency for the answer of the murmured kind; PPS NOM = Test of Sequential Patterns of Frequency for the answer of the named kind; SD = standard deviation

DISCUSSION

The performance of both groups showed no difference regarding the variable ear in any of the assessments that were carried out in each moment of the evaluation, initial and final. This finding agrees with other studies[7,23-25] that also found no influence of the variable ear for the results in the DPS and PPS tests.

Considering the results of other studies, including those carried out with elderly people without hearing loss, it is observed that the SG had a superior performance in the final assessment for both patterns of response, murmured and named, of the DPS test. Another study[26] evaluated 21 elderly people, 13 with normal hearing or hearing loss restricted to isolate frequencies, and eight with sensorineural hearing loss ranging from mild to moderately severe. The authors obtained a mean score of 64.62% and 66.13% for the murmured condition, and 50.77% and 43.75% for the named condition, respectively. In relation to the present study, subjects in the CG presented superior performance in the final assessment only for the named condition in the DPS test. Even so, this performance was not as favorable as the one presented by the SG, which showed quite superior results in the final evaluation.

In the named task of the DPS test, only the SG presented a superior performance in the final assessment when compared to another study[25]. It is important to mention that 25 elderly people with normal hearing and no history of central auditory impairments were evaluated, and the results were considered lower when compared to the SG elderly subjects with hearing loss after rehabilitation.

The SG showed results similar to those of elderly people with normal hearing, mild hearing loss and moderate hearing loss, obtained in another study[27], for the named condition of the DPS test in the initial assessment. However, the most satisfactory results were again observed in the elderly people with hearing loss after auditory rehabilitation, even when compared to another study[27], the ones who had normal hearing.

In the mentioned study[27], 65 elderly patients were evaluated, divided into three groups according to the audiometric results: normal hearing (up to 25 dB) to the average of 0.5/1/2 and 3/4/6 kHz; normal hearing or mild hearing loss (40 dB) to the average of 0.5/1/2 kHz, and mild hearing loss (26-40 dB) to the average of 3/4/6 kHz; and normal hearing or mild hearing loss light (40 dB) to the average of 0.5/1/2 kHz, and moderate hearing loss (41-55 dB) to the average of 3/4/6 kHz. The mean score obtained for the whole sample was 63.1%, and for the three groups was 57.5%, 69% and 63.9%, respectively[27].

The same study[27], by finding similar performance in older adults with and without hearing loss in the named task in the DPS test[25], suggests that the results are suggestive of the aging process and not because of the peripheral hearing loss. In this context, there is incompatibility of the results of different studies that evaluated elderly people with normal hearing[25,27]. This reinforces the hypothesis that other factors associated with aging, such as attention, memory, language skills and education,

are related to the results, since it was already verified that the hearing loss did not influence the responses obtained in the DPS test[26,28].

Although both groups did not show results within normal standards for the DPS test, it was observed there was modification in the performance of the SG, with improvement in the final assessment for the patterns of response of the test, both murmured and named. On the other hand, the SG, especially for the named condition, kept the performance very similar to the initial assessment. Possibly, this finding is related to the auditory rehabilitation that was not carried out, since both groups have adapted and used hearing aids during the same interval of time between assessments. The intervention was the differential aspect between the groups.

The results of the PPS test obtained by the CG and SG were compared to those of another study[26], which evaluated 21 elderly people, 13 with normal hearing or hearing loss restricted to isolated frequencies, and eight with sensorineural hearing loss ranging from mild to moderately severe. The previous research had a mean score of 69.23% and 83.75% for the murmured condition, and 39.23% and 57.50% for the named condition, respectively. It was observed that, compared to subjects without hearing loss in the initial assessment, both the CG and the SG had higher number of correct answers for the named and murmured conditions. However, when compared to those with hearing loss in this study[26], only the SG had higher mean in the final assessment for the murmured condition.

Considering the results for the murmured task in the PPS test, it was observed that the mean of correct answers for the SG were superior at the final assessment when compared to the data that obtained in another study[7], from the evaluation of 40 elderly people who reported to have good hearing. The mentioned research had a mean score for the named and murmured condition, respectively, of 86.5% and 66.8% in the right ear, and of 88.0% and 67.9% in the left ear. In addition, it was observed that both groups, CG and SG, had higher mean score classified as superior for the PPS test at the initial assessment when compared to the other study[24], which found 76 to 100% of correct answers in the murmured and named conditions after the evaluation of 80 young adults without any evidence of auditory alterations. The results obtained in the present study are also higher than those of another study[25], which found a mean percentage score of 49.2% in elderly individuals with normal hearing for the named task.

This variability of results considers the hypothesis of other authors[26] that mention that peripheral hearing loss is probably not determinative of the ability of temporal ordering, but aging and other associated factors. To properly perform the ability of sequencing processing time it is necessary to involve other functions.

Another study[29] also considers that aging may be associated with difficulties in performing the temporal processing of sounds. In order to assess the impact of a program of auditory training in elderly patients with healthy aging and normal hearing sensitivity and/or mild sensorineural hearing loss, the authors found that all participants showed improvement in the PPS scores. However, despite this improvement, 50% of the sample (five subjects) had results outside the normal standards[29].

Considering the performance of subjects in the DPS and PPS tests for the patterns of response, murmured and named, it was verified that the SG and CG showed better results for the discrimination of frequency patterns in relation to the patterns of duration. This finding is consistent with the results reported by other studies[24,26]. Such difference is due to the fact that the distinction of duration is an activity that requires more cortical functions in relation to the distinction of frequency, which occurs primarily due to the tonotopic organization of the cochlea. The frequency distinction is repeated along the auditory pathway, while the difference in duration involves the learning of short and long sound concepts starting at the brain stem.

Thus, the processing of rapid changes of duration is more specialized and mediated by the left hemisphere, while the variation in frequency is mediated by the right hemisphere. Another hypothesis mentions the involvement of the cerebellum in the identification of the pattern of duration[24]. In other studies[23,25,29], the results were different, with more correct answers for the DPS than for the PPS test, which may possibly be explained by the use of other materials/recordings during the evaluation.

CONCLUSION

The auditory rehabilitation program for elderly users of hearing aids provides satisfactory improvement in the abilities of recognition, temporal ordering, and naming of the patterns of duration and frequency of sounds.

All auditory information is somehow influenced by time, and difficulties in the perception of rapid changes in the acoustic signal can affect the perception of phonemes and broader aspects that occur in speech recognition. Therefore, the improvement observed in the temporal ability of sequencing of sounds, in elderly patients submitted to auditory rehabilitation, might contribute to a better performance in speech recognition.

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