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Investigation on the influence of the use of individual sound amplification apparatus on the temporal resolution ability of a group of elderly people

Investigação sobre a influência do uso de aparelho de amplificação sonora individual na habilidade de resolução temporal de um grupo de idosos

Investigación sobre una influencia del uso de la amplificación sonora individual en la habilidad de resolución temporal de un grupo de adultos mayores

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Abstract

Introduction: The temporal resolution auditory ability is characterized by the perception of silence between sounds presented as a function of time. Older normal listeners and users of individual sound amplification apparatus (AASI) need longer time intervals than normal young listeners to realize the silence interval between sounds. **Objective:** To investigate the influence of the use of individual sound amplification equipment on the temporal resolution ability of a group of elderly individuals. **Method:** The sample consisted of 40 elderly patients with mild, moderate and severe bilateral neurosensory hearing loss who received their hearing aid pair through the hearing health program. The mini mental state examination (MMSE), the RGDT test and the International Questionnaire for the Evaluation of

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Authors' contributions:
ACAC – Conducted the literature survey and data collection and wrote the discussion.
TMM-S – Guided the study, made necessary corrections and assisted in writing the manuscript.

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Individual Sound Amplification Apparatus (IQ-AASI) were applied. The data were collected with 15 and 90 days of use of the hearing aid. **Results:** Comparing the results of the RGDT test before and after the use of AASI, it was observed an improvement in the performance of the elderly. However, the variables: gender, age, cognitive performance and satisfaction of the use of HAI were not statistically significant for the improvement in the results of the RGDT test. **Conclusion:** The use of hearing aids in the elderly was efficient by itself in improving the performance of temporal resolution hearing ability.

Keywords: Hearing; Hearing Loss; Seniors; Auditory perception**.**

Resumo

Introdução: A habilidade auditiva de resolução temporal é caracterizada pela percepção de silêncio entre sons apresentados em função do tempo. Os idosos ouvintes normais e usuários de aparelho de amplificação sonora individual (AASI) necessitam de intervalos de tempo maior que jovens ouvintes normais para perceber o intervalo de silêncio entre os sons. **Objetivo:** Investigar a influência do uso de aparelho de amplificação sonora individual na habilidade de resolução temporal de um grupo de idosos. **Método:** A amostra foi composta por 40 idosos portadores de perda auditiva neurossensorial, simétrica de grau leve, moderado e severo bilateralmente que receberam seu par de AASI por meio do programa de saúde auditiva. Foram aplicados os testes do mini exame do estado mental (MMSE), teste de detecção de intervalo de silêncio aleatório (RGDT) e questionário Internacional de Avaliação dos Aparelhos de Amplificação Sonora Individual (QI-AASI). Os dados foram coletados com 15 e 90 dias de uso do AASI. **Resultados:** Comparando os resultados do teste RGDT antes e depois do uso de AASI observou-se melhora no desempenho dos idosos. No entanto, as variáveis: sexo, idade, desempenho cognitivo e satisfação do uso de AASI não foram estatisticamente significantes para a melhora nos resultados do teste RGDT. **Conclusão:** O uso de AASI em idosos, por si só foi eficiente na melhora do desempenho da habilidade auditiva de resolução temporal.

Palavras-chave: Audição; Perda Auditiva; Idosos; Percepção auditiva.

Resumen

Introducción: La habilidad auditiva de resolución temporal se caracteriza por la percepción de silencio entre sonidos presentados en función del tiempo. Los adultos mayores oyentes normales y usuarios de aparatos de amplificación sonora individual (AASI) necesitan intervalos de tiempo mayor que los jóvenes oyentes normales para percibir el intervalo de silencio entre los sonidos. **Objetivo:** Investigar la influencia del uso de aparato de amplificación sonora individual en la habilidad de resolución temporal de un grupo de adultos mayores. **Método:** La muestra fue compuesta por 40 adultos mayores portadores de pérdida auditiva neurosensorial, simétrica de grado leve, moderado y severo bilateralmente que recibieron su par de AASI por medio del programa de salud auditiva. Se aplicaron las pruebas del mini examen de estado mental (MMSE), prueba de detección de intervalo de silencio aleatorio (RGDT) y Cuestionario Internacional de Evaluación de los Aparatos de Amplificación de Sonido Individual (QI-AASI). Los datos fueron recolectados con 15 y 90 días de uso del AASI. **Resultados:** Comparando los resultados de la prueba RGDT antes y después del uso de AASI se observó una mejora en el desempeño de los adultos mayores. Sin embargo, las variables: sexo, edad, desempeño cognitivo y satisfacción del uso de AASI no fueron estadísticamente significantes para la mejora en los resultados de la prueba RGDT. **Conclusión:** El uso de AASI en adultos mayores, por sí solo, fue eficiente en la mejora del desempeño de la capacidad auditiva de resolución temporal.

Palabras clave: Audición; Pérdida auditiva; Adultos Mayores; Percepción auditiva.

Introduction

Communication is fundamental to interactions among human beings, especially verbal interactions, as it is through language that humans share knowledge, feelings and thoughts. Just as a person's body ages over time, so does their inner self. In September 2010, the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE) announced that the life expectancy of Brazilians increased almost three years between 1999 and 2009 and that Brazilians are expected to live approximately 73.1 years. This increased longevity is explained by the search for a better quality of life and advances in medicine, and it has stimulated new research seeking to diminish the effects of aging[1, 2].

The aging of the auditory system is known as presbycusis, a hearing loss that first affects high frequencies and then low frequencies, generating a progressive and bilateral sensorineural loss. This deficiency is due to degenerative and physiological changes in the auditory system[3]. Regardless of the degree, hearing loss can generate several sound perception impairments and speech alterations, hindering the person's ability to communicate, thus resulting in secondary difficulties that involve social isolation, cognitive and emotional aspects[3]. The ability to "listen" involves both attention and intent; it is part of complex tasks and activities that require effort to achieve the listener's goals[4]. Listening is a multi-stage process that goes from identification, discrimination and recognition to the highest level—comprehension.

The comprehension stage occurs through a one-way pathway, as it depends on individual experiences that encompass both peripheral hearing and more complex cognitive functions[5]. However, communication differs from comprehension, as communication is a bidirectional exchange of information; that is, it shows communicative intent between people, meaning that both comprehension and communication involve hearing, auditory information processing and cognitive skills[6,7].

"Depending on the disability type and degree, medical treatment, whether pharmacological or surgical, may not be appropriate. In such cases, the patient is instructed to 'test' the individual sound amplification apparatus (ISAA)." This is where the hearing rehabilitation process begins. The benefits of the ISAA are not always universal. Factors such as a lack of user guidance, lack of counseling, generation of false expectations, patient neuropsychological aspects and device limitations can result in the apparatus not being used. The program of adaptation to hearing aids includes guiding the patient in their use, what to expect from the new device, how to handle it and motivating the patient to use the apparatus continuously, among other information, and if possible, using strategies to optimize the device's benefits[8,9]. The application of self-assessment questionnaires helps to identify the major obstacles to the use of ISAAs to improve the programming of these devices to facilitate acclimatization and, consequently, to provide real benefits to users and improve their quality of life[10,11,12].

It is common for this population to complain that they can "hear but not understand", especially when the speed of speech of whom they are talking with is relatively fast. This fact may be explained by the altered auditory processing of sound.

Auditory temporal resolution ability is characterized by the perception of silence between sounds, presented as a function of time. The integrity of this ability is the key point in differentiating listening from hearing. It is necessary to "detect" the smaller acoustic aspects of sound to comprehend continuous speech and each isolated segment to consequently obtain a complete understanding of the message heard[13].

One test widely used in studies assessing this auditory ability is the Random Gap Detection Test (RGDT), which shows to what extent changes in auditory temporal resolution may be related to deficits in phonological processing, auditory discrimination, receptive language and reading. This test was used in this study.

To resolve the complaint mentioned, several studies have sought to find strategies to minimize this situation. The key factor for patient improvement is neural plasticity, which is present in all patients, and allows brain reorganization when exposed to stimulation[1,2,3].

Studies have proposed strategies to minimize complaints of difficulties in communication among elderly and young patients with some changes in auditory ability[2, 3].

In light of the above, the objective of this study was to evaluate whether the use of ISAA provides benefits to the elderly based on the possible reorganization of the auditory nervous system and to identify whether age, sex, cognitive performance

and satisfaction with the ISAA are determinant of auditory temporal resolution performance in this population.

Method

This was a quantitative, exploratory, prospective and descriptive study with elderly individuals who received an ISAA from the granting program of DERDIC, a non-profit institution managed by the São Paulo Foundation. Research project no. 416/2010 was approved by the Research Ethics Committee of the Pontifical Catholic University of São Paulo (PUC/SP).

The inclusion criteria were the following: age older than 60 years; having mild, moderate or moderately severe sensorineural hearing loss and being able to walk upright; having performed bilateral fitting of an ISAA through the auditory health program between August 2010 and July 2011; having signed an informed consent form before the start of the study; and being present at the two evaluation times of temporal resolution ability, at 15 and 90 days after fitting the ISAAs.

Participants who presented neurological or psychiatric alterations that prevented them from collaborating or understanding the procedures used in the study and who had severe sensorineural hearing loss were excluded. Based on these criteria, 91 individuals agreed to participate in the study.

This population underwent the following procedures: otoscopy; cognitive assessment through the Mini Mental State Examination (MMSE)[14]; self-evaluation of hearing aid benefit - International Outcome Inventory for hearing aids (IOI-HA), which was dubbed International Questionnaire - Individual Sound Amplification Apparatus (QI-ISAA)[15]; and evaluation of auditory perception of temporal resolution through the Random Gap Detection Test (RGDT)[16], developed by Keith (2000). This test was applied without the use of ISAAs and at two different times: (a) 15 days after ISAA fitting and (b) three months after ISAA fitting. According to the literature, three months is the expected period for the user to adapt to the individual sound amplifier[17].

Data were analyzed using descriptive and inferential analyses. In the inferential analysis, the following were applied: correlation analysis between pairs of variables. Pearson's linear correlation coefficient was calculated, and the hypothesis that there is no linear correlation between the variables was tested using the Mann-Whitney test for comparison of medians of two groups (females and males) in which the observations were independent and the Kruskal-Wallis test for comparison of medians of three groups (GI, GII and GIII) in which the observations were independent. The level of significance adopted was 5%. The assumptions for the application of the tests were evaluated via the construction of normal probability plots and tests of equality of variances.

To identify whether cognitive performance affected the difference between RGDT scores, we categorized the scores of the MMSE test into the following categories: up to 15 points, from 16 to 22 points and greater than 22 points. We named each category GI, GII and GIII, respectively.

Results

Of the 91 patients who agreed to participate in the study, only 55 returned 15 days after beginning ISAA use and participated in the procedures; at 90 days, 15 patients were absent. Of these individuals, two explained their absence, and when contact was made with the remaining 13 missing individuals, they claimed to be well acclimatized to the ISAA and did not want to return. Therefore, the sample was composed of 40 individuals (24 women and 16 men).

During the first fitting of the ISAA, all patients underwent evaluations of functional gain and word lists with and without the ISAA to assess whether they benefited from the ISAA models tested, using the same technology (category B) for all individuals.

Tables 1 and 2 and Figures 1, 2 and 3 show the results of the descriptive analyses of the mean, median, mode and standard deviation values of the variables age, MMSE score, IQ-ISAA, RGDT before (RGDTB), RGDT after (RGDTA) and the difference in RGDTA and RGDTD values.

The mean and median of the variable differences between RGDT results before and after the use of the ISAA were positive and well above zero, indicating that the mean and median RGDTA were much higher than the mean and median RGDTD.

Table 1. Means, medians, modes and standard deviations of the variables age, MMSE and QI-AASI; values in ms.

Variable	N	Mean	Median	Mode	Standard Deviation
Age (years)	40	74.17	73.00	72.00	7.81
MMSE	40	23.05	25.00	25.00	5.34 ms
QI-AASI	40	27.63	28.00	30.00	3.17

Legend: MMSE; QI-AASI

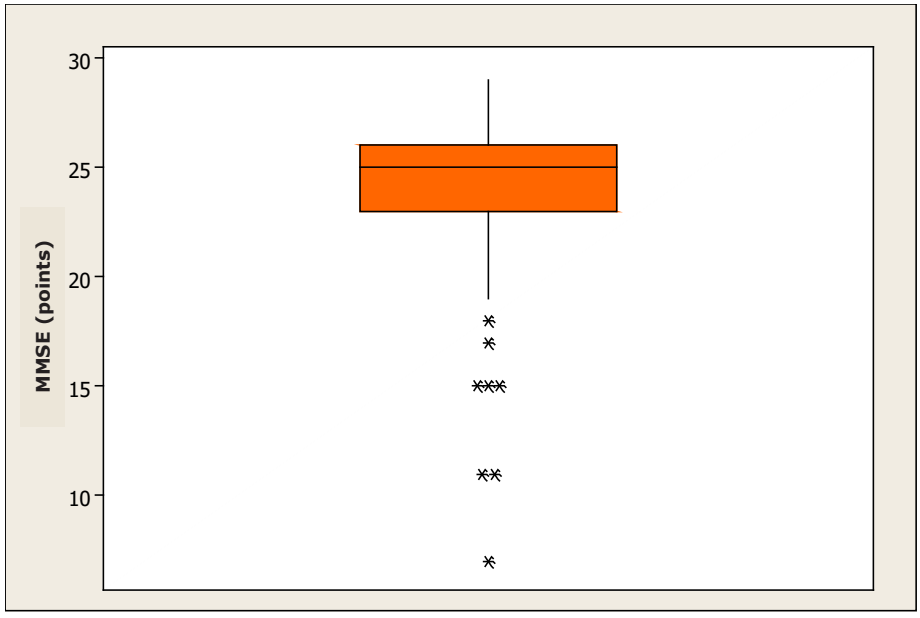

Figure 1. Boxplot of the variable MMSE score.

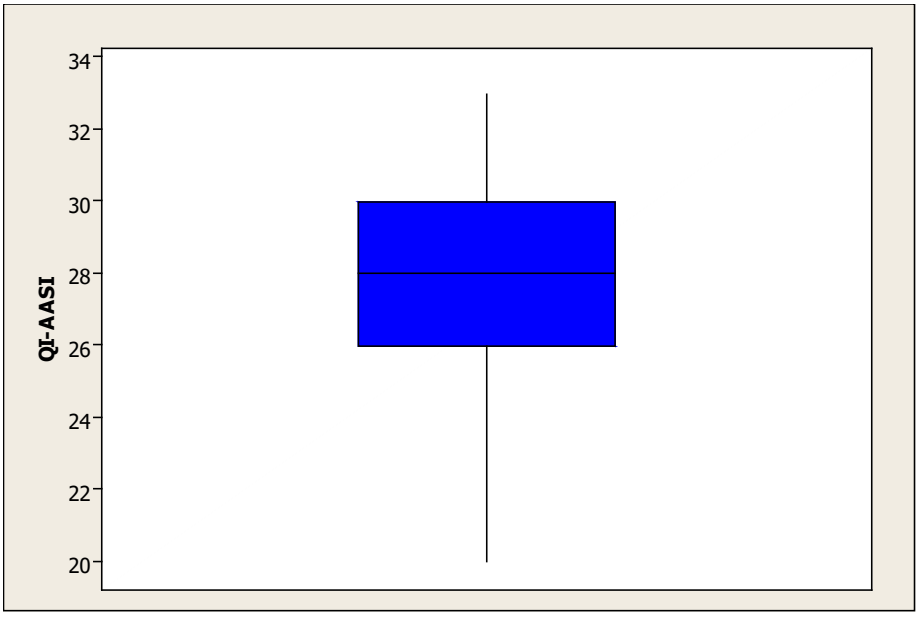

Figure 2. Boxplot of the variable IQ-ISAA.

Table 2. Means, medians, modes and standard deviations of the variables RGDTB and RGDTA.

	n	Mean	Median	Mode	Standard Deviation
RGDTB	40	60.16	52.5	50.00	41.45 ms
RGDTA	40	34.44	22.5	17.50 e 50.00	25.72 ms
Difference	40	25.73	17.00	5.00	26.37 ms

Legend: RGDTB – RGDT before using the ISAA; RGDTA – RGDT after using the ISAA

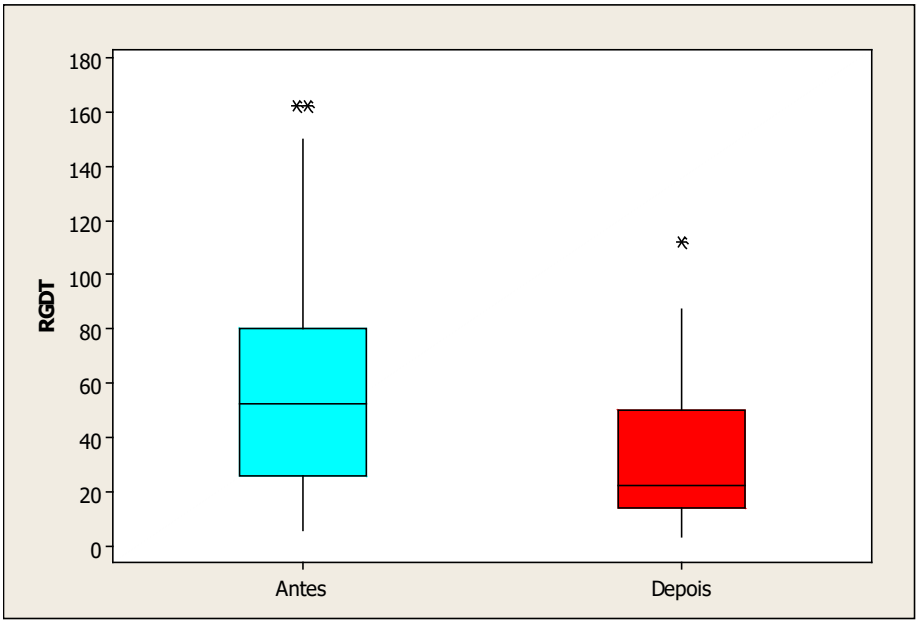

Figure 3. Boxplot of the variable RGDT per evaluation time point.

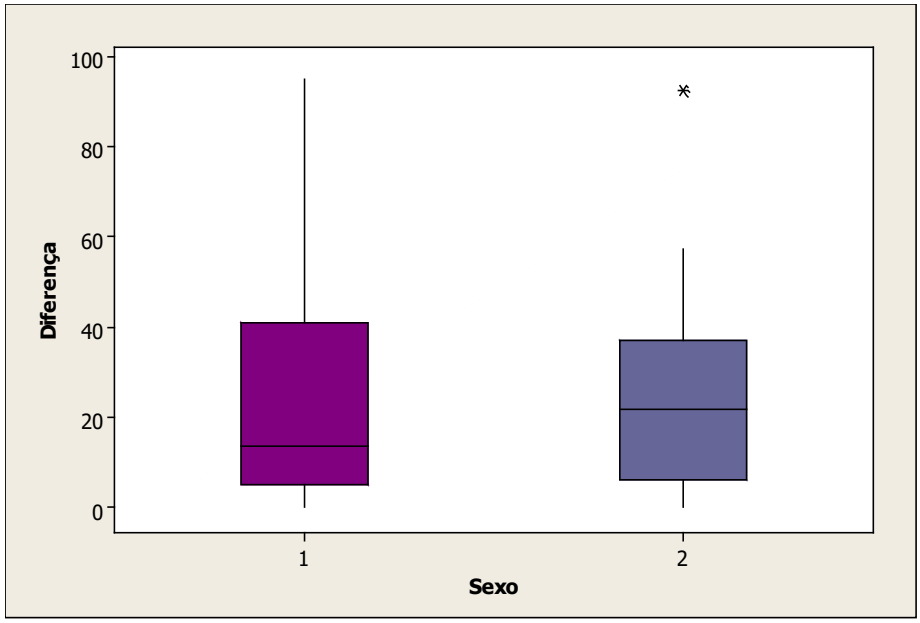

Figure 4. Boxplot of the variable difference according to sex.

Table 3. Means, medians and standard deviations of the RGDT threshold and difference of the RGDT thresholds in the conditions before (RGDTB) and after (RGDTA) the use of the individual sound amplification apparatus for the variable MMSE test scores.

Variable	Group	N	Mean	Median	Standard Deviation
RGDTB	GI	6	64.4	70.0	33.1
	GII	3	73.7	52.5	80.4
	GIII	31	58.0	50.0	39.9
RGDTA	GI	6	39.2	38.8	18.8
	GII	3	40.6	47.5	33.4
	GIII	31	32.9	20.0	26.8
Difference	GI	6	25.2	23.8	25.9
	GII	3	33.1	5.0	51.5
	GIII	31	25.11	17.5	24.7

GI – Group of individuals who scored up to 15 points on the MMSE test.

GII – Group of individuals who scored 16 to 22 points on the MMSE test.

GIII – Group of individuals who scored over 22 points on the MMSE test.

Discussion

One of the earliest and most common signs of hearing loss in most age groups is the inability to hear and comprehend speech, especially in noisy environments.[18] In general, these difficulties processing auditory information occur in the temporal and spectral components of hearing.[19] Another important aspect concerns the fact that hearing loss may contribute to changes in cognitive function. The loss of the quality of auditory information received and processed by the auditory system in the elderly is particularly characterized by deficits in temporal processing.[4]

The ISAA is responsible for amplifying sounds and thus allowing previously inaudible sounds to be detected. It is part of the auditory rehabilitation of children, adolescents, adults and the elderly. Thus, verifying the satisfaction of users of these devices has been the subject of many studies. The interest in conducting this study arose from the concern for investigating and identifying the main benefits and difficulties provided by the use of ISAAs and defining the satisfaction obtained from their use.

The following variables were studied: age, sex, type and degree of hearing loss, performance in the temporal ability test 15 and 90 days after fitting the ISAA and performance in the auditory device benefit self-assessment questionnaire. This study included individuals with sensorineural hearing loss, since this type of hearing loss is more frequent in individuals over 60 years of age and increases progressively with aging[20].

The simple placement of ISAAs does not guarantee that the perceptual and mental processes associated with auditory information are similar to those that occurred prior to hearing loss. For this to happen, it is necessary for the brain to rescue functions that were "hibernating" and for it to "reorganize" and/or "relearn to hear."

The key factor of this rescue/reorganization that can produce improvement in the performance of the individual is the auditory stimulation produced by sound amplification. This stimulation of an impaired hearing pathway (with hearing loss) is responsible for the "activation" of the reorganization process and of the rescue of auditory and mental functions, consequently increasing the chances of a successful rehabilitation[21, 22].

In an attempt to explain these perceptual modifications that occur in ISAA users, studies have described that the central nervous systems of adults can reorganize based on changes occurring in the environment and that auditory rehabilitation should be based on functional plasticity. These studies have shown that such adults, when using ISAAs, presented significant perceptual changes when compared with a group of adults with hearing loss not using sound amplification devices[9,23].

Taking into consideration the rescue of these functions, it was observed that age, cognitive performance and satisfaction with the ISAA did not affect the improvement of the results of the temporal resolution performance test, as previously described in another study that reported that age had no effect on the rescue of this auditory ability[24]. Satisfaction may not necessarily be linked to the individual having better hearing performance but rather to the simple fact of being well cared for and having acquired the technology from the Brazilian public health program (known as SUS in Portuguese); for this reason, the result of the handicap assessment may not be reliable.

Analysis of performance on the RGDT before and after the sound amplification stimulation period showed that there were positive differences that were well above zero, indicating that the performance in the test was greater after stimulation than before stimulation with sound amplification. In this case, the use of the ISAA improved the performance of the elderly in this test. The influence of sound amplification on the improved performance of the elderly with hearing loss observed is corroborated by a study conducted with elderly non-users of hearing aids, in which no difference was found in the results of the temporal resolution tests[25, 26].

It was also found that there was no significant difference between the males and females. However, the literature shows that, among the elderly with normal hearing, males had better performance in the RGDT[1,27].

In all of the cited studies, the benefit provided by the use of ISAAs requires a period of at least three months to occur and can vary from subject to subject. However, good adaptation to this electronic device does not only depend on the acclimatization period and neural plasticity, it depends mainly on well-defined guidelines in all adaptation phases and controlling patient expectations. The results were positive, and there was evidence of improvement for users in everyday situations involving com-

munication compared with the time before they had acquired the hearing aids.

The satisfaction may be explained by the advancement of technology in reducing background noise with a focus on speech comprehension, efficient microphone elimination resources and feeling welcome during encounters.

Auditory stimulation promotes increased self-confidence and reduces difficulties in social relationships. These factors have also been reported in other studies[28, 29]. The use of the hearing aids reduces difficulties during interactions between people and restrictions on activities of daily living.

The main objective of the auditory rehabilitation process is to reintegrate the user to minimize both the auditory and emotional and social effects that hearing impairment can generate[30].

Conclusion

According to the analysis, only the use of the ISAA produced a favorable effect in the stimulation of neural plasticity, which contributed to improvement in the auditory temporal resolution performance of the elderly with sensorineural hearing loss. This improvement occurred regardless of factors such as age, sex, auditory handicap and cognitive performance.

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