

# PERFORMANCE OF ELDERLY ADULTS WITH BINAURAL VS. MONAURAL FITTING IN SPEECH TESTS IN SILENCE AND IN NOISE

## *Desempenho de idosos com adaptação binaural x monoaural em testes de fala no silêncio e no ruído*

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### ABSTRACT

**Purpose:** to evaluate the sentence recognition in silence and in noise, by elderly individuals with symmetrical hearing loss, users of hearing aids with mono and binaural adaptation, and to investigate in which of the situations it may be verified the best performance under conditions that simulate daily communication situations. **Methods:** 27 subjects, 20 males and seven females, aged between 60 and 80 years, with moderately severe sensorineural hearing loss, from mild and symmetrical configuration, were evaluated. Using the Portuguese Sentence List test, it was performed the research of the **sentence recognition threshold in quiet** and in **noise** and of the percentual indexes of sentence recognition in quiet environment and under noise, in different hearing situations, with binaural and monoaural adaptation. **Results:** Average values for the indexes in silence were 80.89% with binaural, 76.33% only in the right ear and 71.16% only in the left ear. The averages obtained in the noise levels were 62.05% with binaural, 60.52% only in the right ear and 60.33% only in the left ear. In the comparison of the different hearing conditions, it was not found statistically significant difference. **Conclusion:** No statistically significant difference between the elderly hearing aid users with monoaural and binaural adaptation was found, both in quiet and in noise

**KEYWORDS:** Hearing Loss, Sensorineural; Hearing Aids; Aged; Auditory Perception; Audiometry, Speech

### ■ INTRODUCTION

It is important to consider that aging is a natural and irreversible process which gradually causes biological, social and psychological changes. One of the changes that occur in this process is hearing loss, with a significant increase from 65 years of age onwards<sup>1</sup>.

For many elderly, hearing in noisy environments is an arduous and exhausting task, because at that time of life they start complaining that they hear sounds, but do not understand what is said to them<sup>2</sup>. Hearing aid fitting is consistently used as an alternative to assist in the rehabilitation of this type of patient, in order to minimize negative consequences caused by such deficiency, by providing improved social integration and autonomy<sup>3</sup>.

The selection of hearing aids involves a detailed and careful process, covering aspects such as the patient's general health, audiological history, hearing needs, manufacture of ear molds, features and models of hearing aids and the type of fitting - monoaural or binaural<sup>4,5</sup>.

It is known that when hearing loss occurs in both ears, the use of binaural hearing aids is generally advised<sup>6,7</sup>, since there are many advantages of

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binaural hearing, including best location of the sound source, binaural summation, elimination of the head shadow effect, ability to distinguish sounds from background noise and better speech recognition in noise<sup>7</sup>.

Considering all these advantages, binaural amplification is preferable for all individuals, unless there is a particular contraindication or the patient is happy to use one hearing aid only. However, recent studies have questioned the benefits of binaural fitting<sup>8,9</sup>.

In a survey<sup>10</sup>, 28 elderly individuals were evaluated, and it was reported that 71% of the subjects had better speech performance in noise with monaural fitting. Another study<sup>11</sup> evaluated 94 adult and senior subjects, with symmetrical hearing loss, and 46% of them reported that they preferred to use only one device. These studies stressed that there are no protocols that allow the assumption that patients will adapt better to using one or two hearing aids. Other studies agree that binaural fitting is not always the best choice<sup>12-14</sup>.

Therefore, it can be seen that there is no consensus in the literature, as it used to be believed, about the indication of binaural hearing aids in symmetrical hearing losses. Thus, it is believed that binaural fitting can be monitored and have its benefits proven, including specific assessments for this purpose, in the selection and fitting of hearing aids, in order to investigate and check whether or not good results are provided.

Thus, the present study aimed to evaluate recognition of sentences in quiet and in noise by elderly individuals with symmetrical hearing loss, hearing aid users with monaural and binaural fitting, and to investigate which of the two situations resulted in the best performance under conditions that simulate daily communication situations.

## ■ METHODS

The study was characterized as a cross-sectional quantitative study. Evaluations were performed at the Laboratory of Hearing Aids at the Hearing Pathology Assistance Service (SAF) of the Federal University of Santa Maria (UFSM), registered in the Projects under number 032630 and approved by the Research Ethics Committee with certificate number 05765712.3.0000.5346. All individuals participating in the study signed an informed consent form after receiving information about the purpose and methodology of the study.

To participate in this research, individuals should meet the following inclusion criteria:

- 60 years of age or older<sup>15</sup>;

- Symmetric sensorineural hearing loss from mild to moderately severe, acquired in the postlingual period<sup>16</sup>, considering a maximum difference of 10 dB between the same frequencies in both ears;
- Being a user of hearing aids provided by the hearing aid program of the Ministry of Health, with digital technology and binaural fitting, adapted at the Laboratory of Hearing Aids of that institution, from January 2009 to August 2012.

Exclusion criteria:

- Diseases of the outer and/or middle ear;
- History of neurological disorders and/or cognitive and articulatory factors that interfere in the evaluation.

The subjects were selected from the database of the Laboratory of Hearing, according to the eligibility criteria described. Nine out of the 108 selected patients chose not to participate in the study, seven did not attend, eight had a recent history of neurological disorders and/or cognitive and articulatory factors, 13 had some kind of disease that precluded attendance, 30 patients could not be contacted, and three had already died. Thus, 38 individuals volunteered to participate in the study, but only 27 of them were able to undergo all evaluations.

Evaluations were performed at the Laboratory of Hearing Aids of the Speech Pathology Service (SAF) of the Federal University of Santa Maria, from January to December 2012.

First, the case history of the patients was surveyed, collecting information about personal data, education level, profession, daily living habits, otologic history, issues related to the handling and use of hearing aids and ear molds.

Next, their cognitive function was screened<sup>17</sup>. Individuals with a history of cognitive, neurological and articulatory changes, observed along the anamnesis, were excluded from the study.

Before the audiological evaluation started, the external auditory canal was examined to rule out possible changes in the outer and middle ears. Subsequently, a basic audiological evaluation was performed using earphones, consisting of: pure tone audiometry (PTA) via air conduction at frequencies 250-8000 Hz and bone conduction at frequencies 500-4000 Hz, identification of speech recognition threshold (SRT) with disyllabic words and identification of speech recognition percentage index (SRPI) with monosyllabic words.

Finally, to assess the ability to recognize speech in a condition that simulates daily communication situations, the Sentence List test was used in Portuguese (PSL)<sup>18</sup>, whereby the subjects underwent the determination of Recognition Thresholds for Sentences in Silence (RTSS) and in

Noise (RTSN) and Recognition Percentage Indexes for Sentences in Silence (RPISS) and in Noise (RPISN), with the use of sentences of the PSL test.

The PSL test was developed in Brazilian Portuguese, consisting of a list of twenty-five sentences, called List 1A; seven lists with ten sentences each, called 1B, 2B, 3B, 4B, 5B, 6B and 7B; with speech-spectrum noise.

Measurements of speech recognition with PSL were performed in open field, using loudspeakers, and the patients were evaluated using their hearing aids in both ears, as well as in the right ear and left ear, separately. Before the evaluations started, hearing aids were checked for operation, thus ensuring the audibility of sounds.

For RTSS and RTSN, the technique for presenting the sentences was based on the strategy referred to as sequential or adaptive, or ascending-descending<sup>19</sup>. Patients were asked to repeat the sentence they had heard, which was considered correct only when the whole sentence was repeated correctly; then, the intensity of presentation of the next stimulus was decreased, and a new sentence was repeated; when the response was incorrect, the intensity of presentation of the next sentence was increased, using pre-established intervals until the end of the sentence list.

The presentation intervals of sentences recommended in the literature<sup>19</sup> are 4 dB at first, until the first change in the type of response, and then 2 dB. However, the equipment used for this study did not present the possibility of intervals of 4 and 2 dB; thus, intervals of 5 and 2.5 dB were used, respectively. The values of the presentation of each sentence were recorded in the study protocol, and then the averages were calculated, based on the intensities of sentence presentation after the first change in the type of response.

Importantly, RTSS and RTSN were screened only as a reference to determine the intensity at which RPISS and RPISN were to be investigated. Both RTSS as the S/N ratio were different for each subject, as the values were obtained individually. For the intensity found, the indexes were investigated.

For identification of RPISS and RPISN, the value of sentence presentation was held fixed at the threshold found in the search for RTSS and RTSN for each individual, respectively<sup>20</sup>. Different lists of sentences were presented in each condition (silence and noise) and while the test was applied. Individual responses were recorded in a protocol, and the percentage of correct answers was calculated based on the score of words repeated correctly<sup>21</sup>. This method classifies the words in each sentence into two types, content or function words, and they were respectively assigned two points

and one point because their importance is different when understanding the message. Therefore, when the responses were scored, they yielded a score of correct answers.

Before starting the actual evaluation, training was provided. It consisted of the presentation of the first five sentences of list 7B, under binaural hearing with hearing aids, in silence.

The first measure obtained was RTSS under binaural hearing with hearing aids in both ears. Sentences 1-10 from list 1A were presented.

After RTSS was obtained, RTSN was searched under binaural hearing with hearing aids in both ears, using list 1B. Then, RPISS was identified under the monaural condition, with a hearing aid in the right ear, and list 2B, while RPISN was measured with a hearing aid in the left ear, and the sentences of list 3B.

Subsequently, the same procedure was carried out in the presence of a constant background noise of 55 dB SPL (A). The noise level used in this study was chosen because the experiment was to be conducted with elderly hearing aid users that would be subjected to an extensive evaluation. For this reason, a choice was made for a competing noise at a fixed intensity of 55 dB SPL (A) in order to avoid subjecting patients to a very loud noise and consequently tire them down, which could affect the results. It was found that the RTSS values of hearing aid users allowed this intensity to be perceived by the patients.

For auditory training in noise, the last five sentences of list 7B were used for binaural hearing with hearing aids.

For RTSN, under binaural hearing with hearing aids in both ears, sentences 11-20 of list 1A were used. For measurement of RPISN under binaural hearing, list 4B was used; after that, under monaural hearing, with a hearing aid in the right ear, RPISN was applied with list 5B; under monaural condition with a hearing aid in the left ear, the sentences of list 6B were applied.

Measurements were obtained in free field in a sound treated booth, using a Fonix®, FA-12 digital two-channel audiometer (type I) and Telephonics® TDH 39-P earphones. The speech stimuli were presented through a 4149 Toshiba® Digital Compact Disc Player, connected to the audiometer.

For the application of PSL, equipment calibration for the measurements in free field was previously held at the site where patients were to be positioned, at one meter from the loudspeakers at 0°/0° degrees azimuth in the horizontal and vertical planes, and speech and noise were presented in the same loudspeakers.

Measurements were kept constant using as a reference the *VU meter* of the equipment adjusted at position 0 (zero), using the calibrated pure tone available on the first track of the *Compact Disc* (CD), to control speech stimuli, because this is a complex sound which varies widely (30 dB) between the more intense and less intense sound<sup>22</sup>, while the noise was adjusted and controlled by itself, because it is a continuous sound.

The Wilcoxon test for dependent variables was used to compare non-normally distributed RPISS values, while the t-test for dependent variables was used to compare RPISN values with normal distribution.

## ■ RESULTS

In this context, 27 subjects out of the 108 previously selected patients were included in the study because they met the eligibility criteria. They were seven females and 20 males, aged between 60 and 89.

Tables 1 and 2 show the results of the mean, the median and the comparison of variables, the recognition percentage index of sentences in silence (RPISS) and recognition percentage index of sentences in noise (RPISN), first applied in both ears, then in the right ear and the left ear, with the use of hearing aids.

## ■ DISCUSSION

Table 1, which contains data for analysis of the variable RPISS under different hearing conditions, with monaural use (RE and LE) and binaural use (BE), shows that the mean obtained with binaural amplification was 80.89% while the mean values for monaural fitting were 76.33% and 71.16% in the RE in LE, with no statistically significant difference when comparing the results obtained with the use of one or two hearing aids.

The literature reports several advantages of using binaural hearing aids. This allows individuals to enjoy the benefits of interaural differences, such as length and spectrum of sound stimuli, which resemble normal auditory experiences<sup>8,9,11,23</sup>.

Binaural hearing provides better localization of the sound source and binaural summation, as well as eliminates the head shadow effect, improves the ability to distinguish sounds from background noise and facilitates the task of auditory figure-ground discrimination<sup>7,8,24</sup>.

Among the advantages described, binaural summation plays an important role, because when sounds are presented in both ears, they are perceived as if they were more intense compared to monaural use<sup>25</sup>, and the binaural hearing threshold can be 6-10 dB better than the monaural one, providing patients with better audibility and auditory perception of sounds<sup>26</sup>.

**Table 1 - Recognition Percentage Index in silence in monaural and binaural fitting (n = 27)**

RPISS	Mean%	Median%	Value
RE	76,33	81,36	p=0,248213
LE	71,16	71,37	
RE	76,33	81,36	p= 0,441418
BE	80,89	87,84	
LE	71,16	71,37	p= 0,899999
BE	80,89	87,84	

\*p significant  $\leq 0.05$ , for the Wilcoxon test.

Caption: RE-right ear; LE- left ear; BE - both ears.

**Table 2 - Recognition Percentage Index of sentences in noise in monaural and binaural fitting (n = 27)**

IRPSN	Mean%	Median%	Value
RE	60,52	61,20	p=0,943997
LE	60,33	65,49	
RE	60,52	61,20	p= 0,682844
BE	62,05	67,28	
LE	60,33	65,49	p= 0,623078
BE	62,05	67,28	

\*p significant <0.05, for the t-test.

Caption: RE-right ear; LE- left ear; BE - both ears.

These advantages of binaural fitting, addressed in the literature, were not confirmed in this study, as pointed out earlier, because the difference between the results obtained in the two hearing conditions was not statistically significant, although it has been observed that the RPISS values obtained were 4.56% (BE x RE) to 9.73% (BE x LE) better, on average, when compared to the results for monaural and binaural fitting.

Thus it is suggested that this is due to the various issues related to aging, including the decline in temporal resolution and auditory ground-figure discrimination skills, which affects the elderly population. When the temporal resolution and auditory ground-figure discrimination skills are compromised, and still associated with hearing loss, they may contribute significantly to increased difficulty in understanding speech<sup>27</sup>. Thus, even though hearing aids provide better audibility, the latter does not necessarily result in improved speech perception and discrimination.

It should also be stressed that although the degree of audibility is known to have a significant influence on understanding of speech, many elderly subjects seemed to have more difficulty than expected, based on the analysis of audiometric configurations. The difficulty of the elderly subjects in recognizing speech was partly due to age-related decline in cognitive abilities, changes in auditory processing, or a combination of both<sup>28</sup>.

Another factor that may explain the findings of the present study is the effective use of hearing aids in situations other than testing. It is believed that not all of the devices of the patients evaluated had a daily record of use, and while many of them reported binaural, daily and effective use of their hearing aids, they may not have reported this information truthfully. Because they had been given the aids free of charge and been treated nicely by the professionals in the assistance service, they might have felt embarrassed to tell the real facts. Thus, this may have contributed to the lack of a very

significant improvement in the test situation, during binaural use, because the ear that had not been acclimatized<sup>29</sup> will not provide the expected results.

As for RPISS (Table 2), results in different hearing situations were 62.05% in BE, 60.52% in RE and 60.33% in LE. When comparing the different conditions, no statistically significant difference was found, either.

One of the benefits of binaural hearing, as mentioned above, especially with regard to speech perception in noise, is improved figure-ground discrimination ability<sup>25</sup>. This is one of the most important advantages described for the use of binaural hearing aids, because when the hearing process occurs for both ears, the right auditory pathway is more adept at detecting and giving meaning to verbal sounds that were heard, while the left auditory pathway acts particularly on non-verbal sounds, attenuating background noise. Thus, the central auditory system decreases the influence of noise, allowing better understanding of the received message in situations that are not always favorable, providing better speech recognition in noise<sup>7,8,24</sup>.

In the literature, several international studies are being conducted to address the following question: "Is binaural fitting more appropriate than monaural fitting?" Different answers have been found. Many studies indicate that binaural fitting is actually the most suitable, others, however, report that it is not always the best choice<sup>9-11,13</sup>.

A study<sup>11</sup> evaluated 94 subjects with symmetrical hearing loss to verify their preference as to monaural or binaural fitting, and 46% (43 subjects) chose to use only one hearing aid. It was found that when patients used the two hearing aids, environmental sounds caused some discomfort. Therefore, even though audibility allows for better understanding of speech sounds, the uncomfortable feeling of the noise made them choose to use only one hearing aid.

In the same study, the results showed that the preference criteria used by patients to choose to

use one or two hearing aids are different. Users with monaural fitting reported more comfort and better sound quality as well as the fact that using only one hearing aid already meets their needs. In contrast, those who prefer binaural use reported sense of balance between the ears, better sound perception, and the fact that only one hearing aid did not provide enough audibility. The authors emphasized that, based on their study, about 30-40% of patients will prefer the use of a hearing aid. However, the trust and confidence shown by the professional encourages patients' willingness to binaural fitting.

Other surveys have found better performance with binaural fitting<sup>8,9</sup> and reported that users of bilateral hearing aids showed better speech intelligibility in noise and sound source location, but showed greater discomfort to loud sounds compared to unilateral hearing aid users<sup>30</sup>. Other studies reported better speech recognition in noise with unilateral fitting<sup>10,14</sup>.

Moreover, one should be very careful with monaural fitting, because it is extremely important to take into consideration auditory deprivation, described as a reduction in the rate of speech recognition, arising from hearing loss without the use of amplification and consequent sensory deprivation<sup>7</sup>. A study<sup>11</sup> shows that the effect of the lack of stimulation begins to appear after five years of auditory deprivation, and that the greater the degree of hearing loss, the greater the consequences. Therefore, when patients do not have preferences for monaural or binaural use, and their performance in speech tests does not indicate a change that justifies unilateral fitting, binaural use may be the

best choice to avoid sensory deprivation and provide the benefits of binaural hearing.

During the rehabilitation process, one should emphasize the training of auditory skills. In the case of the elderly, audibility, as provided by the use of two hearing aids, will not always be sufficient to provide better understanding of speech because of frequent changes of auditory processing in this population. It is also an effective resource to reduce the degree of difficulty in the adaptation process<sup>31</sup>.

Apart from hearing changes, the elderly had very different results within the group, and they are directly associated with the style and quality of life that they had had hitherto, as well as associated diseases and other factors that may be related.

Thus, given all the studies analyzed and the result of this study, it can be inferred that the process of hearing aid fitting requires special attention by audiologists. Therefore, it should be emphasized that each individual patient needs to be monitored throughout the process, from collecting history information to carrying out specific tests, so that the best solution can be offered based on the results obtained.

## ■ CONCLUSION

Based on these results, no significant difference was found among elderly hearing aid users with monaural and binaural fitting, both in silence and in noise. Therefore, it was not possible to determine what the situation (monaural or binaural fitting) had better performance in the elderly population.

**RESUMO**

**Objetivo:** avaliar o reconhecimento de sentenças no silêncio e no ruído de indivíduos idosos com perdas auditivas simétricas, usuários de próteses auditivas com adaptação mono e binaural; investigar em qual das duas situações pode ser verificado o melhor desempenho em condições que simulam situações de comunicação do dia a dia. **Métodos:** foram avaliados 27 indivíduos, 20 do gênero masculino e sete do feminino, com idades entre 60 e 80 anos, com perda auditiva neurosensorial de grau leve a moderadamente severo e configuração simétrica. Utilizando o teste Listas de Sentenças em Português, realizou-se a pesquisa dos Limiares de Reconhecimento de Sentenças no Silêncio e no Ruído e Índice Percentual de Reconhecimento de Sentenças no Silêncio e no Ruído, em diferentes situações de escuta, com adaptação binaural e monoaural. **Resultados:** os valores médios obtidos para os índices no silêncio foram de 80,89% com adaptação binaural, 76,33% com aparelho somente na orelha direita e 71,16% com aparelho somente na orelha esquerda. Já as médias obtidas nos índices no ruído foram 62,05 % com adaptação binaural, 60,52% com aparelho somente na orelha direita e 60,33% com aparelho somente na orelha esquerda. Ao comparar as diferentes condições de escuta, não foi encontrada diferença estatisticamente significativa. **Conclusão:** não foi encontrada diferença estatisticamente significativa entre os idosos usuários de próteses auditivas com adaptação mono e binaural, tanto no silêncio como no ruído.

**DESCRITORES:** Perda Auditiva Neurosensorial; Auxiliares de Audição; Idoso; Percepção Auditiva; Audiometria da Fala

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