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Correlation between speech recognition, time of auditory deprivation, and duration of cochlear implant use in people with postlingual deafness

Correlação entre reconhecimento de fala, tempo de privação auditiva e tempo de uso de Implante Coclear em usuários com surdez pós-lingual

Correlación entre el reconocimiento del habla, el tiempo de privación auditiva y el tiempo de uso del implante coclear em usuários com sorder apos lingual

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Abstract

Introduction: It is essential to measure the benefits provided by the cochlear implant, to which end various assessment methods have been described. Of these, the speech perception tests are still the most

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Authors' contributions:
CDCS – developed the experiment, data collection, statistical data analysis, manuscript writing, text adjustments to the norms of the journal, text revision.
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used, including the List of Sentences in Portuguese – LSP. Determining the factors that influence the speech recognition of CI users helps in preoperative instructions, improves adaptation and rehabilitation, and reveals necessary changes to be made in the device. **Purpose:** To verify the correlation between time of auditory deprivation and duration of use of the cochlear implant (CI) with the results of the speech perception in silence and noise tests in CI users with post lingual hearing loss aged 14 to 60 years old. **Method:** The 27 participants were submitted to the following assessments: data collection to characterize the previous hearing loss, such as the time of auditory deprivation and beginning of CI use; free-field audiometry with CI at the frequencies of 250 to 4000 Hz; speech recognition assessed through the Lists of Phrases in Portuguese (LPP), presented in favorable (silence) and unfavorable (noise) hearing conditions. In the statistical analysis, Pearson's linear correlation coefficient was used, as well as bidimensional dispersion graphs and descriptive data analysis. **Results:** There was no statistically significant relationship between auditory deprivation and speech perception in silence and noise. On the other hand, there was a statistically significant positive correlation between the duration of CI use and the performance in sentence recognition in silence. **Conclusion:** A significant correlation was verified only between duration of implant use and sentence recognition in silence in implant users with post lingual deafness.

Keywords: Cochlear Implantation; Deafness; Disability Evaluation; Adult.

Resumo

Introdução: A mensuração do benefício proporcionado pelo Implante Coclear é fundamental e há vários métodos de avaliação descritos, mas, os testes de percepção de fala ainda são os mais utilizados, dentre eles a "Lista de Sentenças em Português" - LSP. Determinar os fatores que influenciam o reconhecimento de fala nos usuários de IC auxilia nas orientações da etapa pré-operatória, melhora a adaptação, reabilitação e evidencia mudanças necessárias no dispositivo. **Objetivo:** Verificar a correlação das variáveis: tempo de privação auditiva e tempo de uso de Implante Coclear (IC) com os resultados dos testes de percepção de fala no silêncio e no ruído em usuários de IC com deficiência auditiva pós-lingual e idade entre 14 e 60 anos. **Método:** Os 27 participantes foram submetidos às seguintes avaliações: levantamento de dados– para coleta de informações que caracterizem a perda auditiva prévia, como tempo de privação auditiva e início do uso do IC -, audiometria em campo livre com IC nas frequências sonoras de 250 a 4000 Hz e o reconhecimento de fala que foi avaliado por meio do teste "Listas de Sentenças em Português" - LSP aplicado na condição favorável (silêncio) e na condição desfavorável (ruído) de escuta. Na análise estatística foram utilizados o coeficiente de correlação linear de Pearson e gráficos de dispersão bidimensional, além disso, a análise descritiva dos dados. **Resultados:** Não houve relação estatisticamente significante entre a privação auditiva e a percepção de fala no silêncio e no ruído. Por outro lado, houve correlação positiva estatisticamente significante entre o Tempo de Uso do IC com o desempenho no teste de reconhecimento de sentenças no silêncio. **Conclusão:** Verificou-se correlação significante apenas entre tempo de uso de implante e reconhecimento de sentenças no silêncio em usuários de implante com surdez pós-lingual.

Palavras chave: Implante Coclear; Surdez; Avaliação da Deficiência; Adulto

Resumen

Introduccion: La medición del beneficio proporcionado por el implante coclear es esencial y existen varios métodos para evaluar lãs pruebas, pero lãs pruebas de percepción Del habla son aún más utilizadas, entre ellas la "Lista de oraciones em portugués" - LSP. Determinar los factores que influyen o El reconocimiento de lãs conversaciones em los usuários del IC auxiliar em lãs instrucciones pre-operatorias, mejora La adaptación, la rehabilitación y la evidencia de cambios alterados em el dispositivo.**Objetivo:** Verifique la correlación de las variables: tiempo de privación auditiva y tiempo de uso del implante coclear (CI) com los resultados de las pruebas de percepción del habla en silencio y el ruído em usuarios de CI com audición poslingual y edad entre 14 y 60 años. **Método:** los 27 participantes se sometieron a los siguientes pasos: recopilación de datos - para la recopilación de datos que caracteriza la pérdida auditiva previa, como el tiempo de privación auditiva y el comienzo del uso de CI -, audiometria e nel campo

libre con CI a 250 a 4000 Hz frecuencias de sonido y El reconocimiento de voz se evaluó mediante la prueba "Lista de oraciones em portugués" - LSP aplicado em la condición favorable (silencio) y em la condición desfavorable (ruido) de la escucha. Em el análisis estadístico, se utilizaron coeficientes de correlación lineal de Pearson y gráficos de dispersión bidimensionales, además, um análisis descriptivo de los datos. **Resultados:** No hubo una relación estadísticamente significativa entre la privación auditiva y la percepción del habla en silencio y ruido. Por otro lado, hubo una correlación positiva estadísticamente significativa entre el tiempo de uso del implante coclear y el rendimento em la prueba de reconocimiento de oraciones en silencio. **Conclusión:** Hubo una correlación significativa solo entre el tiempo de uso del implante y el reconocimiento de oraciones en silencio em usuarios de implantes com sordera poslingual.

Palabras clave: Implantación coclear; Sordera Evaluación de La Discapacidad; Adulto

Introduction

Many deficiencies affect humans, of which hearing loss (HL) is one of the most impacting. Regardless of its degree of severity, it impairs communication, hindering verbal responses from being functional and interfering with interactional relationships[1].

The negative impact of this deficiency can vary depending on biological and psychological characteristics and circumstances in which the person lives. Also, the communication process can be affected in various instances[2], such as in expression and comprehension, voice, reading, and writing. To attenuate the impairment brought about by the HL and improve the quality of life of these individuals, there are some compensatory procedures, for example, the Brazilian Sign Language (Libras, its Portuguese acronym), hearing aid (HA), and the implantable hearing aids – among which is the cochlear implant (CI).

The cochlear implant is an alternative for individuals with severe to profound sensorineural hearing loss. It electrically stimulates the nerve fibers, allowing the electrical signal to be transmitted to the auditory nerve to be decoded by the cerebral cortex[3].

It is essential to measure the benefit provided by the cochlear implant, to which end various objective and subjective assessment methods have been described. Of these, the speech perception tests (objective method) are still the most widely used[4].

Speech recognition can be assessed by presenting words and sentences surrounded by either silence or noise. In this regard, sentences represent the characteristics of a conversation better than isolated words do. When combined with noise, they enable speech recognition to be assessed in a simulation of day-to-day situations[5].

This type of assessment opens a way to establish the relationship between the auditory capacity and auditory performance of a person with hearing loss[6], besides simulating experiences lived by CI users in their daily routine[7].

The performance of CI users in speech perception tests varies greatly and is worse in unfavorable hearing environments. Some users report oral comprehension difficulties both in public settings (such as restaurants and parties) and in conversations between three or more people when they talk simultaneously[8, 9, 10].

In Brazil, there are currently only two recorded tests to assess sentence recognition – the Lists of Phrases in Portuguese (LPP), developed by Costa[11], and the Hearing in Noise Test (HINT-Brazil), translated by Bevilacqua[12] – which can be conducted in both silence and noise. The LPP has already been studied in Brazil in different populations to assess their speech recognition skill in silence and noise.[13,14, 15]

Determining the factors that influence speech recognition in CI users can help instruct them in the preoperative stage, improve their adaptation and rehabilitation, and reveal necessary changes in the device.[16]

Given the above, this study aimed to verify the correlation between speech recognition in silence and noise, time of hearing deprivation, and duration of CI use in people with hearing loss with postlingual deafness.

Method

Ethics procedures

A total of 27 CI users who attended the Center for People with Hearing Loss (*Centro do Deficiente*

Auditivo – CDA), an integral part of the Department of Otorhinolaryngology of the *Hospital São Paulo* participated in this study. This research was approved by the Research Ethics Committee of the Federal University of São Paulo (*Universidade Federal de São Paulo* – UNIFESP), under number 1572015.

The following criteria were used for inclusion in the sample:

- Being over 12 years old.
- Having postlingual hearing loss – i.e., after three years old.
- Having used a unilateral cochlear implant for at least one year, at least eight hours a day.
- Attending the follow-up sessions to map the speech processor.
- Having a free-field threshold means ≤ 40 dB HL at the frequencies of 500,1000, 2000, and 4000 Hz.

Procedures

The participants were submitted to individual interviews to collect data, such as full name, date of birth, and time of sensory deprivation, considering the beginning of the severe to profound hearing loss. Other data, such as activation date, and model and brand of the implant were collected from their medical records at the CDA.

All the procedures were conducted using the programming, volume, and sensitivity the participant had been using in their processor in their daily activities. The bimodal users were asked to use only the CI during the assessment.

The free-field audiometry with a cochlear implant was conducted at the sound frequencies of 250 to 4000 Hz and SRT – speech recognition threshold. The sound booth was used, in which the participant was positioned at 0° azimuth, one meter away from the loudspeaker. The free-field threshold mean was used as an inclusion criterion in the study to discard users that did not have the expected audibility with the CI.

The Lists of Phrases in Portuguese – LPP (Costa, 1998) were used to assess speech recognition. The LPP enables the speech recognition skills to be measured in simulated hearing situations in a sound booth[5]. The LPP material is recorded in a CD; the sentences and the noise are recorded in independent channels, which makes it possible to present them with either silence or noise. The LPP sentences to be used in this research were chosen based on the routine of the service, as the authors do no suggest that a specific list be used in each situation. Moreover, a study reported similar results when using lists 1B, 2B, 3B, 4B, 5B, or 6B[5].

Two measures of speech recognition were taken in the sound booth, with the participants positioned one meter away from the loudspeaker, at 0º azimuth; the main message and the noise were presented in the same loudspeaker. The participant was asked to repeat the sentences they heard.

Initially, list 1B was presented for the CI user to get acquainted both with the recorded stimuli and the task.

For the speech recognition in silence, which assesses speech recognition skill in a favorable hearing situation, list 4B was used, presented at 65 dBA. The number of correctly repeated words was multiplied by 100 and divided by the total number of words (51 words). Hence, the result of the speech recognition in silence was obtained as a percentage of correct answers.

For the speech recognition in noise, which assesses the user's capacity to recognize sentences in an unfavorable hearing condition, list 5B was used, in the SNR of +10 dB – i.e., the sentences were presented at 65 dBA, while the noise was fixed at 55 dBA, both in the same loudspeaker. The percentage of correct answers was calculated as in the sentence recognition in silence.

It is important to highlight that all the participants had bilateral severe and/or profound hearing loss. Therefore, the ear contralateral to the cochlear implant could not influence the individual's performance in the tests.

Data analysis

The data were submitted to statistical treatment with the STATISTICA® software, version 12.

The descriptive statistical analysis was done through some summary measures, such as mean, median, minimum and maximum values, standard deviation, absolute and relative frequencies (percentage), besides bidimensional dispersion graphs.

Pearson's linear correlation coefficient (p) was estimated in the quantification of the correlation between sensory deprivation, duration of use of the implant, and the users' performance in speech perception tests both in silence and noise; the alpha significance level was adopted (alpha = 5%).

Results

The sample in this research comprised 27 individuals with bilateral HL – 15 men and 12 women (Table 1). At the time of the assessment, the mean age was 50.4 years (SD16.7); the mean time of auditory deprivation was 121.3 months – approximately ten years – (SD 103.2); the mean duration of CI use was 56.3 months – approximately four years – (SD 27.5).

The performance of the participants in the sentence recognition in silence and noise are characterized in Table 2.

There was no relationship between the time of auditory deprivation and sentence recognition in silence and noise (Figures 1 and 2, respectively). Thus, the values of Pearson's linear correlation coefficient (p) were not statistically significant – p = 0.169 in silence and p = 0.976 in noise (Table 3).

Table 1. Sample characterization

Gender	Male	15	55,6%
	Female	12	44,4%
Implanted side	Right	17	63.0%
	Left	10	37.0%
Age (years)	N (Total)	27	
	Mean	50.4	
	Median		51
	Minimum		17
	Maximum		75
	Standard deviation		16.7
Duration of implant use (months)	N (Total)	27	
	Mean	56.3	
	Median	47	
	Minimum	12	
	Maximum	104	
	Standard deviation	27.5	
Time of auditory deprivation (months)	N (Total)	27	
	Mean	121.3	
	Median	96	
	Minimum	11	
	Maximum	420	
	Standard deviation	103.2	

Table 2. Performance in the Speech Recognition Test

Sentence recognition in silence	N (Total)	27
	Mean	80%
	Median	85%
	Minimum	42%
	Maximum	100%
	Standard deviation	19
Sentence recognition in noise	N (Total)	27
	Mean	30%
	Median	25%
	Minimum	0%
	Maximum	88%
	Standard deviation	27

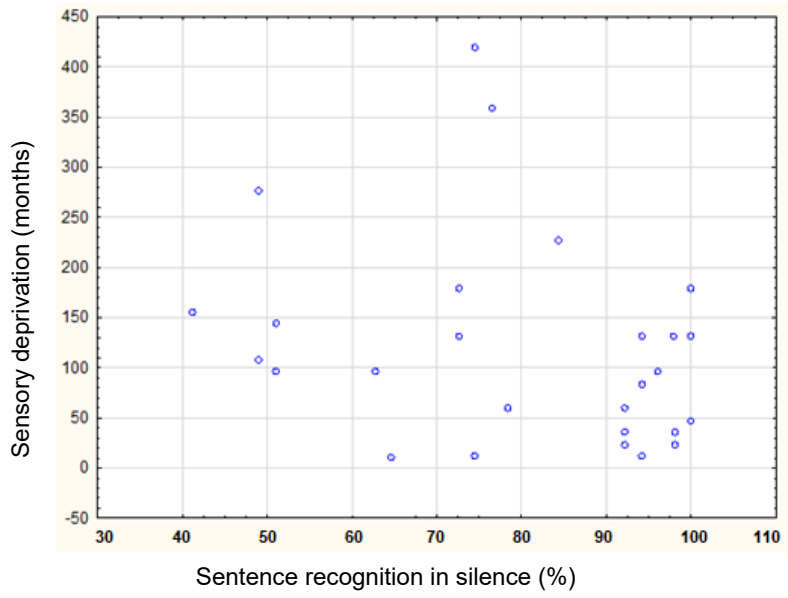

Figure 1. Time of Auditory Deprivation and Sentence Recognition in Silence

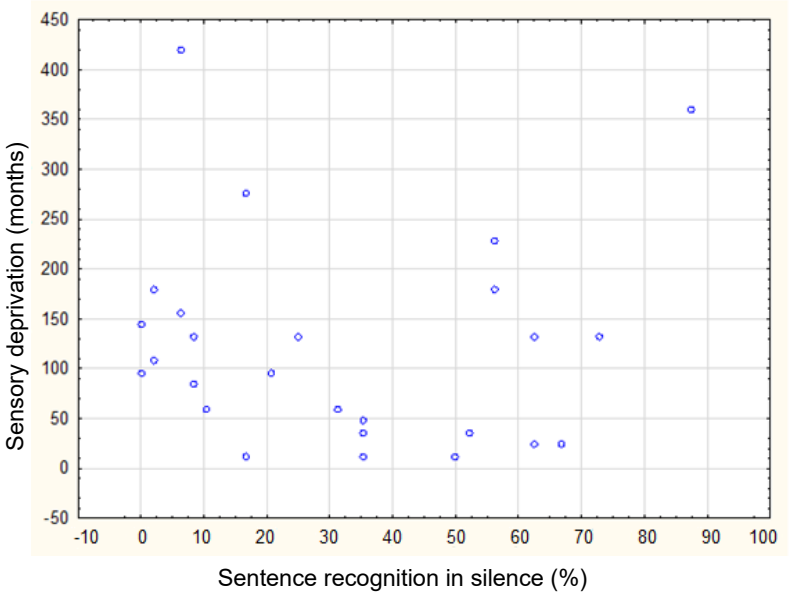

Figure 2. Time of Auditory Deprivation and Sentence Recognition in Noise

Table 3. Pearson's linear correlation coefficient

Variable	Significant correlation p < 0.050 N=27	
	Sentence recognition in Silence	Sentence recognition in noise
Auditory Deprivation (months)	- 0.272 p = 0.169	- 0.006 p = 0.976

In contrast, when correlating the duration of use of the cochlear implant with the sentence recognition in silence, there was a statistically significant positive relationship (Figure 3). Pearson's linear coefficient value corroborated the situation in the graph. However, such a significance did not occur with the sentence recognition in noise (Table 4).

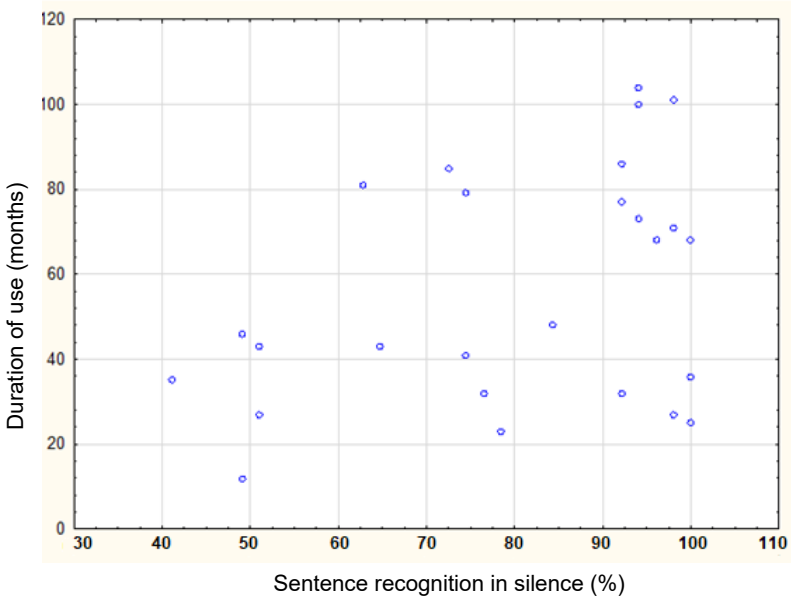

Figure 3. Duration of use and Sentence Recognition in Silence

Table 4. Pearson's linear correlation coefficient in the duration of use

Variable	Significant correlation p < 0.050 N=27	
	Sentence recognition in Silence	Sentence recognition in noise
Duration of use (months)	0.390 p = 0.049	0.0602 p = 0.770

Discussion

In this study, the mean sentence recognition in silence was 80% in implant users with postlingual deafness. These findings were higher than those in the meta-analysis of 34 articles, whose mean was 74.37% in adult CI users – most of whom had postlingual hearing loss[17]. A study conducted in Brazil, which used the same speech material, found better results for recognition in silence in the SG (study group: 91.1%) and the CG (control group: 88.3%)[18]. Another study, conducted in 2010, found a mean 96% of sentence recognition in silence using the HINT test in 34 postlingual CI users[19] – i.e., higher than the value found in this study.

As for the speech recognition in noise, the mean of correct answers in the SNR +10 was 30%. These results were lower than the ones found in the abovementioned meta-analysis (49.78%)[17] but higher than those found in the study with the same speech material, whose mean of correct answers in noise in an SNR +10 dB was 24.8% in the SG and 21% in the CG.

The literature points out that CI users are extremely satisfied with using it. However, there are still negative opinions regarding its maintenance costs and the low performance in speech recognition in noise[20, 21].

In the literature, there is evidence that the unfavorable hearing environment interferes with the communication of normally hearing subjects, as well. For instance, there is a Brazilian study that researched the threshold of sentence recognition in noise using the Lists of Phrases in Portuguese (LPP) in 50 normally hearing individuals aged 19 to 32 years old, with and without complaints of hearing speech in noise. Their purpose was to compare the performance results of the individuals with their respective complaints[22]. It was verified that the mean signal-to-noise ratio (SNR) values of the individuals who did not have complaints were better when

compared with those who had complaints regarding the comprehension of speech in noise. Nonetheless, they still had difficulty understanding. The group without complaints recognized approximately 50% of the speech stimuli presented with competing noise (65 dB HL) with a less favorable SNR.

In this research, no statistically significant relationship was observed between the time of auditory deprivation and sentence recognition in silence and/or noise. However, there are some results in the literature concerning this relationship – auditory deprivation and sentence recognition performance. One example is an international study whose sample was similar to the one in the present research[9]. It assessed 64 CI users with postlingual hearing loss in the recorded sentence recognition AzBio and HINT tests and correlated the results with the time of auditory deprivation. A positive partial correlation in both tests was verified.

As for silence, other authors observed that the CI users with more than 10 years of deprivation had worse performance in trisyllable recognition in silence than those with less time of deprivation[23]. There may have been a difference in the result of this study due to the nature of the material used to assess speech recognition in silence (words x sentences).

The analysis revealed statistical significance in the correlation between duration of cochlear implant use and performance in speech recognition in silence (see Figure 3). It was verified that the longer the device was used, the better was the performance in the speech perception in silence test (favorable hearing condition). In such a condition, the loss of acoustic information is compensated by other contextual clues. These findings corroborate a study whose assessment of sentence recognition in silence had a relationship with duration of CI use, though restricted to the first year of use[21]. The same happened in a similar study, although with a sample who had been using the CI for more than six months[24], and in another one that used monosyllables as speech material[16]. A study used the lists of sentences from the CPA (*Centro de Pesquisas Audiológicas* – Audiology Research Center).

Nevertheless, in the sentence recognition in noise test, there was no statistically significant correlation with the duration of CI use. This lack of a relationship was also observed in another study with unilateral, bilateral, and hybrid CI[25]. This result corroborates those reported in the study that compares speech recognition in noise with the different types of implant in 40 people with hearing loss[26]. They assessed their degree of difficulty in day-to-day situations with competing noise using the Sentence Recognition Test of the *Centro de Pesquisas Audiológicas* (CPA), of the *Hospital de Reabilitação de Anomalias Craniofaciais* (Craniofacial Anomalies Rehabilitation Hospital), and the SHHI questionnaire (Social Hearing Handicap Index). They did not find any statistically significant difference in the CPA sentence recognition indexes or the SHHI difficulty scores obtained with the different types of CI.

Conclusion

The duration of cochlear implant use is a predictive factor for performance in speech recognition in silence of unilateral CI users with postlingual hearing loss. Hence, an improvement in recognition performance is to be expected as the duration of use increases.

The time of auditory deprivation was not able to predict these participants' results in speech perception in either silence or noise.

The CI users can have a satisfactory performance in speech recognition in silence. However, poor recognition in noise can cause difficulties in communication tasks in unfavorable hearing environments.

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