Original Article

https://doi.org/10.1590/2317-6431-2023-2820en

Audiology Communication Research
ISSN 2317-6431

Speech self-perception algorithm objective analysis with elderly hearing aids users

Análise objetiva do algoritmo de autopercepção da fala em idosos usuários de próteses auditivas

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ABSTRACT

Purpose: To analyze, by electroacoustic verification at 65 dB SPL, the Speech Intelligibility Index (SII), with the speech self-perception algorithm activated and deactivated in elderly hearing aid users. **Methods:** This is a cross-sectional observational study. The participants were 40 older adults with mild to severe bilateral symmetrical sensorineural hearing loss, aged between 60 and 80 years, who attended a hearing center, users of *Rexton* receiver-in-the-canal (RIC) devices, *My Core* platform with speech Self-perception algorithm. After an audiological evaluation, the hearing aids were programmed using the NAL/NL2 prescriptive method and fine-tuned according to individual needs. The speech self-perception algorithm was calibrated and after performing the electroacoustic verification, the Speech Intelligibility Index was quantified. Electroacoustic verification was performed with and without the self-perception of speech algorithm enabled. Statistical analysis was performed using the SPSS Statistics software, version 28.0. The statistical significance value was equal to 5% ($p \leq 0.05$). **Results:** In the right ear, without activation of the algorithm, the average SII was 58.9% (±14.7) and with activation, 57.85% (±14.8). In the left ear, without activation of the algorithm, the SSI was 63.1% (±15.13) and with activation, 61.9% (±15.2). There was statistical significance between the SII obtained with the algorithm on and off ($p<0.001$). In both ears, with the self-perception activated algorithm, the mean SII was lower than without. **Conclusion:** There is a reduction in SII with the self-perception of speech algorithm activated in strong mode.

Keywords: Hearing loss; Hearing aids; Algorithms; Aging; Technology

RESUMO

Objetivo: Analisar, pela verificação eletroacústica de mapeamento de fala a 65 dB NPS, o *Speech Intelligibility Index*, com o algoritmo de autopercepção de fala ativado e desativado em idosos usuários de próteses auditivas. **Métodos:** Trata-se de estudo observacional transversal. Participaram 40 idosos com perda auditiva neurossensorial bilateral simétrica de grau leve a severo, idade entre 60 e 80 anos, que frequentavam um centro auditivo, usuários de dispositivos da marca Rexton, com receptor no canal, (*Receiver In the Canal* - RIC), plataforma *My Core* e com o algoritmo de autopercepção de fala. Após avaliação audiológica, as próteses auditivas foram programadas utilizando-se o método prescritivo NAL/NL2 (*National Acoustic Laboratories/ Non linear 2*) e ajustes finos realizados conforme necessidades individuais. O algoritmo de autopercepção de fala foi calibrado e, depois de realizada a verificação eletroacústica, foi quantificado o *Speech Inteligibility Index*. A verificação eletroacústica foi realizada com e sem o algoritmo de autopercepção da fala habilitado. A análise estatística foi realizada com o *software* SPSS Statistics, versão 28.0. O valor de significância estatística foi igual a 5% ($p \leq 0{,}05$). **Resultados:** Na orelha direita, sem o algoritmo ativado, o *Speech Inteligibility Index* médio foi de 58,9% (±14,7) e ativado, 57,85% (±14,8). Na orelha esquerda, sem ativação do algoritmo, o *Speech Inteligibility Index* médio foi 63,1% (±15,13) e com ativação, 61,9% (±15,2). Houve significância estatística entre o *Speech Inteligibility Index* obtido com o algoritmo ativado e desativado ($p<0{,}001$). Nas duas orelhas, com o algoritmo de autopercepção ativado, o *Speech Inteligibility Index* médio foi menor que sem o algoritmo ativado. **Conclusão:** Há redução do *Speech Inteligibility Index* com algoritmo de autopercepção de fala ativado no máximo.

Palavras-chave: Perda auditiva; Auxiliares de audição; Algoritmos; Envelhecimento; Tecnologia

Study carried out at Centro Auditivo Espaço da Audição, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brasil.
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Conflict of interests: No.
Authors' contribution: RS was responsible for data collection, statistical analysis, literature review, and developing the thesis and the article; MCM was responsible for assisting in the statistical analysis, developing the best line of reasoning for the results, correcting the thesis and the article, and reviewing the bibliographic references.
Funding: None.
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Received: June 15, 2023; **Accepted:** May 15, 2024

INTRODUCTION

The sounds perceived by an individual arise from their propagation through the air and the effects produced on the sound signal by the environment[1] The perception of one's own voice also depends not only on its propagation through the air but also through bone conduction. It is understood that these bone vibrations occur because when the voice is emitted, the bones of the individual's skull vibrate, reaching the cochlea, and the voice is then perceived through bone conduction[2,3].

Thus, an individual perceives their own voice through their auditory system, both via bone conduction vibration and through air propagation. This mechanism of self-voice perception is altered when a sound amplification device is fitted to a patient, especially in those with mild to moderate hearing loss, who often report that their voice sounds different[2].

With the use of hearing aids, it is common for various complaints to arise among users, regarding the sound quality of their own voice and other sounds around them[4,5].

A study[6] investigated satisfaction with one's own voice among users of hearing aids and found that only 58% of respondents attributed a rating of "satisfied" or "very satisfied" with the sound of their own voice.

Another study[1], conducted with nearly 400 users of hearing aids, of whom 78% had been using aids for more than two years, investigated satisfaction with one's own voice. The majority had mild to moderate hearing loss and used open-fit adaptations. Only 41% of hearing aid users were satisfied with the sound of their own voice.

In order to provide quality and effectiveness in prostheses, researchers and manufacturers have developed specific algorithms to capture and reproduce both the person's voice and other sounds with better quality.

It is known that amplification improves audibility and, therefore, access to speech sounds. Through validated prescriptive methods, it is possible to adjust the amplification to achieve prescribed targets and, through electroacoustic verification, obtain the Speech Intelligibility Index (SII), a term adopted by the ANSI S3.5-1997 standard (American National Standards Institute) to presumably focus on the SII goal of predicting speech intelligibility[7]. The Speech Intelligibility Index - SII is part of speech mapping and provides the percentage of speech sounds to which the patient has access (0 to 100%), with and without amplification[8].

Hearing loss is the second most prevalent chronic condition and the third leading cause of years lived with disability[9]. It is known that hearing loss increases exponentially with age[10]. According to the World Health Organization (WHO), the number of elderly individuals is increasing, and Brazil will be the fifth country with the largest number of elderly individuals by 2050. Therefore, studying the effects of new algorithms available in electronic sound amplification devices in this population is essential.

Hearing loss in elderly people is called presbycusis or age-related hearing loss (ARHL). It is a degenerative and multifactorial disease, characterized by progressive and symmetrical loss of high-frequency hearing. It significantly affects individuals' quality of life, leading most of them to social isolation and/or even depression[11,12].

Given that the speech-language pathologist is the professional responsible for the patient's prosthetic fitting[13], this study aimed to verify, through electroacoustic measurement at 65 dB SPL, the Speech Intelligibility Index (SII), by activating and deactivating the speech self-perception algorithm, in elderly users of hearing aids.

The guiding hypothesis of this research was based on questioning whether the activation of the speech self-perception algorithm would produce any alteration or compromise in the amplified speech signal.

METHODS

This is a cross-sectional observational study, submitted to the Ethics and Research Committee of the Federal University of São Paulo - CEP/UNIFESP, approved under number 0938/2021. All participants were provided with explanations about the type of research, read, and signed the Informed Consent Form (ICF) to confirm their participation, fully aware that they were volunteers. The research was conducted at the Auditory Center "*Espaço da Audição*," with authorization from its owners.

Participants were selected from the medical records of users of hearing aids equipped with the speech self-perception algorithm, acquired at the aforementioned auditory center. Contacts were made by phone to schedule individual face-to-face interviews, each lasting two hours.

The inclusion criteria for sample participation defined the selection of individuals aged 60 years or older, with bilateral symmetrical sensorineural hearing loss ranging from mild to severe (World Health Organization 2014), and the absence of evident neurological alterations.

A total of 40 elderly individuals were selected and evaluated, comprising 24 women and 16 men, with ages ranging from 60 to 80 years, effective users of Rexton brand hearing aids, My Core platform, equipped with the speech self-perception algorithm. The selected models were: Emerald S 8C; Emerald M 8C; Stellar Li 8C, all devices featuring Receiver-in-Canal (RIC) receivers.

The receiver-in-canal powers used and their respective gains and outputs were: S 45 dB/108 dB SPL, M 60 dB/119 dB SPL, and P 70 dB/124 dB SPL (SPL = sound pressure level in decibels). All patients were users of various coupling types, including open, semi-open, closed, and double, depending on the degree and configuration of their hearing loss. They underwent the audiologic evaluation research protocol, comprising pure-tone audiometry and uncomfortable loudness level (UCL) testing. Pure-tone audiometry was conducted in an acoustic booth using the Callisto Audiometer – Interacoustics, with supra-aural headphones.

Uncomfortable loudness level testing was performed with a pulsed pure tone of two seconds duration, with a one-second interval between each presentation, at frequencies of 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, and 4000 Hz, starting from 80 dB HL in ascending mode, at 5 dB intervals. If discomfort was reported by the patient, attempts were made to confirm this level with new presentations at the same or nearby level, conducting the procedure separately for each ear and immediately repeating (test-retest situations). Logoaudiometry was also performed, including the Percent Correct Speech Recognition Index (PCRI) and Speech Recognition Threshold (SRT)[14].

Assessments and adjustments in hearing aids were performed according to the internationally validated prescriptive method NAL/NL 2 (National Acoustics Laboratories/Nonlinear 2).

Fine-tuning was conducted based on the patient's auditory needs. Subsequently, the speech self-perception algorithm was activated via software.

For voice calibration, the patient was comfortably seated in a chair without a headrest, positioned at least one meter away from walls and reflective objects, as such interferences could compromise the three-dimensional scanning of the individual's head in relation to their own mouth (sound source). Additionally, the patient was instructed not to move and not to stand in front of the computer during scanning due to potential visual interference.

After following the above instructions, the software itself indicated the next step for activating voice self-perception. Following a bilateral beep, the patient was instructed to count aloud continuously starting from the number 21, as the software needed to identify uninterrupted speech without pauses.

During this calibration, the microphones were automatically activated to acoustically digitize the user's head effects, enabling recognition of the user's speech. This algorithm was activated when the hearing aids were positioned behind the user's auricle. Upon completion of the acoustic scan, the algorithm was enabled concurrently with the user's speech and disabled when the user finished speaking.

Once the scan was completed, the software indicated "successful training," a feature that, when activated, allows the algorithm to be worked on in three ways: minimum, standard, and maximum. The software initially activates the standard mode. However, for this study, the maximum form of the feature was utilized for better visualization of potential changes.

After activating this algorithm, the adjustment of the hearing aids was recorded in the adaptation software database, followed by in-situ electroacoustic verification using the Interacoustics Callisto equipment.

The Visible Speech Mapping (VSM) protocol was applied, in which the International Speech Test Signal (ISTS) stimulus was presented at 65 dB SPL. The ISTS stimulus was created from speech recordings in six different languages (German, English, French, Spanish, Arabic, and Mandarin) and is completely unintelligible but internationally accepted for hearing aid verification[15].

Prior to the electroacoustic verification, the calibration of the microphones of the Callisto equipment verification system was performed. Subsequently, the participant was seated, positioned 80 cm from the equipment's speaker. A resonance response of the outer ear was obtained, a measurement reflecting the natural amplification of the outer ear [pinna, concha, and external auditory canal (EAC)] left unoccluded.

Following this, the Real Ear Occluded Response (REOR) was performed, which measures the difference in decibels between the signal level measured at the external auditory canal (EAC) and at the level of the tympanic membrane and at the entrance of the auricular pavilion with the hearing aids turned off in the patient's ear. The same ISTS signal at 65 dB SPL was used to assess whether there was loss or modification of the natural amplification provided by the structures of the outer ear when the receiver was inserted into the EAC, as this measurement also allows visualization of whether the selected coupling type is suitable for the patient[16].

Following the REOR measurements, the Real Ear Aided Response (REAR) was performed, which is the frequency response of the hearing aids in operation in the auricular pavilion. The ISTS stimulus at 65 dB SPL was used. This measurement aimed to verify if the targets prescribed by the selected method (NAL/NL2) were achieved. Adjustments were made as necessary, and under this amplification condition, bilateral SII values were collected. The Speech Intelligibility Index (SII) allows quantifying the percentage of access to speech sounds by accounting for the signal captured near the patient's tympanic membrane[8].

These values were obtained under two conditions: with the speech self-perception algorithm deactivated and with the speech self-perception feature activated.

The statistical method consisted of descriptive and inferential statistics. The SPSS Statistics software, version 28.0 (IBM Corp, Armonk, NY, USA), was used. The adopted level of statistical significance was 5% ($p \leq 0.05$).

For the calculation of 95% confidence intervals, the bias-corrected and accelerated method based on 1000 bootstrap samples was used. The values within brackets in the results tables indicate the upper and lower limits of the 95% confidence intervals.

The interpretation of effect sizes followed a classification[17] proposing the following criteria: for the coefficient d, the following criteria were defined: small: between |0.200| and |0.499|; medium: between |0.500| and |0.799|; large: above |0.800|. For the coefficient r and correlation coefficients, the following criteria were adopted: small: between |0.100| and |0.299|; medium: between |0.300| and |0.500|; large: above |0.500|.

The theoretical basis used for the detailed statistical analysis can be found in the referenced work[17].

RESULTS

The effect of the speech self-perception algorithm was measured in 40 elderly individuals aged 60 to 80 years, including 24 women.

Measures of central tendency and dispersion of tonal auditory thresholds by frequency were calculated for the 40 elderly individuals, according to the ear side. The mean tonal thresholds at frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz were 54.72 dB HL (±12.57) in the right ear and 51.94 dB HL (±13.37) in the left ear (Table 1).

Measures of central tendency and dispersion of the Speech Recognition Threshold (SRT) and Percent Correct Speech Recognition Index (PCRI) were calculated according to the ear side. The mean PCRI was 65.78% (±17.63) in the right ear and 66.95% (±19.11) in the left ear. The mean SRT in the right ear was 52.45 dB HL (±16.20) and 54.88 dB HL (±21.41) in the left ear (Table 2).

The mean data logging was 10.62 hours in the right ear and 10.75 hours in the left ear. The mean Speech Intelligibility Index (SII) without hearing aids was 26.70% in the right ear and 29.50% in the left ear, and after appropriate adjustments, it was approximately doubled, both with the speech self-perception algorithm activated and deactivated (Table 3).

Comparisons between PCRI and SII with and without activation of the speech self-perception algorithm were made based on the measures of central tendency and dispersion of SII according to the ear side, using the paired samples t-test. The results showed a statistically significant difference between the SII obtained with the speech self-perception algorithm activated and deactivated conditions (Table 4).

Table 1. Sample characterization of the study regarding pure-tone audiometric thresholds according to the ear

Pure-Tone Audiometry	Ear	n	Mean	SD	Median	Min.	Max.
250 Hz (dB HL)	RE	40	34.25	15.21	30.00	5.00	70.00
	LE	40	33.63	14.72	32.5	10.00	60.00
500 Hz (dB HL)	RE	40	42.13	15.27	40.00	5.00	75.00
	LE	40	40.13	15.17	42.50	10.00	70.00
1000 Hz (dB HL)	RE	40	47.63	13.73	45.00	20.00	70.00
	LE	40	45.38	15.50	45.00	20.00	75.00
1500 Hz (dB HL)	RE	6	58.33	17.51	52.50	40.00	80.00
	LE	4	41.25	6.29	40.00	35.00	50.00
2000 Hz (dB HL)	RE	40	59.12	16.87	60.00	25.00	105.00
	LE	40	55.62	15.28	52.50	25.00	95.00
3000 Hz (dB HL)	RE	40	65.50	16.08	60.00	35.00	110.00
	LE	40	63.25	15.95	60.00	40.00	110.00
4000 Hz (dB HL)	RE	40	70.00	16.01	70.00	35.00	110.00
	LE	40	66.62	16.15	65.00	35.00	110.00
6000 Hz (dB HL)	RE	40	68.87	15.08	70.00	40.00	100.00
	LE	40	69.25	15.55	67.50	30.00	100.00
8000 Hz (dB HL)	RE	40	77.00	16.52	75.00	35.00	100.00
	LE	40	75.50	15.18	75.00	30.00	100.00
Median (dB HL) (500, 1k, 2k and 4k Hz)	RE	40	54.72	12.57	53.75	30.00	82.50
	LE	40	51.94	13.37	50.00	30.00	81.25

Subtitle: n = Number of patients; SD = Standard deviation; Min. = Minimum; Max. = Maximum; dB HL = Decibels Hearing Level; Hz = Hertz; k = is used as an abbreviation for 1000; RE = Right ear; LE = Left ear

Table 2. Characterization of the study sample regarding the parameters of speech audiometry: Speech Recognition Threshold and Percentage of Speech Recognition according to the ear

Speech Audiometry	Ear	n	Mean	SD	Median	Min.	Max.
PCRI – Mono (%)	RE	40	65,80	17,63	66,00	28,00	100,00
	LE	40	66,95	19,11	74,00	20,00	92,00
SRT (dB HL)	RE	40	52,45	16,20	55,00	10,00	85,00
	LE	40	54,88	21,41	55,00	15,00	95,00

Subtitle: n = Number of patients; SD = Standard deviation; Min. = Minimum; Max. = Maximum; % = Percentage; dB HL = Decibels Hearing Level; PCRI = Percentage of Speech Recognition; SRT = Speech Recognition Threshold

Table 3. Characterization of the study sample regarding the Speech Intelligibility Index according to the ear and the activation of the self-perception algorithm for speech, and characterization of the study sample regarding Data Logging according to the ear.

SII	Ear	n	Mean	SD	Median	Min.	Max.
Without hearing aids (%)	RE	40	26.70	21.40	26.50	0.00	79.00
	LE	40	29.50	22.83	24.00	0.00	73.00
With hearing aids and self-perception algorithm disabled (%)	RE	40	58.93	14.77	58.00	30.00	85.00
	LE	40	63.15	15.13	64.50	34.00	89.00
With hearing aids and self-perception algorithm enabled (%)	RE	40	57.85	14.80	55.50	29.00	86.00
	LE	40	61.90	15.29	64.00	34.00	85.00
DL (hours)	RE	40	10.62	4.02	11.50	2.00	18.00
	LE	40	10.75	4.00	12.00	2.00	18.00

Subtitle: SII = Speech Intelligibility Index; n = Number of patients; SD = Standard deviation; Min. = Minimum; Max. = Maximum; % = Percentage; RE = Right Ear; LE = Left Ear; DL = Data Logging

Table 4. Descriptive values and comparative analysis of conditions with and without the self-perception speech algorithm according to the ear regarding the Speech Intelligibility Index

Variable	Ear	*My Voice*	n	Mean	SD	Median	Min.	Max.	p-value	Effect Size
SII (%)	RE	No	40	58.93	14.77	58.00	30.00	85.00	< 0.001*	0.073
		Yes	40	57.85	14.80	55.50	29.00	86.00		
	LE	No	40	63.15	15.13	64.50	34.00	89.00	< 0.001*	0.082
		Yes	40	61.90	15.29	64.00	34.00	85.00		

*Paired samples t-test

Subtitle: n = Number of patients; SD = Standard deviation; Min. = Minimum; Max. = Maximum; SII = Speech Intelligibility Index; % = Percentage; RE = Right Ear; LE = Left Ear; < = less than

Table 5. Correlation analysis of the Percent Speech Recognition Index with the Speech Intelligibility Index with and without the self-perception speech algorithm for the right ear and left ear

Variable	SII			
	Deactivated self-perception speech		Activated self-perception speech	
	Coef.	p-Value	Coef.	p-value
PCRI RE	0.443 [0.120, 0.724]	0.004*	0.443 [0.123, 0.729]	0.004*
PCRI LE	0.418 [0.054, 0.655]	0.007*	0.428 [0.048, 0.669]	0.006*

*Statistically significant value at the 5% level ($p \leq 0.05$)

Subtitle: SII = Speech Intelligibility Index; Coef. = Correlation coefficient; PCRI = Percent Speech Recognition Index; RE = Right Ear; LE = Left Ear

The measurement made with the speech self-perception algorithm activated showed a lower mean SII compared to the deactivated condition.

The correlation analysis of PCRI and SII, using Pearson's correlation test, with and without the speech self-perception algorithm, revealed equally statistically significant and positive correlations for both ears. That is, an increase in one variable was associated with an increase in the other variable: a) PCRI and SII with the speech self-perception algorithm deactivated; b) PCRI and SII with the speech self-perception algorithm activated (Table 5).

DISCUSSION

The quality and effectiveness of hearing aid algorithms, increasingly abundant, remain perpetual reasons for new research endeavors aimed at providing improved auditory experiences for hearing-impaired individuals. However, it is imperative to investigate their benefits, as algorithms may also introduce amplification distortions, thereby compromising the sound quality received by the patient[4,5].

In order to investigate the effect of the speech self-perception algorithm in hearing aid users, an objective evaluation was conducted through probe microphone verification, utilizing a speech stimulus at 65 dB SPL, and determining the Speech Intelligibility Index (SII).

Therefore, it was chosen to assess elderly individuals with predominantly moderate symmetrical sensorineural hearing loss (only one patient exhibited mean thresholds consistent with severe hearing loss), as this demographic constitutes the elderly population with the highest prevalence of hearing impairment[9]. Hearing loss exponentially increases in the elderly population[10]. In this study, the elderly participants were required to exhibit certain audiologic characteristics to enable the evaluation of the effect of the speech self-perception algorithm on amplification (for example, having audibility of their own voice).

As a result, 40 elderly individuals with ages ranging from 60 to 80 years and similar audiologic characteristics were evaluated. The mean threshold was 54.72 dB HL and 51.94 dB HL for the right and left ears, respectively. The mean Speech Recognition Threshold (SRT) was 52.45 dB HL in the right ear and 54.88 dB HL in the left ear, and the mean Percent Correct Speech Recognition Index (PCRI) was 65.80% (±17.63) for the right ear and 66.95% (±19.11) for the left ear.

Descriptive statistics of the data logging, categorized by ear, revealed an average daily usage of 10.62 hours (±4.02) for the right ear and 10.75 hours (±4.00) for the left ear. This finding indicated that the patients were effectively utilizing their devices bilaterally, facilitating acoustic stimulation of the auditory pathways throughout most of the day. As known, this finding is positive since acoustic stimulation through the use of hearing aids can reverse cortical reorganization occurring in sensory deprivation[18] and reduce the risk of cognitive decline and depressive symptoms[19]. More than 50% of individuals were utilizing their hearing aids for ten hours or more per day. The data obtained from the data logging demonstrated that the device settings should be adequate and satisfactory to enable effective use. Increased acceptance and usage occur due to improvements in daily life activities.

Through the descriptive characteristics of the presented audiological measures, it was observed that the elderly participants exhibited similar mean thresholds, as well as results from speech audiometry. The hearing losses were symmetrical and susceptible to substantial improvement in the Speech Intelligibility Index (SII) as they were predominantly moderate in severity[20]. The Speech Recognition Threshold (SRT) and Percent Correct Speech Recognition Index (PCRI) were consistent with the degree of hearing loss, and the elderly participants were effectively utilizing amplification.

The objective of amplification is to improve audibility and access to speech sounds. Greater access to speech sounds may lead to improved speech recognition, facilitating better communication and reducing the adverse impacts of hearing loss[18].

However, when quantifying access to speech sounds without the algorithm enabled, an average Speech Intelligibility Index (SII) of 58.93% (±14.77) was obtained in the right ear and 63.15% (±15.13) in the left ear. With the algorithm enabled, the average SII was 57.85% (±14.80) in the right ear and 61.90% (±15.29) in the left ear. In other words, there was a reduction in the percentage of access to speech sounds with the enabled algorithm, and this reduction was significant. Although it is possible to enable or disable the algorithm in the manufacturer's software, it is known that even when enabled, it is triggered by the patient's own voice emission. However, the verification was conducted with the International Speech Test Signal (ISTS) and not with the patient's own voice. Despite the advanced mathematical calculations that allow the development of different algorithms, in certain situations, they may fail due to various environmental conditions. Hence the importance of investigating the effect of different algorithms on the amplification received by the user under more objective conditions, which was the motivation for the present research.

It is worth noting that the SII, which represents access to speech sounds, is not directly related to the performance the patient will have according to their hearing loss, regardless of the listening situation and difficulty, as speech understanding does not depend exclusively on audibility. Thus, each individual may use auditory information in different aspects, including selective attention (figure-background and closure), cognition, and education[18].

These results revealed that during the test with the algorithm enabled in the maximum mode, there was a significant reduction in acoustic gain for the interlocutor's speech. It was believed that there would be no compromise in audibility with the enabled algorithm; however, a reduction in the SII percentage of approximately 1.5% was observed, which is considered significant, albeit small in absolute values, given the total possible variation (0 to 100%).

However, an important question arises: "Could the user's performance actually be compromised by a 1.5% reduction in moderate losses?"

The correlation study between the Percent Correct Speech Recognition Index (PCRI) and the SII with and without the speech self-perception algorithm enabled revealed a statistically significant positive correlation in both ears. In the right ear, with the algorithm disabled, a correlation coefficient of 0.443 [0.120, 0.724] p = 0.004* was observed; with the algorithm enabled, a coefficient of 0.443 [0.123, 0.729] p = 0.004* was observed. In the left ear, with the algorithm disabled, a correlation coefficient between PCRI and SII of 0.418 [0.054, 0.655] p = 0.007* was observed; with the algorithm enabled, a coefficient of 0.428 [0.048, 0.669] p = 0.006 was observed.

While there is an assumption that greater access to speech sounds leads to better Percent Correct Speech Recognition Index (PCRI), it is known that increased time of acoustic stimulation and cognition, among other factors, contributes to improving the communicative performance of patients with hearing loss[21]. In this regard, a study conducted[18] to identify the correlation between Speech Intelligibility Index (SII) and PCRI through the analysis of records of 55 patients revealed a correlation between SII and PCRI, albeit weak.

Despite the relevance of complaints from patients using hearing aids regarding discomfort with their own voice, in order for the self-perception algorithm not to impair access to speech sounds specifically, one may question whether improving the complaint of one's own voice is more important than the loss of audibility.

A limitation of the present study is the lack of subjective analysis of user self-perception. Additionally, the analysis was performed only with the algorithm activated in the "maximum" mode.

What can be concluded is that algorithms can interfere with amplification negatively, regardless of how or to what extent they interfere. Different studies have assessed the effect of specific algorithms on the performance of their users, and the results are varied[22-24].

Therefore, professionals should be aware of these possibilities. Hence, more studies are needed to assess the effects of different algorithms on the perception of speech signals.

CONCLUSION

The present research identified that the Speech Intelligibility Index (SII) is lower with the self-perception speech algorithm enabled.

ACKNOWLEDGMENTS

Raphael Fernandes da Silva, Maria das Graças Pereira da Silva, Elida Kaminskas Manfrinato, Aline Yoshie Fujii Katatani and Claudia Santos

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