Reference values for amplified speech Intelligibility index (SII) according to the DSL*m*[i/o]v5 prescription

Valores de referência para o índice de Inteligibilidade de fala (SII) amplificado de acordo com a regra prescritiva DSL*m*[i/o]v5

Valores de referencia para el índice de inteligibilidad de discurso (SII) amplificado según la regla prescriptiva DSL*m*[i/o]v5

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Abstract

Objective: *build the reference curves for amplified SII values of speech signal in the intensities of 55 and 65 dB NPS, considering the differences between targets prescribed by DSLm[i/o] v5 and the curves obtained in the verification process, as a criterion for a proper amplification, noting the limitations of amplification for the different degrees of hearing loss configurations.* ***Methods:*** *41 children aged between 3 and 80 months participated in the study, totalizing 78 ears. Auditory thresholds at 250, 500, 1000, 2000, 4000 Hz were considered and SII values for the input signals 55 and 65 dB NPS were obtained in*

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Authors' contributions: RSLF Research project planning (doctorate degree): bibliographical and methodological study, collection and analysis of data. Production and reviewing. BCAM Research project evaluation. Final text review. TMD Final text review, including data analysis. MCVC Data collection. Review the final text. BCACN Supervisor of the research project that lead to this article: methodological study, data analysis. Production and reviewing the final text.

Funding: This study is originated from a Phd thesis supported by CAPES - PROSUP.

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Received: 07/05/2016
Accepted: 07/09/2016

the Verifit®Audioscan hearing aid analyzer. ***Results:*** *All hearing aids were set as close to the target as possible. According to degree and configuration of the hearing loss, limitations in amplification were observed. Reference curves and equations to predict amplified SII values for the intensities of 55 and 65 dBNPS were generated.* ***Conclusion:*** *reference curves for amplified SII values were built and equations were generated to predict SII values according to audiological characteristics, and features can be included in protocols of indication of sound amplification and indicate the audiologic follow-up. Reference curves and equations do not override the verification process.*

Keywords: *Speech Intelligibility; Hearing Aids; Hearing Loss*

Resumo

Objetivo: *construir curvas de referência para valores de SII amplificado com sinal de fala nas intensidades de 55 e 65 dB NPS, considerando as diferenças entre os alvos prescritos pela regra DSLm[i/o] v5 e as curvas de resposta obtidas na verificação da amplificação, em função de frequências obtidas na verificação dos AASI, como critério para uma amplificação adequada, observando as limitações da amplificação para os diferentes graus e configurações de perda auditiva.* ***Método:*** *foram selecionadas 41 crianças com idades entre três e 80 meses, totalizando 78 orelhas. Foram considerados limiares auditivos nas frequências de 250 a 4000 Hz e analisados valores de SII para os sinais de entrada 55 e 65 dB NPS, obtidos na verificação da amplificação no equipamento Verifit®Audioscan. Resultados: A partir das curvas de resposta obtidas na verificação da amplificação registraram-se valores de SII. Todos os aparelhos de amplificação foram ajustados o mais próximo do alvo possível. Limitações na amplificação foram observadas de acordo com grau e configuração da perda auditiva. Curvas de referência e equações para prever valores de SII amplificado nas intensidades de 55 e 65 dBNPS foram geradas.* ***Conclusão:*** *Curvas de referência para valores de SII amplificado foram construídas e equações foram geradas para prever e avaliar os valores de SII de acordo com as características audiológicas e podem ser incluídas nos protocolos de indicação da amplificação sonora e acompanhamento audiológico. As curvas de referência e equações não substituem o processo de verificação dos aparelhos de amplificação.*

Palavras-chave: *Inteligibilidade da Sala; Auxiliares de Audição; Perda Auditiva*

Resumen

Objetivo: *construir curvas la referencia para los valores de la señal de voz amplificada de SII en las intensidades 55 y 65dB NPS, teniendo en cuenta las diferencias entre los objetivos previsto en la regla DSLm[i/o]v5 y respuesta curvas obtenidas en la verificación de amplificación, en función de la frecuencia obtenida en la verificación del audífono, como criterio para una amplificación adecuada, teniendo en cuenta las limitaciones de amplificación para los diferentes grados de configuraciones de la pérdida de la audición.* ***Métodos:*** *hemos seleccionado 41 niños entre 3 y 80 meses, total de 78 orejas. Se considera audiencia umbrales en las frecuencias 250 - 4000Hz y se analizaron valores SII de la señales de entrada 55 y 65 dB NPS, obtenidos en la verificación de equipo amplificación Verifit®Audioscan.* ***Resultados:*** *de las curvas de respuesta obtenidas en la verificación de los valores registrados de amplificación SII. Todos los dispositivos de amplificación se fijan lo más cerca la meta como sea posible. Limitaciones de amplificación según el grado y la configuración de la pérdida auditiva. Se generaron ecuaciones para predecir valores de SII amplificaron en las intensidades 55 y 65 dBNPS y curvas de referencia.* ***Conclusión:*** *curvas de referencia para valores SII amplificado se construyeron y fueron generado ecuación para predecir y evaluar los valores SII según el audiologic y características pueden ser incluidas en protocolos de indicación de amplificación de sonido e indican el seguimiento audiológico. Ecuaciones y curvas de referencia no anular el proceso de verificación de dispositivos de amplificación.*

Palabras claves: *Inteligibilidad del Habla; Audífonos; Pérdida Auditiva*

Introduction

The appropriate amplification parameters should consider the audibility and the intelligibility of speech without discomfort and with sound quality in all environment conditions[1]. In this sense, the verification stage is of paramount importance in order to check and adjust amplification characteristics in each case, after the programming of hearing aids (HA) using the *software* of the manufacturers.

According to some studies[2,3], not to check the devices according to prescriptive rules based on evidence is to neglect the importance of audibility of all speech sounds with quality for users of hearing aids (HA), especially in the pediatric population undergoing development language and who is not able to speak about the sound quality.

The DSL prescriptive rule was designed to meet the acoustical needs of the pediatric population, assuming that the speech sounds are the most important ones[4,5]. The current version of the rule is the DSL*m*[i/o]v5, available in proprietary software of some amplification devices brands and in some hearing aids (HA) verification equipment.

In this sense, to evaluate the adequacy of the amplification according to validated prescriptive rules becomes a decisive stage in the hearing aid (HA) selection process.

Indexes that estimate speech intelligibility can contribute to the qualitative analysis during the verification stage. The calculation of the SII - Speech Intelligibility Index - is automatically available in some HA verification equipment, based on the response curves regarding frequencies of amplification checked for different input signal intensities.

The SII has a high correlation with speech intelligibility, because it determines the portion of the speech that is audible and useful to the listener[6]. It can also be used as a measure to assess the adequacy of amplification in addition to providing interference of the distance to the audibility of speech sounds in each case and, thus, guiding the clinician and the family in regard to therapeutic strategies that guarantee access to all speech sounds[8].

This is one of the reasons why the team from the University of Western Ontario has developed a pediatric follow-up protocol (UWO PedAMP)[7] which includes questionnaires on language development and SII data to assess the adequacy of the amplification in each case. On the amplification data, the protocol provides normative data SII values in relation to the average of thresholds at 500, 1000 and 2000 Hz. The protocol was used in the last five years and the results on the development of language and data on the amplification have been described by the group, which shows once again the importance of adequacy of the amplification and the importance of care audibility for developing the child's speech and appropriate language[9].

In this perspective, being aware of reference values for the speech intelligibility index related to the characteristics of hearing loss, considering the limitations of amplification inherent in different degrees and configurations of hearing loss, can be of great value in routine clinical treatments.

Therefore, the objective of this study was to build reference curves for amplified SII values with speech signal intensities of 55 and 65 dB SPL, considering the targets prescribed by DSL*m*[i/o]v5 and response curves, based on the frequency obtained in the verification of hearing aids as criterion for an adequate amplification, while observing the limitations of amplification for the different degrees and configurations of hearing loss, from the data obtained during the verification of the amplification in a study proposed by Figueiredo et al[10].

Methods

Place of research and ethical principles

This study was conducted at Centro Audição na Criança (CeAC) Center of Child Hearing associated to DERDIC/PUC-SP, the Division of Education and Rehabilitation of Communication Disorders at the Pontifical Catholic University of São Paulo - Divisão de Educação e Reabilitação dos Distúrbios da Comunicação da Pontifícia Universidade Católica de São Paulo - to the Program of Postgraduate Studies in Speech/Line of Research Audit in Children, Faculty of Human and Health Sciences at PUC-SP. This is a highly complex service accredited by the Unified Health System (SUS – Sistema Único de Saúde), which provides care to children below three years of age suspected or already diagnosed as having hearing loss.

Belonging to a larger study project on the process of selecting hearing aids for babies in their first years of life, this project followed the regulations established in the code of ethics for research with human beings, and was approved by the PUC-SP's ethics committee, in agreement to the protocol of research No 337/2010.

Research subjects

The study included 41 patients, ranging from three months to 80 months of age, of which six (14.6%) were up to 12 months of age, 11 (26.8%) were between 12 and 24 months of age, 13 (31.7%) were between 24 and 38 months of age and 11 (26.8%) were between 39 and 80 months of age. They were all diagnosed with sensorineural hearing loss of any degree and configuration. They participated in the process of hearing aid selection during the year 2011, a total of 78 ears for analysis. Two ears of subjects who were cochlear implant users and two ears of two subjects with anacusis were excluded from the analysis. Nonlinear hearing aids were indicated for all children.

The analyzed ears were classified according to the groups suggested by Figuereido et al[10]. Figure 1 summarizes the audiological characteristics of each group.

Groups	Audiological characteristics
Gr1	Profound degree/horizontal configurations
Gr2	Profound degree/mild descending configuration
Gr3	Profound degree/sharp or in ramp descending configurations
Gr4	Profound and severe degree up to 90dB HL/horizontal and mild descending configurations
Gr5	Moderate and severe degree up to 66dB HL/ horizontal and mild descending configurations

Figure 1. Classification of hearing loss per group according to Figueiredo et al (2016)

Material

For verification of hearing aids (HA):

Model equipment Verifit®Audoscan.

This is a scan of hearing aids that checks the electroacoustic performance of hearing aids in 2cc coupler and measurements with probe microphone.

For verification measures in coupler or *in situ* based on response curves of HA, depending on the frequencies obtained with a speech input signal, the device calculates SII values in percentage for a 65 dB SPL input without amplification and, with amplification, it calculates SII values for different speech stimuli inputs, at the intensities 40-75 dB SPL. The calculation performed by the equipment uses a 1/3 octave frequencies method described by ANSI S3.5-1997 without considering the frequency band of 160 Hz and no masking noise, that is, the equipment calculates the SII for an ideal environment[11].

The SII values are represented on a scale ranging from 0% to 100%, where 0% means no audibility and 100 means audibility for all speech sounds.

The stimulus used for the verification of hearing aids in all measures was Standard-speech (Speech-std 1) – Carrot passage.

For hearing aids programming:

NOAH System 3.0 program with *softwares* of the HA manufacturers and the Hi-Pro USB programming interface.

Procedures

Determination of auditory thresholds for analysis

Hearing threshold used in programming of the devices were determined based on audiological evaluation, according to the protocol established by the staff of the institution. Whereas the threshold used in the analysis were: 250, 500, 1000, 2000 and 4000 Hz. When the answer to the frequencies were absent up to the limit of the equipment, the value considered was recorded in Noah® software for programming of hearing aids, which generally uses the maximum values of the audiometer AC-33 by *Interacoustics*, namely: to the frequency 250 Hz, the maximum of the equipment is 105 dB; for 500 Hz, the maximum is 110 dB; for 1000, 2000 and 4000 Hz, it is 120 dB. For the ears in which the frequency 250 Hz was not recorded, the 250 Hz threshold was considered equal to the frequency 500 Hz.

Obtaining values SII

Based on the threshold established in the diagnostic process, hearing aids were selected and programmed according to the prescriptive rule DSL*m*[i/o]v5. RECD measures with ear molds were produced. When that was not possible, we used the values predicted by the Verifit®Audioscan equipment.

With hearing thresholds and RCED (measured or predicted), the hearing aids were programmed through the *software* of the respective device companies. Features such as compression frequencies or transposition frequencies*, when available for the model of hearing aids, have been disabled.

In the Verifit®Audioscan equipment, verification measurements were performed for speech sounds of 55, 65 and 75 dB SPL and maximum output MPO (90 dB SPL) in the coupler. To determine the values similar to the electroacoustic characteristics of prescribed gain and output in the DSL*m*[i/o]v5 software and the values found in hearing aids, the difference of 3 positive or negative dB was used. A study[12] reported that exceeding these values may mean over or under amplification.

This study analyzed the SII values for speech stimuli 55 and 65 dB SPL.

During the verification process of hearing aids, SII values were obtained for each ear studied, totaling 156 SII values.

Data analysis

Analyses of the differences between target and the response curve based on the frequencies obtained in the programming of the hearing aids

Differences were analyzed between the given target by the prescriptive rule DSL*m*[i/o]v5 and the response curve of the frequency function. They were obtained in the verification of hearing aids in the five frequencies studied (250, 500, 1000, 2000 and 4000 Hz). In addition, the percentage of ears with difference higher than 3 dB, in module, at each frequency and group was calculated.

Construction of reference curves for values of SII 55 and 65 dB SPL

Regression models were adjusted in order to describe the relationship between the SII 65 and the average of the thresholds at 500, 1000 and 2000 Hz, and between SII 55 and the average at 500, 1000 and 2000 Hz. Based on the results obtained in the adjustment of the models mentioned, reference curves were constructed for SII 65 and SII 55[13].

Results

Analysis of the difference between the target and the response curve based on the frequencies obtained in the programming of hearing aids.

It is at the verification stage of the hearing aid when we evaluate if the electroacoustic characteristics of the hearing aids are in agreement with the goals prescribed by the selected method (DSL*m*[i/o] v5) for setting the devices for each patient.

Based on the response curves of frequencies of the hearing aids obtained in the verification process, as for the different levels of test stimuli, it was possible to obtain the values of the SII and assess the adequacy of hearing aids to targets calculated by prescriptive rule. All the hearing aids were set as close as possible to the target required by regulation, for the three stimulus levels measured and the maximum output (MPO).

Figure 2 depicts the differences between the desired targets (according to DSL*m*[i/o] v5) and the values obtained for the verification of the hearing aids (by frequency and by group for the levels of 65 dB SPL). Horizontal lines representing the boundaries of 3 dB positive and negative have been added, as suggested by Scollie[12].

It is possible to observe that - at a frequency 4000 Hz - all the ears Gr1, Gr2 and Gr3 have lower difference (more negative) than -3 (or even that the difference is higher than the module 3), suggesting limiting amplification, inherent to auditory characteristics for higher frequencies.

* *Frequency transposition*: to transpose inaudible sounds at high frequencies into a low frequency zone. *Frequency compression*: to compress the bandwidth of the output signal frequency into a specific proportion where there is audibility.

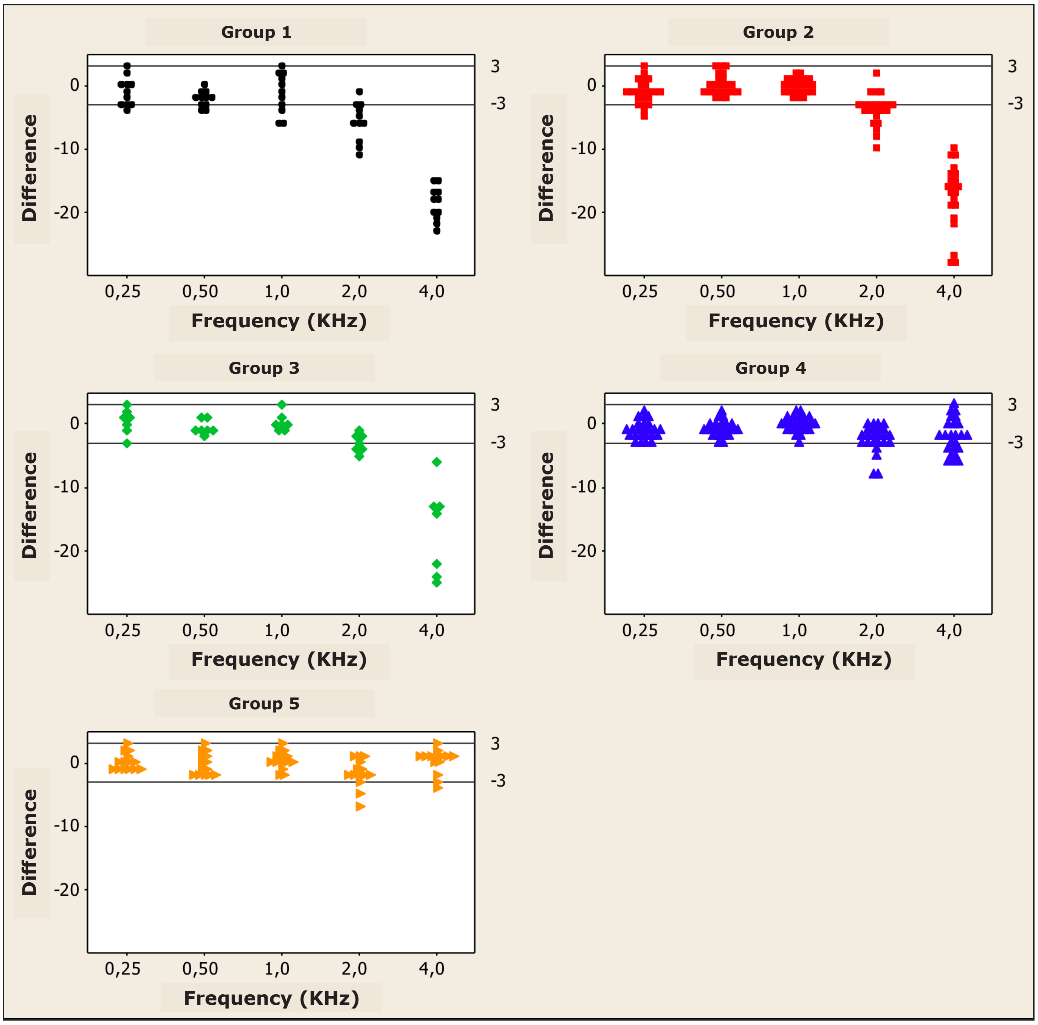

Figure 2. Differences between the desirable target and the obtained target in the verification of hearing aids HA per frequency and per group for intensity of 65 dB SPL

Table 1 shows the percentage of ears with absolute value of the difference higher than 3, in each group and frequency for the representation level at 65 dB SPL.

We noticed that, in general, the highest percentage of differences higher than 3, in absolute terms, ocurred in frequencies 2000 and 4000 Hz. These percentages are lower in Gr4 and Gr5, which are mostly groups composed by hearing loss ranging from severe to moderate, which have hearing dynamic range that is able to adjust to the hearing aid response curve in order to reach the intensity of 65 dB input signal SPL. However, a deficit is still observed in higher frequencies (2000 and 4000 Hz) in which it is not possible to achieve the desired target by the rule in some ears on those frequencies.

Figure 3 depicts the difference between the desirable target, according to DSL*m*[i/o]v5, and the target obtained in the verification of the hearing aid. The difference takes place by frequency and by group for the 55 dB SPL presentation levels. Horizontal lines representing the boundaries of positive and negative 3 dB have been added, as suggested by Scollie[12].

Table 1. Percentages of ears with absolute values of difference higher than 3 per group and per frequency for intensity of 65 dB SPL (n=78)

	Frequency (kHz)				
Group	**0.25**	**0.5**	**1**	**2**	**4**
Gr1	9	18.2	27.3	72.7	100
Gr2	9,1	0	0	50	95.5
Gr3	0	0	0	21.4	50
Gr4	0	0	0	16.7	33.3
Gr5	0	0	0	28.6	7.1
Total	3.8	2.6	3.8	35.9	62.8

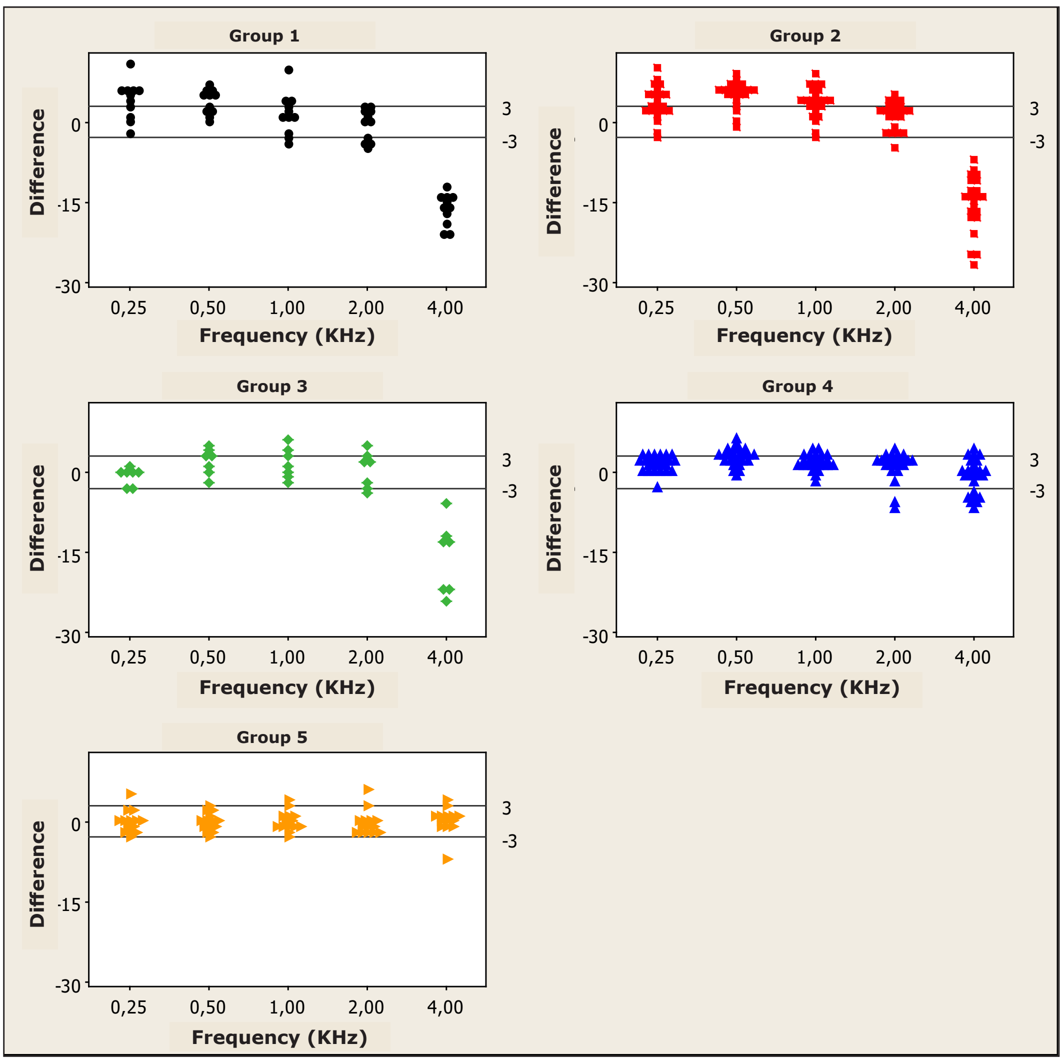

Figure 3. Differences between the desirable target and the obtained target in the verification of hearing aids per frequency and per groups for the intensity of 55 dB SPL

For the presentation level of 55 dB SPL, frequency 4000 Hz, all individuals of Gr1, Gr2, and Gr3 have a difference less (more negative) than -3 (or actually, the difference module is higher than three). It is also observed that, in general, the difference was higher (more positive) than 3 dB in the frequencies of 250, 500 and 1000 Hz for the ears of Gr1, Gr2 and Gr3. This suggests that the response curves related to frequency of weak input signal (55 dB SPL) exceed the prescribed values in the most severe degree of hearing loss with reduced dynamic range, because it is necessary to increase the gain for the strongest input levels (65 dB and 75 dB SPL) and, in most cases, the prescribed values for low intensity sounds are close to the auditory threshold or below it, out of hearing dynamic range.

For each group, Table 2 shows the percentages of ears with absolute value of difference higher than 3 (positive or negative) and the frequency for the presentation level of the signal in 55 dB SPL.

Table 2. Percentages of ears with absolute values of difference higher than 3 per group and per frequency for intensity of 55 dB SPL (n=78)

	Frequency (kHz)				
Group	**0.25**	**0.5**	**1**	**2**	**4**
Gr1	63.6	54.5	36.4	27.3	100
Gr2	45.5	81.8	59.1	22.7	100
G3	0	14.3	14.3	14.3	100
Gr4	0	25	8,3	12,5	33.3
Gr5	14.3	0	14.3	14.3	14.2
Total	23	41	28.2	17.9	64.1

It was noted that, in total, the difference in percentages higher than 3, in absolute value, are higher than the differences obtained in analyzing 65 dB SPL, except for the frequency of 2000 Hz (17.9%).

Overall, the Gr1, Gr2 and Gr3 showed higher percentages of difference that are higher than 3 in relation to Gr4 and Gr5.

Construction of reference curves for SII 55 and SII 65

Based on analyzes carried out with the amplification devices set as close as possible to the values prescribed by the DSL*m*[i/o]v5 rule, reference curves were constructed for values of amplified SII of 65 and 55 dB SPL, with the aim of providing a tool to support the clinician to be able to assess the adequacy of the amplification matching the hearing loss characteristics based on SII values.

An average of 500, 1000 and 2000 Hz frequencies was used in order to build the reference curves for the 55 and 65 SII values.

The choice of these frequencies for the construction of the reference curves of the amplified SII value for presentation levels of 65 and 55 dB SPL is due to the fact that, in many cases, hearing thresholds at all frequencies were not available at the beginning of the hearing aids recommendation.

Scatter diagrams of SII 55 and 65 and the average thresholds at the frequencies of 500, 1000 and 2000 Hz are found in Figure 4.

The relationship between the SII 55 and the average of the threshold at the frequencies of 500, 1000 and 2000 Hz can be adjusted with the following equation:

SII 55 set = 147.8 to 2.06 x average threshold + 0.007 average threshold^2.

The results obtained in the model setting are summarized in Table 3.

Reference curves of 95% for the SII 55 based on the average thresholds at 500, 1000 and 2000 Hz are shown in Figure 5. The upper and lower limit for SII to a certain value of the average threshold are given by:

Upper limit = 147.8 to 2.06 x average threshold + 0.007 average threshold^2 + 1.96 $\sqrt{16}$
Lower limit = 147.8 to 2.06 x average threshold + 0.007 average threshold^2 + 1.96 $\sqrt{16}$

where 16 is the average square of the residue obtained adjusting the regression model.

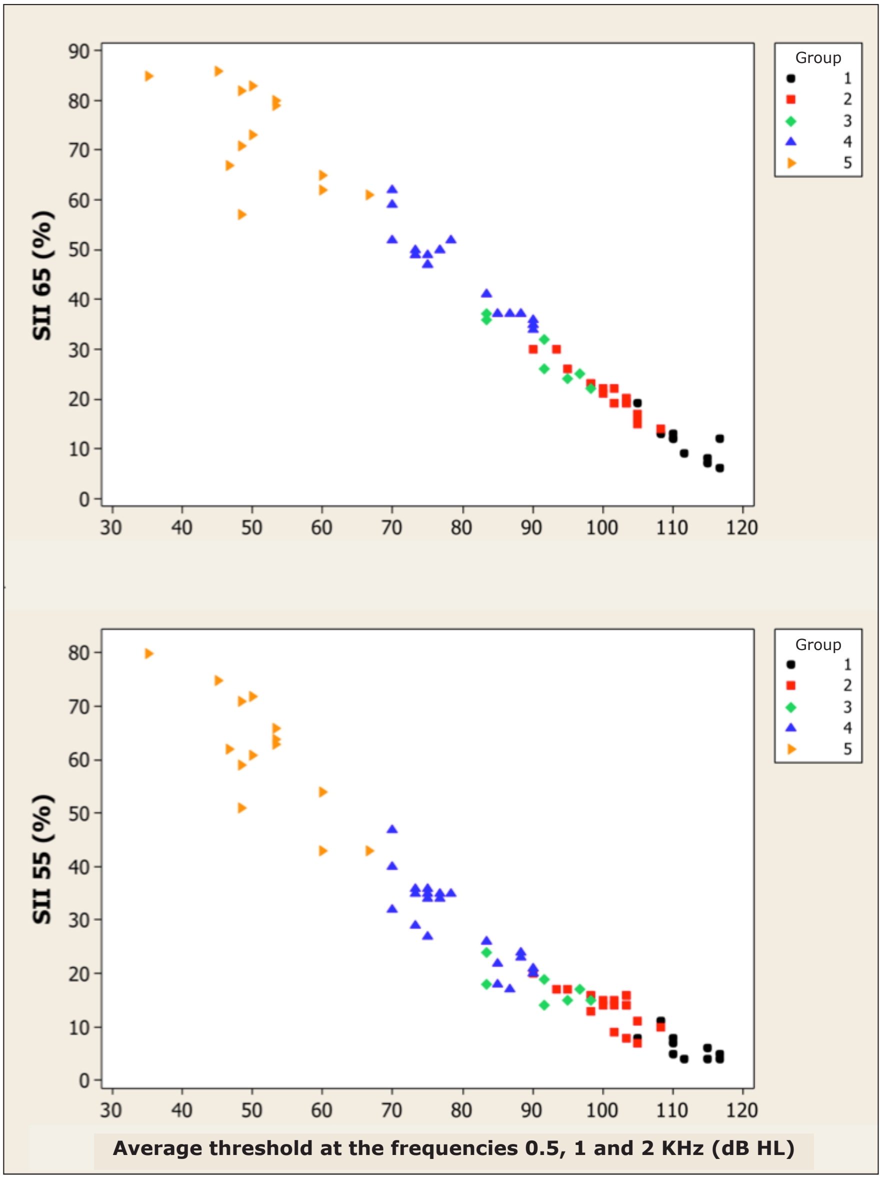

Figure 4. Scatter diagrams of SII 65 (top) and SII 55 (bottom) and the average of the hearing threshold at frequencies 500, 1000 and 2000 Hz

Table 3. Summary of the results obtained in adjusting the regression model with SII 55 as response variable, and the average of threshold at frequencies 500, 1000 and 2000 Hz as explanatory variable

Variable	Coefficient	Standard error	p	R^2
Constant	147.8	6.54	<0.001	0.96
Average	-2.06	0.17	<0.001	
Average ^{2}	0.007	0.001	<0.001	

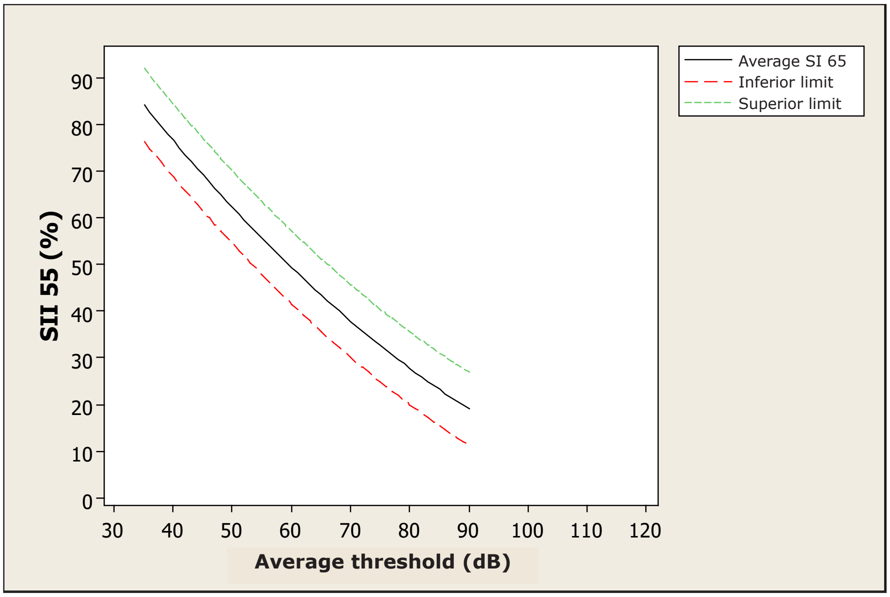

Figure 5. Reference curves of 95% for SII 55 in relation to the average thresholds at frequencies 500, 1000 and 2000 Hz

The relationship between the SII 65 and the threshold average at the frequencies 500, 1000 and 2000 Hz can be adjusted by the following equation:

SII 65 set = 131.3 to 1.09 x threshold average.

The results obtained in adjusting the model are summarized in Table 4.

References curves of 95% for the SII 65 based on the average threshold at 500, 1000 and 2000 Hz are shown in Figure 6. The upper and the lower limit for SII 65 to a given value of the average threshold are given by:

Upper limit = 131.3 to 1.09 x average threshold + 1.96 * $\sqrt{10}$
Lower limit = 131.3 to 1.09 x average threshold + 1.96 * $\sqrt{10}$

In the expressions mentioned above, value 10 corresponds to the average square value of the residue obtained in the regression model adjustment.

Table 4. Summary of the results obtained in adjusting the regression model with SII 65 as response variable, and the average of threshold at frequencies 500, 1000 and 2000 Hz as explanatory variable.

Variable	Coefficient	Standard error	p	R^2
Constant	131.30	1.63	<0.001	0.98
Média 500.1 e 2	-1.09	0.02	<0.001	

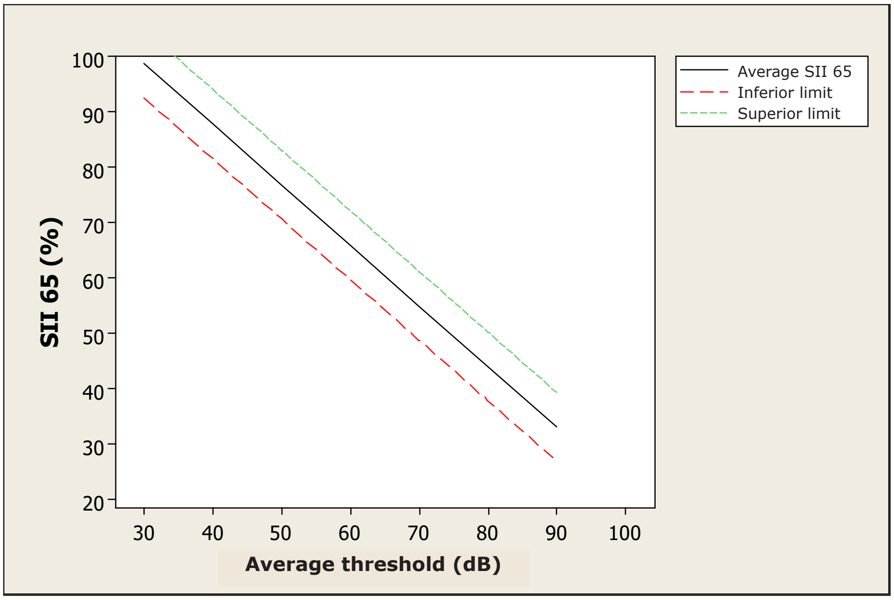

Figure 6. Reference curves of 95% for SII 65 in relation to the average thresholds at frequencies of 500, 1000 and 2000 Hz

Discussion

Based on the verification procedure and according to the prescriptive rule DSL*m*[i/o]v5, in this study it was possible to adjust the frequency response curves of hearing aids to different presenting levels of input signal for each ear. The SII values were obtained from a hearing aid programming with frequency response curves as close as possible to the target.

When analyzing the target output ratio for DSL*m*[i/o]v5, it is noted that, in the groups with greater hearing loss, the difference between target and output are higher. This is due to the limitations of hearing aids inherent to hearing loss with reduced dynamic range. We also observe that the frequency 4000 Hz is the one that most shows the difference between target and output, except Gr5, in which we find thresholds up to 85 dB HL and an ear at 95 dB HL.

The analysis of the differences between hearing aid target and output showed the limitations of amplification at certain frequencies and at certain degrees and hearing loss configurations.

It is possible to observe that for the presentation level of 65 dB SPL input signal in Gr1 and Gr2, all frequencies showed differences between the prescribed target and the hearing aid response, mainly at the frequencies 2000 and 4000 Hz, where the differences were higher and negative.

For the presentation level of 55 dB SPL input signal, the percentage of ears with absolute values of the difference higher than 3 were higher, when comparing the results to the input signal 65 dB SPL.

For frequencies up to 1000 Hz**,** positive differences higher than 3 dB were obtained between the target and the response curve in relation to the hearing aid frequency, because, in order to adjust the response curve of hearing aids to targets prescribed for the 65 dB NPS input signal, it is necessary to adjust the gain to the maximum power of the hearing aids. Consequently, low intensity sounds exceed the prescribed values that, in general, are out of the dynamic range of hearing,leading to the observed differences.

In Gr2 and Gr3, the amplification device programming seems to be effective only for access to high intensity sounds. The hearing aids do not provide audibility for intensity sounds of weak intensity.

In Gr3, Gr4 and Gr5, frequencies 2000 and 4000 Hz for intensity 65 dB SPL, differences were observed between the prescribed target and the value obtained in the verification of hearing aids.

In Gr3, percentages of absolute value were higher. In Gr4 and Gr5, percentages of values of differences were lower, showing that there are limitations of amplification at higher frequencies, even for hearing loss with lower average hearing thresholds.

Some models and hearing aid brands offer either compression frequency technology or transposition frequency technology that provides access to speech sounds with acoustic characteristics at high frequencies.

Studies on technologies that provide audibility speech for speech sounds at high frequencies, such as /s/ and /ʃ/, were performed in order to assess improvement in speech intelligibility[14–17]. This study does not consider this technology in the analysis of SII values generated during verification of hearing aids.

Therefore, regarding the suitability of frequency response curves based on the amplification devices related to the prescribed target, it was found that: for hearing loss with characteristics of Gr1, Gr2 and Gr3, the programming of hearing aids needs to be as close as possible to the prescribed target in order to ensure that high intensity sounds are within the dynamic range of the hearing, reaching at least the 1000 Hz frequency, aware of the fact that, for the weak input signal (55 dB SPL), the values may exceed the prescribed (up to 1000 Hz); for ears with characteristics of Gr4 and Gr5, the program needs to be up to 3 dB of positive or negative difference in the frequencies 250 to 1000 Hz and it needs to be the closest to the prescribed target ranging from 2000 to 4000 Hz frequency for input 65 and 55 dB SPL.

Such data are in line with the study[7] that referred the amplification adequacy criteria in different degrees of hearing loss so that it establishes SII reference values in the preparation protocol assessing results of the development on hearing impaired children between zero to six years of age

The verification of hearing aids in children is decisive to determine the adequacy of hearing aids for each case. Studies[2,3] have proved the need of verification in order to assess the appropriate audibility for each case, recommending the use of prescriptive rules, such as DSL*m*[i/o] v5, which are based on scientific evidence. The use of hearing aid manufacturers' rules is not advisable.

From the analysis, SII 65 and SII 55 reference curve values were built in order to assist speech language pathologists in assessing the adequacy of the amplification for each case.

The data found in this study relative to the reference curves for SII 65 values are in accordance with the curve proposed by the protocol developed by the University of Western Ontario (UWO PedAMP)[7] . The authors studied the SII values and determined reference values for conversational intensity (65 dB SPL).

In this study, in addition to the reference curves for 65 dB SPL, the reference values for the presentation level of 55 dB SPL input signal was also determined to evaluate the amplification for weak intensity speech sounds

The analyses were performed based on the average of the 500, 1000 and 2000 Hz frequencies due to the fact that often at the beginning of the hearing aids selection process in children, these are the first available. The pediatric audiological diagnostic protocols emphasize that the frequencies 500 and 2000 Hz are minimally necessary to establish degree and configuration of loss. Therefore, the beginning of the intervention process with hearing aids recommendation happens with the auditory thresholds in the available frequencies[18].

The SII values of reference curves can be included in the protocols of selection and adaptation of hearing devices as well as in audiological monitoring to assess the adequacy of the amplification, as suggested by the protocol UWO PedAMP[7,9].

Conclusion

For hearing loss with characteristics of Gr1, Gr2, and Gr3, the programming of hearing aids generally reaches the target prescribed for the 65 dB SPL input up to frequency 1000 Hz in Gr1 and Gr2 and up to frequency 2000 Hz in Gr3. Due to the very reduced hearing dynamic range and the need to prioritize the conversational input signal (65 dB SPL), the response curve based on frequencies for 55 dB SPL input end up exceeding the prescribed values;

For hearing loss ears with characteristics of Gr4 and Gr5, the programming of hearing aids generally reaches the prescribed target, with up to 3 dB of positive or negative difference infrequencies ranging from 250 to 2000 Hz for 65 and 55 dB SPL inputs. However, at the frequency 4000 Hz, it may not be possible to achieve the prescribed target. In these cases, it is necessary that the hearing aid response is as close as possible to the target, at the frequency 4000 Hz, for the 65 and 55 dB SPL inputs;

Reference curves with amplified SII values for input signal levels of 65 and 55 dB SPL presentation were built based on the criteria described in the above conclusions. The curves can be included in the protocols of selection and recommendation of hearing aids and audiological monitoring in order to contribute the adequacy of amplification, according to the prescriptive rule DSL*m*[i/o]v5, even when the SII values cannot be measured in specific equipments.

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