SPEECH RECOGNITION IN SKI SLOPE SENSORINEURAL HEARING LOSS

Estudo do reconhecimento de fala nas perdas auditivas neurossensoriais descendentes

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ABSTRACT

Purpose: to determine which aspects of the audiometric configuration influence speech recognition in ski slop sensorineural hearing loss. **Methods:** a survey of hospital records of patients treated at the Hearing Health Care in the period from March to July 2011 was performed selecting individuals above 18 years old and ski slop sensorineural hearing loss from mild to severe degree, with difference between the means of the frequencies of 0.25 to 2 kHz and 3-8 kHz greater than 15 dB HL. The sample of the study consisted of 30 patients (55 ears), 19 men and 11 women, aged between 26 and 91 years. Based on audiological evaluation, tests of speech recognition were correlated with different average hearing thresholds, including frequencies from 0,5 to 4 kHz. Furthermore, the differences in auditory thresholds between octave frequencies was studied and its impact on speech discrimination. **Results:** excellent correlation was found between the mean thresholds from 0,5 to 4 kHz with speech discrimination, this correlation being stronger with the inclusion of the frequencies of 3 and 4 kHz in tone average. However, increasing the difference in hearing threshold between octaves of frequencies, which implies a ski slop, did not interfere significantly on tests of speech recognition. **Conclusions:** based on the results of this study, we can conclude that the frequencies of 3 kHz and 4 kHz contribute to the speech intelligibility.

KEYWORDS: Speech Perception; Audiology; Hearing Loss; Audiometry, Speech.

INTRODUCTION

In order for verbal communication to be efficient, good speech reecognition is crucial. This depends on the acoustical characteristics of the words and good auditory perception, as well as suprasegmental features. Vowels, whose range of frequency varies between 0.4 and 0.5 kHz, concentrate the greatest amount of acoustical speech energy, while intelligibility relies on consonant sounds, which have a sound spectrum with frequencies above 2 kHz, and less distribution of acoustical energy[1,2]. Because consonants are sounds of lower intensity than vowels, they become more difficult to be detect, especially by individuals with hearing impairment, who, consequently, have difficulties in discriminating words[3].

Hearing losses are classified according to the pure-tone hearing thresholds for air and bone conduction and with the tests of speech. These make it possible to define the type and degree of hearing loss, in addition to measuring speech discrimination[4].

The sensorineural hearing losses deriving from lesions in the cochlea and/or cranial nerve VIII (vestibulocochlear nerve) up to the brainstem auditory nuclei and are characterized by alterations in the hearing thresholds of air and bone conduction[4]. Biochemical alterations, failure in the cellular mechanism of the cochlea or diseases of the inner ear and retrocochlear auditory pathways, or even alterations caused by aging, can lead to

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compromised sound transduction, which, in turn, will impair an individual's hearing and speech comprehension[5].

In sensorineural hearing losses, high frequency hearing thresholds are proportional to the extent of damage to the ciliated cells at the base of the cochlea[6]. Losing the cilia of the internal ciliated cells in that region leads to a reduction or absence of afferences[7]. In these cases, the input of acoustical energy in that frequency region, which is contributive to speech intelligibility, is compromised– among other factors, by an increase in the amplification of the sound energy[8]. For that reason, it is believed that the greater the deficit in the high frequencies in relation to the low frequencies, the worse the word recognition performance.

Speech recognition and the use of amplification in the different audiometric configurations is an issue that has been debated by several authors. One study demonstrated that in the hearing losses with the greatest impairment in the low frequencies, speech recognition improves regardless of the degree of loss when that region is amplified[9]. On the other hand, for more severe hearing losses with a flat configuration, amplifying the low frequency regions is more beneficial to intelligibility than amplifying the high frequency regions[10,11]. In ski slope hearing losses, the amplification over the range of high frequencies is very important for speech recognition[8,10,12].

The objectives of the present study were (a) to assess whether the increase in the difference of the pure-tone hearing thresholds between the frequency octaves interfere with speech recognition, and (b) to assess whether hearing losses in the frequencies of 3 kHz and 4 kHz influence the results of speech recognition tests.

METHODS

The present retrospective and comparative study was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais under Opinion ETIC 0653.0.203.000-10.

The study was based on secondary data and involved a review of the medical records of the patients who were seen at the Auditory Health Care Service of the UFMG Hospital das Clínicas, Anexo São Geraldo, from March through July 2011. The audiometric tests of patients with sensorineural hearing loss showing a ski slope audiometric configuration, candidates for hearing aids, were selected. The following tests were analyzed: pure-tone audiometry (study of the speech recognition threshold –SRT– and study of the speech recognition percent index –SRPI) and acoustic immittance.

To be included in the study sample, the test records should belong to individuals older than 18 years, with a type A tympanometric curve[13], and ski slope sensorineural hearing losses[14] of a mild to severe degree[15]. The hearing loss was regarded as "ski slope" when the difference between the means of the frequencies of 0.25–2 kHz and 3–8 kHz was greater than15 dBHL[14]. Cases of conductive and mixed hearing loss as well as sensorineural hearing loss with flat or ascending audiometric configurations were excluded. In addition, cases with incomplete data such as the lack of acoustic immittance or speech audiometry results were excluded.

The study sample included the audiometric evaluation of 55 ears of 19 men and 11 women aged between 26 and 91 years (mean, 66.5 years; median, 71 years). Because these patients were regularly seen at the Audiology Outpatient Clinic, it was possible to obtain their informed consent with explanations on the theme of the study and its aims.

The values found in the SRPI and SRT studies were correlated with the following averages for the pure-tone hearing thresholds:

- Average 1: mean of the frequencies of 0.5, 1 and 2 kHz
- Average 2: mean of the frequencies of 0.5, 1, 2 and 3 kHz
- Average 3: mean of the frequencies of 0.5, 1, 2, 3 and 4 kHz
- Average 4: mean of the frequencies of 0.5, 1, 2 and 4 kHz

In addition, the SRPI values were correlated with the differences, in decibels, of the pure-tone hearing thresholds between frequency octaves across the following ranges:

- 0.5 –1 kHz
- 0.5 – 2 kHz
- 1 – 2 kHz
- 1 – 3 kHz
- 2 – 3 kHz
- 2 – 4 kHz

For the statistical analysis, the level of significance was set at 0.05 and the confidence intervals were constructed with 95% of statistical confidence. Since the sample data were quantitative and continuous, parametric statistical tests were used. Pearson's correlation test was used to estimate the degree of correlation of SRT and SRPI with the differences of thresholds between the frequency octaves and audiometric averages. To validate the analyses, the correlation matrix pictured below was used:

RESULTS

Table 1 shows the descriptive analysis of the quantitative variables including the averages of the hearing thresholds by frequency, the tone averages, the differences of the pure-tone hearing thresholds between the frequency octaves (in decibels), the SRT and the SRPI (in percent values).

Table 2 depicts the correlations between the SRT and SRPI values with the hearing threshold differences between the frequency octaves.

Table 3 shows the correlations established between the tone averages and SRT, and SRPI.

Table 1 - Descriptive analysis of the quantitative variables

Descriptive	Mean	Median	Standard Deviation	Minimum	Maximum	Confidence Interval
0.25 kHz	31.3 dBHL	32.5 dBHL	14 dBHL	10 dBHL	65 dBHL	3.8
0.5 kHz	33.2 dBHL	32.5 dBHL	14.4 dBHL	10 dBHL	60 dBHL	3.9
1 kHz	47.6 dBHL	45 dBHL	17.4 dBHL	10 dBHL	100 dBHL	4.7
2 kHz	70.7 dBHL	67.5 dBHL	13.3 dBHL	50 dBHL	115 dBHL	3.6
3 kHz	76.8 dBHL	75 dBHL	16 dBHL	50 dBHL	120 dBHL	4.4
4 kHz	80.7 dBHL	80 dBHL	18 dBHL	50 dBHL	120 dBHL	4.9
6 kHz	87.7 dBHL	85 dBHLA	18.5dBHL	45 dBHL	120 dBHL	5
8 kHz	91.8 dBHL	87.5 dBHL	18.5 dBHL	55 dBHL	120 dBHL	5
Average 1	50.5 dBHL	50 dBHL	12.6 dBHL	28.3 dBHL	83.3 dBHL	3.4
Average 2	56.9 dBHL	55 dBHL	12.5 dBHL	35 dBHL	92.5 dBHL	3.4
Average 3	61.7 dBHL	60.5 dBHL	12.7 dBHL	41 dBHL	98 dBHL	3.4
Average 4	58 dBHL	56.3 dBHL	12.4 dBHL	36.3 dBHL	92.5 dBHL	3.4
0.5 – 1 kHz	14.5 dBHL	15 dBHL	12.6 dBHL	-15 dBHL	55 dBHL	3.4
0.5 – 2 kHz	37.3 dBHL	35 dBHL	15.2 dBH	10 dBHL	70 dBHL	4.1
1 – 2 kHz	23.1 dBHL	20 dBHL	15 dBHL	0 dBHL	60 dBHL	4.1
1 – 3 kHz	29.2 dBHL	25 dBHL	17.2 dBHL	-5 dBHL	60 dBHL	4.7
2 – 3 kHz	6.1 dBHL	5 dBHL	8.7 dBHL	-15 dBHL	30 dBHL	2.4
2 – 4 kHz	10.1 dBHL	7.5 dBHL	13.4 dBHL	-15 dBHL	45 dBHL	3.6
SRT	51.5 dBHL	52.5dBHL	13.9 dBHL	20 dBHL	80 dBHL	3.9
SRPI	56.4%	68%	28.8%	0%	92%	7.8

Table 2 - Correlation of the speech recognition threshold (SRT) and the speech recognition percent index (SRPI) with the differences in hearing thresholds (in decibels) between the frequency octaves.

		SRT		SRPI	
	Averages found	Pearson's correlation	*p*-value	Pearson's correlation	*p*-value
0.5 – 1 kHz	14.5 dBHL	18.80%	0.201	-33.60%**	0.015
0.5 – 2 kHz	37.3 dBHL	-25.60%**	0.079	-20.90%**	0.137
1 – 2 kHz	23.1 dBHL	-44.10%*	**0.002**	8.70%	0.541
1 – 3 kHz	29.2 dBHL	-30.00%**	0.04	-4.50%	0.754
2 – 3 kHz	6.1 dBHL	15.10%	0.311	-20.60%**	0.147
2 – 4 kHz	10.1 dBHL	-2.30%	0.878	-10.40%	0.465

Correlation test, $p<0.05$.
(*) moderate correlation, (**) poor correlation – accoding to the classification scale.

Table 3 - Correlation of the speech recognition threshold (SRT) and the speech recognition percent index (SRPI) with the tone averages

Average	Averages found	SRT		SRPI	
		correlation	*p*-value	correlation	*p*-value
Average 1	50.5 dBHL	93.0%***	<0.001	-58.40%	<0.001
Average 2	56.9 dBHL	89.1%***	<0.001	-62.1%**	<0.001
Average 3	61.7 dBHL	82.8%***	<0.001	-63.9%**	<0.001
Average 4	58 dBHL	87.4%***	<0.001	-63.8%**	<0.001

Correlation test, $p<0.05$.
(***) Very good correlation, (**) Good correlation – according to the classification scale.

DISCUSSION

The SRPI and SRT values were correlated to the averages of the pure-tone hearing thresholds, and the SRPI, to the differences of pure-tone hearing thresholds between frequency octaves in order to assess how frequencies of 3 and 4 kHz influence speech recognition tasks.

For the variables described in Table 1, and analyzing the average results found by frequency level, a progressive increase was noted in the threshold as the tone frequency was increased, a characteristic of hearing losses with a sloping audiometric configuration. Regarding the analysis of the differences of the pure-tone thresholds between the frequency octaves, the increase in these values leads to sharper drops in the audiometric curve. Thus, a more marked fall was observed between the frequency ranges of 0.5 – 2 kHz and 1 – 3 kHz.

The average value found for SRT is consistent with Average 1 (0.5, 1 and 2 kHz). However, when the frequencies 3 kHz and/or 4 kHz were included in this average, an increase of 7, 11 and 8 dB HL was noted in Averages 2, 3 and 4, respectively, which render them inconsistent with the SRT value. This finding corroborates the literature, which reports that high frequencies outside the range of 0.5 – 2 kHz are less relevant to the SRT[16].

In the overall sample, the mean SRPI value was low (56.4%). The great number of errors made in the speech test was likely due to an impairment over the high frequencies. The literature reports that individuals with sensorineural hearing losses for high-pitched sounds have difficulties in speech recognition due to decreased acoustic information[3]. However, the present study encompasses an aging population, with a mean age of 66.5 years and median of 71 years. This may have had an influence on the poor levels of speech recognition. Presbycusis, a form of age-related hearing loss, is often associated with difficulties in inteligibility due to the organic and physiological changes that take place in the auditory system over the years. In addition, cognitive aspects should be taken into consideration, since this population frequently present cognitive alterations worsened by the hearing deficits.

The analysis of the data on the correlation between the SRT and the differences between the octaves showed a statistically significant (p= 0.002) moderate correlation (-44.1%) for the difference between intervals 1–2 kHz. This means that these variables are inversely proportional, i.e., the greater the difference between the frequencies, the worse the SRT values. Regarding the other ranges, no significant correlations were found. With respect to the SRPI, there was no statistically significant correlation with the differences between the frequency octaves (p > 0.05) (Table 2).

Table 3 correlates the averages of thresholds to the SRT and SRPI values. The p-value was statistically significant across correlations. Regarding SRT, a very good correlation (>80%) with the analyzed averages was found. Pearson's correlation was 93% for Average 1, i.e., the frequencies 0.5 kHz, 1 kHz, 2 kHz contribute significantly to the speech thresholds. The average of those frequencies is used in most classifications of the degree of hearing loss[16,17]. However, when the frequencies of 3 kHz and 4 kHz were added, this correlation was reduced, although it remained very good according to the scale used in the present study.

Regarding SRPI (Table 3), a good correlation was found with the averages in this study, except for Average 1 (0.5, 1 and 2 kHz), whose correlation was moderate. This result shows that the inclusion of the frequencies 3 and 4 kHz in the tone average improves the correlation with the SRPI values and, consequently, reinforces its importance for speech recognition.

One study correlated the average for the speech-related frequencies (0.5 kHz, 1 kHz and 2 kHz) and the average of 3, 4 and 6 kHz with the Lists of Sentences in Portuguese (LSP) test. Statistically significant relationships were found only with the first average. However, according to the authors, this does not imply that the frequencies 3, 4 and 6 kHz have no bearing on speech recognition; rather, it means that there are factors that should be considered in addition to the audibility of those frequencies[18].

Another study confirmed that high frequency acoustic information—above 3 kHz—could be quite useful in terms of speech comprehension for people with flat sensorineural hearing loss and in high frequencies up to 70 dBHL[19].

Although other studies highlight the importance of the frequencies 0.5 kHz to 2 kHz, it cannot be affirmed that frequencies below 0.5 kHz and above 2 kHz are not imortant for speech recognition. In the present study, both 3 kHz and 4 kHz were found to be important for speech discrimination. Other studies also indicated that the frequencies between 4 and 6 kHz contribute to the recognition of consonants[20,21] .

In the present study, the inclusion of the frequencies 3 and 4 kHz in the tone average used in the classification of the hearing losses was of paramount importance. This inclusion had already been advocated by other authors who see limitations in the classification based on the frequencies 0.5 kHz, 1 kHz and 2 kHz, because by using those three frequencies, priority is given to the speech sounds and thus the actual impairment in communication caused by those losses is not described[17].

CONCLUSION

In the present study, the differences in the pure-tone hearing thresholds between the frequency octaves, i.e., the rise in the audiometric curve slope had no significant influence on the speech recognition task (SRPI). Speech recognition as evaluated by the SRT and SRPI tests shows very good correlation with the averages of the frequencies between 0.5 kHz and 4 kHz. The inclusion of the frequencies 3 kHz and 4 kHz in the tritone average of speech (0.5, 1 and 2 kHz) was important for the determination of the speech recognition percent indices.

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RESUMO

Objetivo: verificar quais aspectos da configuração audiométrica influenciam a discriminação de fala nas perdas auditivas neurossensoriais descendentes. **Métodos:** foi realizado um levantamento de prontuários hospitalar dos pacientes atendidos no Serviço de Atenção à Saúde Auditiva, no período de março a julho de 2011, selecionando-se indivíduos com perdas auditivas neurossensoriais descendentes de grau leve a severo com idade superior a 18 anos. A perda auditiva foi considerada descendente quando a diferença entre as médias das frequências de 0,25 a 2 kHz e 3 a 8 kHz foi maior que 15 dBNA. A partir deste levantamento a amostra do estudo foi composta por 30 pacientes (55 orelhas) sendo 19 homens e 11 mulheres, com idades compreendidas entre 26 e 91 anos. Com base na avaliação audiológica realizada previamente, os testes de reconhecimento de fala foram correlacionados com diferentes médias de limiares tonais, incluindo as frequências de 0,5 a 4 kHz. Além disso, estudou-se as diferenças dos limiares auditivos tonais entre oitavas de frequências, ou seja, o grau de inclinação das curvas audiométricas, e o seu impacto na discriminação de fala. **Resultados:** encontrou-se ótima correlação entre os limiares médios de 0,5 a 4 kHz com a discriminação de fala, sendo essa correlação mais forte com a inclusão das frequências de 3 e 4 kHz na média tonal. No entanto, o aumento da diferença do limiar auditivo entre as oitavas de frequências, que implica em uma maior inclinação da curva audiométrica com queda acentuada nas frequências altas, não interferiu de forma significante nos testes de reconhecimento de fala. **Conclusão:** com base nos resultados deste estudo, pode-se concluir que as frequências de 3 e 4 kHz contribuem para a inteligibilidade de fala.

DESCRITORES: Percepção da Fala; Audiologia; Perda Auditiva; Audiometria da Fala

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