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ORIGINAL ARTICLE

Hearing in Noise Test Brazil: standardization for young adults with normal hearing☆,☆☆

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KEYWORDS
Speech perception;
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Abstract
Introduction: Individuals with the same ability of speech recognition in quiet can have extremely different results in noisy environments.
Objective: To standardize speech perception in adults with normal hearing in the free field using the Brazilian Hearing in Noise Test.
Methods: Contemporary, cross-sectional cohort study. 79 adults with normal hearing and without cognitive impairment participated in the study. Lists of Hearing in Noise Test sentences were randomly in quiet, noise front, noise right, and noise left.
Results: There were no significant differences between right and left ears at all frequencies tested (paired $t-1$ test). Nor were significant differences observed when comparing gender and interaction between these conditions. A difference was observed among the free field positions tested, except in the situations of noise right and noise left.
Conclusion: Results of speech perception in adults with normal hearing in the free field during different listening situations in noise indicated poorer performance during the condition with noise and speech in front, *i.e.*, 0°/0°. The values found in the standardization of the Hearing in Noise Test free field can be used as a reference in the development of protocols for tests of speech perception in noise, and for monitoring individuals with hearing impairment.

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PALAVRAS-CHAVE
Percepção da fala;
Adulto;
Ruído;
Perda auditiva

Hearing in Noise Test Brasil: padronização em campo livre – adultos com audição normal

Resumo

Introdução: Indivíduos com as mesmas habilidades de reconhecimento de fala no silêncio podem apresentar resultados extremamente diferentes em ambientes ruidosos. *Objetivo*: Padronizar a percepção da fala em adultos com audição normal em campo livre no Hearing in Noise Test Brazil.

Método: Estudo de coorte contemporâneo com corte transversal. Participaram 79 adultos com audição dentro dos padrões de normalidade (normo-ouvintes), sem alterações cognitivas. Foram aplicadas aleatoriamente listas de sentenças do HINT no silêncio, ruído à frente, ruído à direita, ruído à esquerda.

Resultados: Não houve diferença significativa entre orelhas para todas as frequências testadas, sexo e interação entre as condições. Observou-se diferença entre as condições testadas, exceto entre as situações de ruído à direita e ruído à esquerda.

Conclusão: Os resultados da percepção da fala em adultos com audição normal em campo livre em diferentes situações de escuta no ruído indicaram pior desempenho na situação ruído e fala à frente, ou seja, 0°/0°. Os valores encontrados na padronização do HINT em campo livre poderão ser utilizados como referência na construção de protocolos para utilização de testes de percepção da fala no ruído e no acompanhamento de indivíduos com deficiência auditiva.

Introduction

Speech perception in noise

Speech recognition is essential for social integration, as it enables efficient interpersonal communication. The ability to understand speech in the presence of background noise is a major challenge for any listener, especially for those with hearing impairment.[1] The evaluation of this skill should be considered a very important aspect to be measured in human auditory function, as it allows for evaluation of receptive communicative function, providing data on how the subject functions in everyday listening situations, by means of easily quantifiable information.[2,3] Speech is an acoustic signal in which information is transmitted by means of changes of frequency, intensity, and time. The normal auditory system has the inherent ability to identify, process, and encode this information.[4,5] The aspects of variability in speech are well known, namely: speaker's gender, rate of speech, dialect, vocabulary, and grammatical complexity.[6] Thus, at the time of assessment, factors such as the type and level of presentation of the material and of its response, and listener characteristics, including language and listening experience, can directly affect the outcome.[7–9]

In daily life, many communicative situations occur in environments where listening is impaired by the presence of competitive noise.[4,10] Because of this, and knowing that the same patient may have very different abilities for speech recognition in a quiet environment than in a noisy one, it is important to emphasize testing in a noisy environment.[3,11]

In order to measure a patient's hearing difficulties, the phonoaudiologist needs to resort to a battery of tests that not only will allow the identification of a potential hearing loss, but also will analyze the understanding of auditory stimuli, including speech in clinical situations and mainly under conditions close to those found in everyday life.[12]

Research shows that patients with normal hearing have their speech perception affected by environmental noise.[3,9,13,14] Complaints of difficulty understanding speech in the presence of noise have become increasingly common, whether or not some hearing impairment exists.[15] To assess and diagnose the impairment of hearing capacity of an individual, several tests are used in clinical practice. However, these tests are unable to detect the patient's functional ability to perceive and understand speech in noisy environments, as these tests are applied in quiet environments.[3]

In Brazil, speech-in-noise tests are not yet part of the conventional audiologic battery; the comparison of performance, in quiet and in noisy environments, is not often performed, based on protocols already standardized. In addition, few studies indicate the perception-of-speech performance in noisy environments expected for adults with normal hearing in the free field, especially with the values obtained in the Hearing in Noise Test (HINT).[1,16,17]

HINT is a speech recognition in noise test simulating hearing situations similar to everyday life, and is available in several languages, including Brazilian Portuguese.[18]

HINT assesses the auditory function by measuring the signal/noise (S/N) ratio for sentences in a quiet environment and in three noise conditions: (a) noise in front (speaking in front and noise at 0° azimuth); (b) noise to the right (speaking in front and noise at 90° to the right), and (c) noise to the left (speaking in front and noise at 90° to the left). The HINT test consists of 12 lists of 20 sentences each, totaling 240 representative sentences of everyday speech. The sentences are short, phonemically balanced, easy to understand, and with the same degree of difficulty.[16] However, for its validation, the HINT-Brazil was applied only *via* supra-aural headset, *i.e.*, the results were not assessed in free field conditions.[18] Thus, its application is not feasible for users of individual hearing aids and/or with cochlear implants. In contrast, many international studies use HINT in free field conditions to assess the performance and specific characteristics of auxiliary hearing devices.[19–23]

Calibration of the test environment

The variables that affect in-noise speech recognition can be divided into categories and subcategories: variables from stimulus used – style and content of the sentences, in-noise intelligibility level, type of noise and loudspeaker; variables of stimulus presentation – method, transducer; subject variables – hearing loss, auditory processing, age, language, cognition; subject's response variables – response channel, classification method; variables of subject's performance – reliability, validity, sensitivity and specificity. It would be helpful to understand the variables affecting speech recognition in order to guide the development of new tests and also to identify factors that could explain results that deviate from those already documented.[1]

The calibration of the free field should be estimated *in situ*, since the results obtained by different researchers vary widely; this variation is justified by a number of aspects that can interfere with the measurements and that, therefore, should be considered, such as room size, acoustic conditions, whether or not a reflective surface exists, level of reverberation, calibration, and even the number of people within the test environment.[11,24]

Thus, it is emphasized that it is critical for the evaluator to have his/her own parameter for the test site; the evaluator also must consider the situation in which the test is being conducted.[12] Authors point to the need for harmonization of in-noise assessments in different languages, to strengthen the clinical practice based on evidence in the audiological community.[25] In order to calibrate the in-noise test in the free field and to compensate for the acoustic effects of the environment, it is recommended that the implementation of HINT be performed first in individuals with normal hearing.[24]

Based on these considerations, this study aimed to standardize the application of the HINT-Brazil in the free field in normal hearing adult subjects.

Method

This was a cross-sectional study, conducted at the Educational Audiology Laboratory in 2011, with approval by the Research Ethics Committee (Protocol 129/2010).

In this study, only individuals who agreed with the procedures necessary for conducting the examination and who signed the informed consent, after having received information on the purpose and methodology of the proposed study, were enlisted.

The adopted inclusion criteria were: age between 18 and 59 years, audiometric thresholds within normal limits,[26] and absence of ear wax plug or other changes in the external or middle ear which could modify the test performance.

The sample was selected by convenience and consisted of 79 adult subjects, 29 males and 50 females, aged 19–44 years (mean, 24 years).

The audiological evaluation occurred following an otoscopic examination performed by the Service's otolaryngologist, and consisted of pure tone audiometry by air conduction at frequencies of 250–8000 Hz. To obtain these measures, a digital two-channel audiometer (Madsen, model Midimate 622) was used, along with TDH35 supra-auricular headphones. The test was conducted in a soundproof booth.

To assess the in-noise speech perception, the following equipment was used: the HINTPro 7.2 Audiometric System; two stereo loudspeakers for the free field; a computer with CD recorder; printer; and a sound-treated room.

The test was conducted in the free field condition in a sound-treated room, according to the HINTPro 7.2 Audiometric System operating instructions manual. HINTPro consists of equipment with interface connected to the computer, which permits the use of HINT. The installation of the specific software for the test on the computer is required, and the free field stereo loudspeakers were coupled to HINTPro 7.2.

Each list of 20 sentences was applied in the following situations: quiet (Q), noise front (NF), noise right (NR), and noise left (NL) and compound noise (CN). The sentences were presented at 0–0° azimuth, and the level of presentation was initially set at 45 dBA, and varied in steps of 4 dB and 2 dB, according to the correct repetition of the level.

However, the competitive noise was introduced at 0–0°, 0–90°, 0–180°, and 0–270° azimuth, at a fixed intensity of 65 dBA.[27] The lists of sentences and the order of noise presentation were selected and presented randomly. The score was expressed in dB, representing the S/N ratio threshold.

For data analysis, the paired t-test and two-way ANOVA were used.

Results

There was no significant difference among ears, gender, and interaction among conditions. We did observe a difference among the conditions tested (Table 1).

Discussion

The subjects of this study reported no difficulty undertaking the test; they understood the instructions and performed properly.

As shown in Table 1, the mean values obtained for the in-noise speech recognition threshold (SRT – HINT Brazil) ranged from −6.47 to −3.20 for different listening situations. The literature contains two studies[16,24] that describe

Table 1 Results obtained in different noise conditions. Equal letters indicate no significant difference.

Condition	Mean (dBNA)	SD
Quiet	10.3[a]	
NL	−6.47[b]	1.55
NR	−6.46[b]	1.63
CN	−4.83[c]	0.80
NF	−3.20[d]	0.89

NL, noise left; NR, noise right; CN, composite noise; NF noise front; SD, standard deviation.

the perception of speech in-noise performance expected for adults with normal hearing in the same listening situation – in the free field. The first study[16] proposes values approaching those findings of this study for all test conditions, while the other[24] found better results; this can be explained by the fact that the characteristics of the speech material and of the individuals who participated in the test can affect intelligibility. These characteristics include the words' phonetic similarity, the rate of speech and the clarity of the speaker, the naturalness of the speaker's voice, the gender of the subject, and his/her dialect.[24,28]

The language skills of the listener interact with grammatical and lexical properties of the material (speech). Likewise, the listener's cognitive and memory abilities interact with the complexity and duration of the discourse. In addition, the age at which the language was acquired and the primary or secondary status of the language affect its intelligibility.[24] Different speakers who speak in different languages and tones are used to record the HINT sentences.

Therefore, the masking effects on a particular speech sample by spectral noise are unpredictable, contributing to an unwanted source of variability in threshold measures.[24] Another factor that can interfere in the results is the calibration for the free field *in situ*, with different conditions from one test to another. In a study on speech recognition in the free field, and also based on the literature review, it was found that the present results were different from those of other studies,[12,16,24] possibly because of variables that can be found in the evaluation of the free field environment, such as room size, acoustic conditions, whether or not a reflective surface exists, as well as reverberation and calibration levels.[10] One of these studies was not conducted in Brazil.[24]

The worst S/N ratio is obtained when the speech and noise are in the same position, explaining the results found for NF. According to the literature, the highest (worst) thresholds occur when speech and noise are presented at the same location, that is, speech and noise at 0° in front of the subject. The results are better when speech and noise are separated by an angle of 90°, with speech at 0° in front of the individual, and the noise to the right or to the left at 90°,[24] the best reported results are seen when the noise and speech conditions are separated by 90°, with speech at 0° in front of the assessed individual and the noise at 90° to the right or to the left of the subject,[3,16,29] which corroborates the findings of the present study.

The statistical difference between S/N ratios obtained at 0–0° in relation to those obtained with the noise positioned at 0–90° occurs because, when moving the sound from the in-front position to the lateral position in relation to the subject assessed, the sound stimulus presented laterally is not equally perceived by both ears, contrary to what occurs when the sound source is located in front of the subject. This difference in perception is due to the presence of interaural time and intensity differences, that occur when speech and noise sources are spatially separated.[7,29]

Importantly, the results of the compound noise (CN) are generated automatically by the HINTPro software, according to the formula $RC = (2 \times NF + NR + NL)/422$. Although age *per se* is not an essential factor in speech perception, there are reports in the literature of performance deterioration in speech perception with increasing age – in association with the natural aging process.[1] Considering that the present study group was composed of young adults (between 19 and 44 years, mean 24 years), future studies with older groups of adults or even with elderly patients would be welcome.

Subjects of both genders and with ages between 18 and 50 years took part in the standardization of HINT Brazil[18] using headsets. In tests performed in-noise, the authors consider questionable the need for adjustments with the introduction of visual cues for the older population, even if only for previous training to the test application, since, when the stimulus is given only by ear, older adults demonstrate less poor performances in speech recognition, when compared to young adults or even to normal hearing individuals.[30,31] The same occurs when only visual cues are used.[30,32,33] Overall, regardless of age, it is common that in difficult listening situations the listener performs lip reading to facilitate his/her understanding.[30,34]

Conclusion

Values were developed for the standardization of HINT in the free field during different listening situations in a noisy environment. The results of speech perception in adults with normal hearing showed worse performance in the situation of NF, *i.e.*, 0–0°.

These results could be used as a reference in the construction of protocols for use of speech perception tests in noise, and in monitoring individuals with hearing loss.

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Conflicts of interest

The authors declare no conflicts of interest.

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