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Benchmarks for the Dichotic Sentence Identification test in Brazilian Portuguese for ear and age☆,☆☆

Adriana Neves de Andrade*, **Daniela Gil**, **Maria Cecilia Martinelli Iorio**

Department of Speech Therapy, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil

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Abstract
Introduction: Dichotic listening tests should be used in local languages and adapted for the population.
Objective: Standardize the Brazilian Portuguese version of the Dichotic Sentence Identification test in normal listeners, comparing the performance for age and ear.
Methods: This prospective study included 200 normal listeners divided into four groups according to age: 13–19 years (GI), 20–29 years (GII), 30–39 years (GIII), and 40–49 years (GIV). The Dichotic Sentence Identification was applied in four stages: training, binaural integration and directed sound from right and left.
Results: Better results for the right ear were observed in the stages of binaural integration in all assessed groups. There was a negative correlation between age and percentage of correct responses in both ears for free report and training. The worst performance in all stages of the test was observed for the age group 40–49 years old.
Conclusions: Reference values for the Brazilian Portuguese version of the Dichotic Sentence Identification test in normal listeners aged 13–49 years were established according to age, ear, and test stage; they should be used as benchmarks when evaluating individuals with these characteristics.

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☆☆ Institution: Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil.
* Corresponding author.
E-mail: adriandrad@hotmail.com (A.N. Andrade).

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PALAVRAS-CHAVE
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Testes de discriminação da fala;
Validade dos testes;
Processamento espacial

Valores de referência para o teste de identificação de sentenças dicóticas em português brasileiro segundo orelha e idade

Resumo

Introdução: Os testes de escuta dicótica devem ser utilizados na língua nativa e adaptados para a população alvo.

Objetivo: Estabelecer critérios de referência para o teste DSI em indivíduos normouvintes segundo a orelha, faixa etária e etapa do teste.

Método: Estudo prospectivo transversal com 200 indivíduos normouvintes, separados em quatro grupos: 13 a 19 anos (GI), 20 a 29 anos (GII), 30 a 39 anos (GIII) e 40 a 49 anos (GIV). O teste DSI foi aplicado em quatro etapas: Treino, integração binaural, escuta direcionada direita e esquerda.

Resultados: Foram observados melhores resultados para a orelha direita nas etapas de integração binaural em todos os grupos avaliados. Houve correlação negativa entre a porcentagem de acertos e a idade, bilateralmente, para as etapas de treino e integração binaural. O pior desempenho, em todas as etapas do teste, foi observado para a faixa etária de 40 a 49 anos de idade.

Conclusões: Os valores de referência para a versão em português brasileiro do teste DSI em indivíduos normouvintes de 13 a 49 anos de idade foram estabelecidos segundo a idade, orelha e etapa do teste e devem ser utilizados como padrões de referência na avaliação dos indivíduos com essas características.

Introduction

Auditory processing assessment targets the understanding of the auditory function and its association with communication and is performed through special behavioral auditory tests aimed at assessing the individual's auditory performance in similar situations to those experienced in daily life.

Dichotic listening tests are among the types of stimulation used for auditory capacity assessment. In dichotic listening tests with linguistic materials, most individuals tend to display better performance for the information offered to the right ear compared to the left ear.[1]

Among the dichotic listening tests utilized in Brazil is the Dichotic Sentence Identification (DSI) test, which was originally created in English.[2]

The Brazilian Portuguese version of the DSI[3] has six parts: calibration, training. binaural integration, directed report on the right, directed report on the left ear, and training. This test allows assessing the auditory capacity of figure-background for verbal sounds (identifying speech sounds in the presence of other speech sounds), with verbal sound recognition in dichotic listening acting as the underlying auditory physiological mechanism.[3] After the tool development for auditory processing assessment, the authors[4] studied the incidence of errors in the sentences given in the DSI in Brazilian Portuguese according to gender. In the study, a higher incidence of errors was observed when the following sentence was presented: ''That ignores the primary purpose is to win,'' regardless of the test presentation stage.

The authors hypothesized that the high incidence of errors in this sentence could be related to a difficulty in visual processing or memory, depending on the strategy used by the individual to indicate the sentence that was heard.[4]

Several factors may influence the individuals' results in behavioral hearing tests; among these factors is age. Studies have shown that with increasing age there may be a decline in the production and comprehension of syntactically complex sentences and changes may also arise in the working memory operation patterns.[5]

It is known that to achieve the diagnosis of auditory processing disorder, it is necessary to use tools that have been validated for the population to be analyzed after cultural adaptation, controlling all factors that are extrinsic to the assessment.[3] The adequate use of auditory processing tests complements peripheral hearing evaluation[6] and must also be performed when assessing individuals with hearing loss, whether or not they are users of individual hearing aids. Therefore, the correct interpretation of results is vital for diagnostic purposes and to assist in the rehabilitation process.[6–8]

Considering the use of standardized tests to assess auditory processing and the effect of age and ear on the dichotic listening tasks, this study aims to establish reference values for the Brazilian Portuguese version of the DSI in normal listeners aged 13–49 years old, according to the ear, age range, and test stage.

Methods

The study was reviewed and approved by the Research Ethics Committee under No. 0322/07. The subjects were invited to participate in the study through Internet advertisement, leaflet distribution, exhibition of posters in places with high concentrations of people (shopping malls, restaurants, businesses, and public and private educational institutions), and verbal invitations made by the researcher and/or third parties. The following equipment was used for the study: Mini Heine 3000 otoscope, Philips Expanium cd-player with MP3, Grason-Stadler GSI – 61 audiometer, with a pair of TDH-39 supra-aural earphones, AT 235 h immittanciometer, compact disk with dichotic digit test,[9] and DSI.[3]

For inclusion in this study, the following eligibility criteria were used: age between 13 and 49 years (both genders), Portuguese as the native language, preferably right handed, reading fluency, no evident neurological alteration and/or mental disorders, auditory threshold lower than 25 dB HL between 250 and 8000 Hz, type A tympanometric curves and presence of acoustic reflexes with contralateral stimulation, difference between hearing thresholds in the right and left ear <10 dB HL in all the assessed frequencies, and performance of $\geq$95% correct answers in the dichotic digit test.[9]

During a 12-month period, a total of 256 individuals voluntarily came to the service, of whom 56 were excluded for not meeting all the eligibility criteria. The study included 200 individuals, matched for gender, with fluent reading, level of schooling of 3–20 years (mean 13.1 years of schooling), divided into four groups according to age: GI – 50 subjects (25 females and 25 males) aged between 13 and 19 years; GII – 50 subjects (25 females and 25 males) aged between 20 and 29 years; GIII – 50 subjects (25 females and 25 males) aged between 30 and 39 years; and GIV – 50 subjects (25 females and 25 males) aged between 40 and 49 years.

All subjects were submitted to the Edinburgh Handedness Inventory,[10,11] basic audiological assessment (anamnesis, meatoscopy, pure tone audiometry, speech audiometry, acoustic immittance measures, and contralateral acoustic reflex) and behavioral auditory processing (sound localization test, sequential memory test for verbal and non-verbal sounds, dichotic digit test – applied and analyzed according to the criteria proposed by Pereira and Schochat)[9] to exclude the presence of peripheral hearing loss and/or auditory processing disorder. After these procedures, the DSI test in Brazilian Portuguese was applied in four stages: training, binaural integration, directed report on the right and directed report on the left.

In all test stages, the assessed subject heard two simultaneous sentences – one in each ear – and the response depended on the task. At the binaural integration stage (training and binaural integration), the individual was asked to indicate both sentences; for the directed report stage (right and left), the subject should only indicate the sentence provided to the ear under assessment.

The analysis of results was performed using the statistical software Minitab version 15 and SPSS version 11. A significance level of 0.05 was set for each hypothesis test.

Results

The test stage and ear variables were crossed with the covariate age, using Analysis of Covariance (ANCOVA) with repeated measures. As a result, there was an association of dependence between the differences of the mean percentage of correct answers in each stage of the test ($p = 0.000$*) and in each ear ($p = 0.007$*).

Spearman's coefficient was used to verify the correlation between the percentage of correct answers in each test stage by ear and age. There was a statistically significant correlation between age and the stages of training and binaural integration, for both the right and left ears ($p < 0.001$).

The behavior of the percentages of correct answers by the assessed population is shown in the scatter plots for the training stage (Fig. 1), binaural integration (Fig. 2), and directed report (Fig. 3). Based on the dispersion of correct answer percentages, a LOWESS curve was drawn to aid visualization of possible trends.

The results showed there was a negative correlation between age and percentage of correct answers for the binaural integration stages of the DSI (training and binaural integration), with a sharper decline to the left. The percentages of correct answers in the directed report stages were higher than in the binaural integration stages.

Using analysis of covariance (ANCOVA) with repeated measures, a statistically significant interaction was observed between the test stages and the side of the ear assessed for individuals aged 13–19 years ($p = 0.001$), 30–39 years ($p = 0.039$), and 40–49 years ($p = 0.007$).

After verifying the effect of the interaction between the test stages by ear and age, the mean percentage of correct answers obtained in different age groups were compared, according to the test stage and ear, using the Kruskal–Wallis test. The age range influenced the individuals' performance for the stages of binaural integration (training and binaural integration) of the DSI ($p < 0.004$), and comparisons were made to locate these differences (Table 1).

There were significant differences between performance comparisons in training for the extreme age groups for the right ear (13–19 *vs.* 40–49 years) and left ear (20–29 *vs.* 40–49 years). For the binaural integration stage, there were significant differences in performance comparisons between the age groups 20–29 years *vs.* 30–39 years in both ears. Finally, the reference values were established according to the observation of the fifth percentile of percentage distribution of correct answers in a given age group (Table 2).

The established reference values were similar for the age groups of 13–29 years and the performance decrease was more marked after 30 years of age.

Discussion

We comparison the results obtained in the DSI in Brazilian Portuguese with the results obtained in other countries, since the Brazilian Portuguese version is recent, compared to the versions in English, and has been little studied. The mean performance in the DSI test in Brazilian Portuguese at the binaural integration stage showed 93.70% accuracy on the right and 88.60% accuracy on the left, with the results corroborating studies carried out in other languages,[2,12] that showed a mean percentage of correct answers of 94.20% on the right and 93.50% on the left for the English version of the DSI[2] test, and 98.36% accuracy on the right and 96.29%

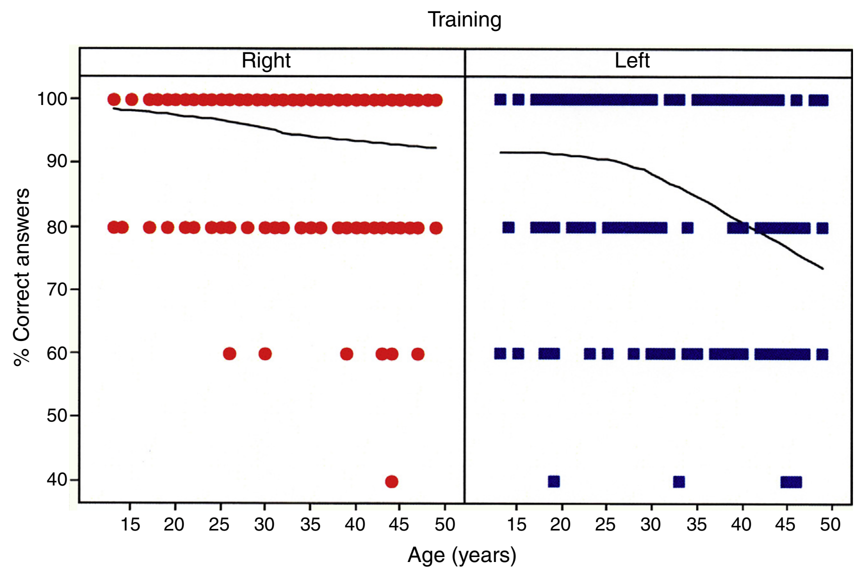

Figure 1 Scatter plots of correct answer percentages in the training stage by age and ear.

on the left for the Australian version of DSI[12] in individuals without hearing loss.

With increasing age, there was a decrease in the percentage of correct answers in the binaural integration stage, demonstrated in the scatter plots in which the LOWESS curve showed a downward configuration, with a sharper decline for the left ear. After the age of 30, test performance tended to decrease in all assessed stages. The performance decrease with increasing age in individuals assessed by dichotic listening tests has been previously reported by several studies[12-20] and has been attributed to a change in the interhemispheric transfer of auditory information *via* the corpus callosum. This scenario becomes more evident in elderly individuals, because in addition to the interhemispheric integration inefficiency, there may be other deficits such as cognitive decline, which further hinders the capacity to recognize speech stimuli presented to the left ear.

The individuals showed worse performance in the binaural integration stages (training and integration) when compared to the directed report stages, with the right ear showing better performance than the left ear at the binaural integration stages for all age groups; these differences were statistically significant.

The significant advantage of the right ear with increasing age in the three listening stages assessed in the DSI test has been reported in another study[14] that found that, for the directed report stage, the right ear advantage was more pronounced after 40 years of age. To explain the effect of the disadvantage of the left ear with increasing age, the authors described three possible occurrences:[14]

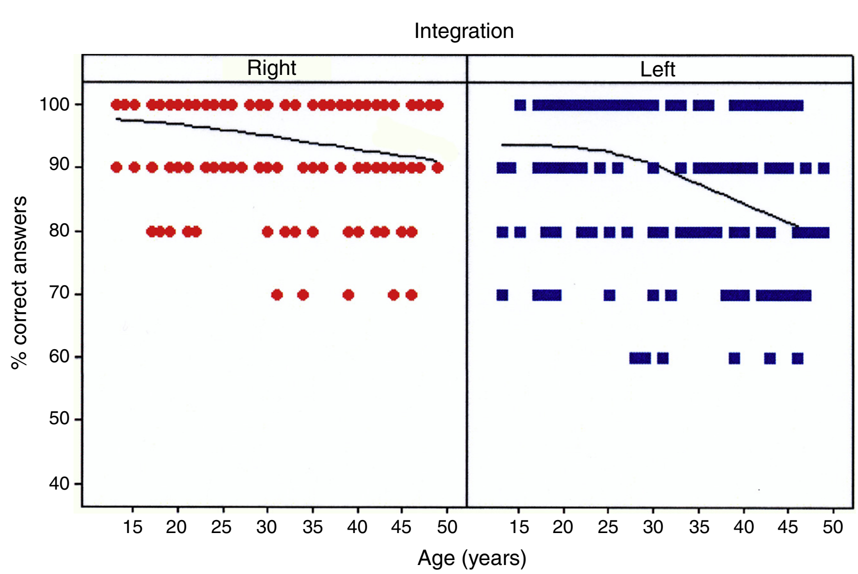

Figure 2 Scatter plots of correct answer percentages in the integration stage by age and ear.

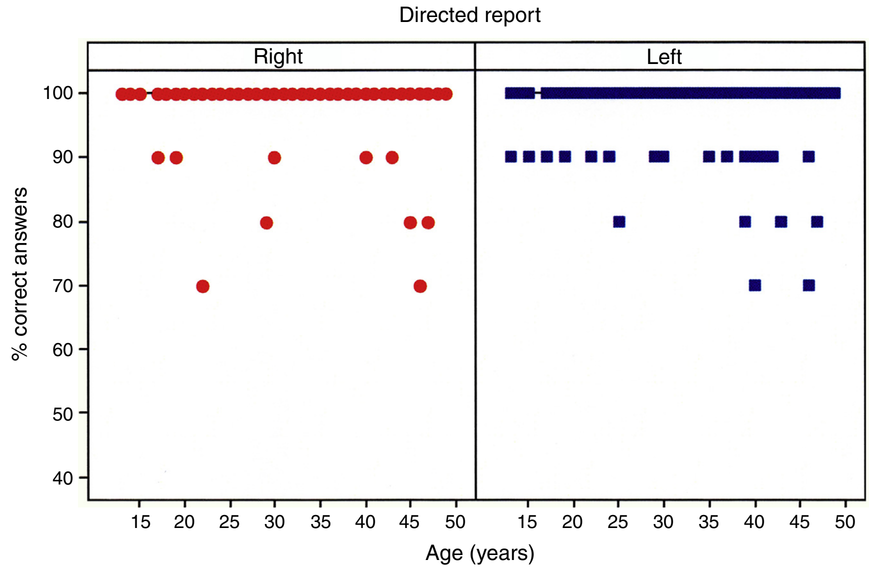

Figure 3 Scatter plots of correct answer percentages in the directed report stage by age and ear.

- Decline of known cognitive factors, such as memory or information processing strategies.
- More accentuated impairment of the auditory pathway structures for information input through the left ear. One possibility would be a relatively higher decrease in the right hemisphere, when compared to the left hemisphere, with increasing age.
- Decreased efficiency in the interhemispheric information transfer due to the reduction in neural elements in the corpus callosum, generating disadvantage for the information received through the left ear.

There was no significant correlation between age and the percentage of correct answers in the directed report stages, both on the right and the left; there was also no effect of age range on the mean percentage of correct answers in both ears in the directed report stage. These results possibly occurred because the directed report stages showed better results when compared to the other DSI test stages, with significant differences. This result was expected, as the individuals included in this study had no auditory processing disorder and so would be able to direct their auditory attention. The capacity to direct the auditory attention was

Table 1 *p*-values obtained from multiple comparisons to locate the effect of age range in the percentage of correct answers by test stage and ear.

Test stage	Ear	Comparison	*p*
Training	Right	13–19 years *vs.* 20–29 years	>0.999
		20–29 years *vs.* 30–39 years	0.643
		30–39 years *vs.* 40–49 years	>0.999
		13–19 years *vs.* 40–49 years	0.032[a]
		13–19 years *vs.* 30–39 years	0.315
		20–29 years *vs.* 40–49 years	0.089
	Left	13–19 years *vs.* 20–29 years	0.597
		20–29 years *vs.* 30–39 years	0.199
		30–39 years *vs.* 40–49 years	0.236
		13–19 years *vs.* 40–49 years	0.063
		13–19 years *vs.* 30–39 years	>0.999
		20–29 years *vs.* 40–49 years	0.001[a]
Integration	Right	13–19 years *vs.* 20–29 years	0.634
		20–29 years *vs.* 30–39 years	0.011[a]
		30–39 years *vs.* 40–49 years	0.711
	Left	13–19 years *vs.* 20–29 years	0.482
		20–29 years *vs.* 30–39 years	0.015[a]
		30–39 years *vs.* 40–49 years	0.068

[a] Bonferroni's method.

Table 2 Reference values for the Dichotic Sentence Identification test by ear and age range.

Test stage	Ear	Age range			
		13–19 years	20–29 years	30–39 years	40–49 years
Training	Right	80%	80%	60%	60%
	Left	50%	60%	60%	40%
Integration	Right	80%	80%	70%	70%
	Left	70%	60%	60%	60%
Directed report	Right	90%	90%	90%	80%
	Left	90%	90%	90%	70%

demonstrated by a mean performance of 98% of correct answers for all age ranges in the directed report stages, both on the right and on the left.

The DSI test was designed to test the central evaluation of individuals with peripheral hearing loss, as it suffers little influence of sensorineural hearing loss of cochlear origin.[2] However, to analyze the performance of special populations in behavioral hearing tests, such as individuals with hearing loss, it is necessary to establish normality criteria for individuals with good hearing acuity without auditory processing disorders.

Considering the requirements established in the inclusion criteria for participation in this study, the results can be extrapolated to the adult population. However, as age directly influences the results of the DSI test, it is suggested that new studies be carried out with individuals aged 50 years and older, to establish reference criteria for this population. It is also necessary to apply the DSI test to special populations, such as individuals with auditory processing disorders, speech and/or language disorders, and sensorineural hearing loss.

Conclusions

After critical analysis of the results, the reference values established for the Brazilian Portuguese version of the DSI test in normal listeners aged 13–49 years old, according to age, ear, and test stage are:

Age range 13–19 years old: 80% correct answers (in the training and binaural integration stages – right ear [RE]), 50% correct answers (in the training stage – left ear [LE]), 70% correct answers (in binaural integration stage – LE), and 90% correct answers (in the directed report stage).

Age 20–29 years old: 80% correct answers (in the training and binaural integration stages – RE), 60% (in the training and binaural integration stages – LE), and 90% correct answers (in the directed report stage).

Age 30–39 years old: 60% correct answers (in the training stages (RE and LE) and binaural integration – LE), 70% correct answers (in binaural integration stage – RE), and 90% correct answers (in the directed report stage).

Age range 40–49 years old: 60% correct answers (in the training RE and binaural integration LE stages), 40% (in LE training stage), 70% correct answers (in RE binaural integration stage) 80% correct answers (in the directed report stage RE), and 70% correct answers (in the directed report stage LE).

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Conflicts of interest

The authors declare no conflicts of interest.

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