Original Article

Artigo Original

Gaps-in-Noise test: gap detection thresholds in 9-year-old normal-hearing children

O teste Gaps-in-Noise: limiares de detecção de gap em crianças de 9 anos com audição normal

Carolina Finetti Marculino[1]
Camila Maia Rabelo[2]
Eliane Schochat[2]

Keywords

Hearing tests/methods
Noise
Auditory perception
Hearing
Child

ABSTRACT

Purpose: To establish the standard criteria for the Gaps-in-Noise (GIN) test in 9-year-old normal-hearing children; to obtain the mean gap detection thresholds; and to verify the influence of the variables gender and ear on the gap detection thresholds. **Methods:** Forty normal-hearing individuals, 20 male and 20 female, with ages ranging from 9 years to 9 years and 11 months, were evaluated. The procedures performed were: anamnesis, audiological evaluation, acoustic immittance measures (tympanometry and acoustic reflex), Dichotic Digits Test, and GIN test. The results obtained were statistically analyzed. **Results:** The results revealed similar performance of right and left ears in the population studied. There was also no difference regarding the variable gender. In the subjects evaluated, the mean gap detection thresholds were 4.4 ms for the right ear, and 4.2 ms for the left ear. **Conclusion:** The values obtained for right and left ear, as well as their standard deviations, can be used as standard criteria for 9-year-old children, regardless of ear or gender.

Descritores

Testes auditivos/métodos
Ruído
Percepção auditiva
Audição
Criança

RESUMO

Objetivo: Estabelecer os critérios de normalidade para o teste *Gaps-in-Noise* (GIN) em crianças de 9 anos de idade com audição normal, obter as médias dos limiares de detecção de intervalos de silêncio no ruído (*gap*) e verificar a influência das variáveis referentes a gênero e orelha. **Métodos:** Foram avaliados 40 indivíduos, 20 do gênero masculino e 20 do feminino, com idade entre 9 anos e 9 anos e 11 meses, normo-ouvintes. Os procedimentos realizados foram: anamnese, avaliação audiométrica, imitanciometria (timpanometria e pesquisa dos reflexos acústicos), teste Dicótico de Dígitos (aplicado para determinar a inclusão no estudo) e teste GIN. Os dados obtidos foram analisados estatisticamente. **Resultados:** Em relação ao desempenho no teste GIN por orelha, o resultado entre as orelhas direita e esquerda foi semelhante na população estudada. Em relação ao gênero, também não houve diferença. Nos indivíduos avaliados, a média dos limiares de detecção de intervalos de silêncio no ruído (*gap*) foi de 4,4 ms para orelha direita e 4,2 ms para orelha esquerda. **Conclusão:** Para crianças de 9 anos, os valores obtidos para a orelha direita e esquerda acrescidos de um desvio padrão podem ser usados como critério de normalidade para a idade independente da orelha ou gênero avaliado.

Correspondence address:
Eliane Schochat
R. Cipotânea, 51, Cidade Universitária, São Paulo (SP), Brasil, CEP: 05360-160.
E-mail: eschocha@usp.br

Received: 1/19/2011

Accepted: 9/1/2011

Study conducted at the Undergraduate Program in Speech-Language Pathology and Audiology, School of Medicine, Universidade de São Paulo – USP – São Paulo (SP), Brazil.
(1) Undergraduate Program in Speech-Language Pathology and Audiology, School of Medicine, Universidade de São Paulo – USP – São Paulo (SP), Brazil.
(2) Department of Physical Therapy, Speech-Language Pathology and Audiology, and Occupational Therapy, School of Medicine, Universidade de São Paulo – USP – São Paulo (SP), Brazil.

INTRODUCTION

In general, auditory processing is understood as the processing of acoustic information and analysis and interpretation of acoustic signals. Speech represents one of those acoustic signals.

Temporal auditory processing is performed when temporal order changes are discriminated along the sound wave. Such processing is fundamental to speech (verbal stimuli) and music (non-verbal stimuli) as the temporal order of acoustic elements is necessary for the comprehension of the message[1].

Temporal processing is divided into four auditory skills: temporal ordering or sequencing, temporal integration or summation, temporal masking, and temporal resolution or discrimination[1-3]. The auditory ability of temporal resolution refers to the minimum time required to segment acoustic events. This ability can be verified by the gap detection test, which goal is for the individual to perceive intervals of silence during the stimulus[4]. In the literature, it is observed that children with learning and reading difficulties exhibit alterations in this skill[5].

The Gaps-in-Noise (GIN) test[1] assesses the temporal resolution ability using intervals of silence embedded in white noise stimuli that are binaurally presented. Normality criteria for normal hearing individuals are needed so that the GIN test[1] can be part of the auditory processing testing battery. In Brazil, studies have been performed in adults with hearing problems[4] and in children with 11 and 12 years of age without hearing problems[6].

The study with 11- and 12-year-olds revealed an averaged gap detection threshold of 5.05 ms in both ears. In addition, there was no difference in GIN test performance according to age, gender and ear evaluated[7].

The relevance of the current study lies in obtaining the GIN test normality criteria for 9-year-old children who have not yet been studied in the Brazilian population.

Thus, the purposes of this study were to establish GIN test normality criteria in 9-year-old Brazilian children with normal hearing sensitivity in order to obtain the mean gap detection thresholds and to analyze the influence of the variables gender and ear on such measures.

METHODS

All parents or guardians signed the informed consent form. The study was approved by the Ethics Committee for Analysis of Research Projects (CAPPesp) of the School of Medicine of Universidade de São Paulo under protocol number 1126/05.

Participants

Forty children with 9 years of age participated in the study. Twenty boys and 20 girls were included in the sample in order to discard possible influences related to gender. To avoid possible biases related to the ear tested, participants were divided as follows:

- Group 1 – 50% of participants started the GIN test at the right ear (ten girls – GF1, and ten boys – GM1);
- Group 2 – 50% of participants started the GIN test at the left ear (ten girls – GF2, and ten boys – GM2).

Materials and procedures

The following inclusion criteria were adopted: presence of audiometric thresholds within normal limits and performance on the dichotic digits test greater than or equal to 95% in both ears[8]. The study excluded children who, according to anamnesis, could present ear diseases, neurological, cognitive and/or learning difficulties.

The following procedures were performed: anamnesis (historic auditory survey of the child); basic audiological assessment (pure tone audiometry, speech audiometry with the Speech Reception Threshold (SRT) and Percentage of Speech Recognition Index (SRI), and impedance (tympanometry and research acoustic reflexes); dichotic listening test[9], and Gaps-in-Noise (GIN) test[1].

The dichotic listening test was used as an auditory processing screening. All participants should have exhibited performance within the normal limits to be included in the study.

The GIN test was developed by Musiek in 2003[10] and standardized values were reported for the adult Brazilian population in 2008 by Samelli and Schochat[11].

The purpose of this test is to determine the gap (silent interval) detection threshold. Several gaps of varying durations are inserted at different positions of the white noise stimulus. The gaps could length 2, 3, 4, 5, 6, 8, 10, 12, 15 and 20 ms. The test consists of one practice track and four testing tracks. Each track consists of several test stimuli of six seconds of white noise, with a five-second inter-stimuli interval. In a single stimulus there could be a single gap, two gaps or three gaps. It is noteworthy that, in each group, half of the test tracks were applied in one ear and the other half in the opposite ear (GF1; GM1; GF2; GM2) to allow the analysis of ear influence.

Statistical analysis was performed using descriptive methods and non-parametric tests. Descriptive statistics aimed to represent the sample and the variables gender and ear. Non parametric tests were used because measures of the GIN test did not present normal distribution. Therefore, the Mann-Whitney test was used on the between-group comparisons of the GIN test measures and the Signed-Rank Wilcoxon test was used to compare the absolute variation between the ears. The significance level adopted was 0.05 (5%), with confidence intervals of 95%.

RESULTS

The results are presented as mean gap detection thresholds (Tables 1 and 2) and analyzed according to ear and gender.

The purpose of the between-ear comparison was to verify the advantage of one ear over another within each gender. Two tracks were applied in each group.

The analyses revealed no difference in performance when comparing the ears (Table 1). The average threshold of the right ear was 4.38 ms and the left one was 4.24 ms.

The results also indicated no between-gender differences

for any of the ears (Table 2). Therefore, these findings suggest that there is no influence of gender in the ability of temporal resolution assessed by the GIN test regarding the average gap detection threshold.

DISCUSSION

The auditory temporal processing is closely related to the perception of suprasegmental features of speech since it involves the ability to perceive and store acoustic stimuli. A processing deficit in this auditory skill can cause poor reading and learning ability[3]. This finding was confirmed in the current study, which evaluated typically developing children without speech and writing reception or expression deficits.

One study showed that children from 6 to 9 years of age with learning difficulties and dyslexia showed abnormal temporal resolution ability (higher gap detection thresholds) when compared to a control group[5]. Thus, resources that assess the temporal resolution are essential on the auditory processing testing battery.

The GIN test was developed to investigate the temporal resolution, determining the threshold of gap detection – i.e. the smallest interval of time in which there is an interruption of the sound stimulus[1]. One study shows that the sensitivity of the GIN test is 73% and the specificity 84% in identifying patients with lesions on the central auditory system[1]. Therefore, the GIN test can be considered an important tool to diagnose deficits in the ability of temporal resolution in both adult and pediatric population[12]. Thus, this study is of great importance because it provides the GIN test results for 9-year-old children, allowing the identification of problems in the temporal resolution ability, and enabling early intervention.

Several studies have been performed using the GIN test to assess the threshold of gap detection in different populations, especially normal hearing adults. Table 1 provides a descriptive comparison of these studies (Chart 1).

The between-ear (right and left) comparison, for both boys and girls, revealed no ear advantage. Similar results were found in previous studies, both in the pediatric and the adult population[1,4,6,11,12,14].

The lack of between-ear difference suggests that the temporal resolution – as measured by the GIN test – is an auditory process that develops symmetrically and relatively early. This also suggests that the maturation of the auditory system proceeds in a similar way for both the right and left sides regarding the temporal resolution ability[12].

In addition, one important aspect is that the GIN test is a monotic test in which both ipsilateral and contralateral pathways are activated. This results in similar performance of right and left ears[1], thus confirming the findings of this study.

Although few studies have applied the GIN test in the pediatric population, it is believed that the temporal resolution ability does not present significant differences regarding age, at least from 7 years of age[6,12]. Research has shown that at the age of 7, American children already exhibit values close to those obtained for adults[12].

When comparing the current results with data from another Brazilian study with 11- and 12-year-old children[7], a subtle difference between the mean thresholds is noticed. This difference may be explained by the maturation of the auditory nervous system. According to a study conducted in 2005, the age of 9 years old is considered transient with respect to the maturation of auditory skills. This might influence and cause a difference, albeit slight, between the thresholds of individuals of these two age groups[15]. It is noteworthy that there are still no studies on the GIN test in other age groups to allow comparison of findings.

With the standardization of the GIN test for 9-year-old children, the diagnosis of Auditory Processing Disorder gains an important and necessary tool. Therefore, it is suggested that the threshold values obtained in this study (Table 1) are used as normality criteria for the age studied; gap detection thresholds higher than the reported average, plus one standard deviation, should be considered abnormal for 9-year-old children.

CONCLUSION

The average threshold gap detection for 9-year-old children found in this study was 4.4 ms to the right ear and 4.2 ms to the left ear on the GIN test. These values plus one standard

Table 1. Descriptive analysis and between-ear comparison of thresholds obtained in the right and left ear

Ear	Mean	SD	Median	Minimum	Maximum	CI 95%	p-value
OD	4.38	0.933	6.00	2.00	6.00	4.17 – 4.58	0.21
OE	4.24	1.058	6.00	2.00	6.00	4.00 – 4.47	

Note: RE = right ear; LE = left ear; SD = standard deviation

Table 2. Descriptive analysis and between-gender comparison of thresholds obtained in the right and left ear

Ear	Gender	Mean	SD	Median	Minimum	Maximum	Z	p-value
RE	F	4.58	0.844	4.00	3.00	6.00	-1.65	0.09
	M	4.18	0.984	5.00	2.00	5.00		
LE	F	4.40	0.928	4.00	2.00	6.00	-1.23	0.21
	M	4.07	1.163	5.00	2.00	6.00		

Note: RE = right ear; LE = left ear; F = female; M = male; SD = standard deviation

Chart 1. Descriptive comparison of GIN test results reported in previous study

Author	Year	Population (age)	Threshold measure	*Gap threshold*
Perez[6]	2009	11 and 12	4 responses of 6 presentations	5,0 ms (RE) 5,11 ms (LE)
Shinn, Chermak e Musiek[12]	2009	9	4 responses of 6 presentations	4,6 ms (RE) 5,10 ms (LE)
Musiek et al.[1]	2005	13 to 46	4 responses of 6 presentations	4,8 ms (RE) 4,9 ms (LE)
Chermak, Lee[13]	2005	7 to 11	4 responses of 6 presentations	4,6 ms (RE) 4,9 ms (LE)
Samelli[4]	2005	18 to 31	3 responses of 6 presentations	3, 98 ms
Samelli e Schochat[11]	2008	18 to 31	4 responses of 6 presentations	4, 19 ms
Zaidan et al.[14]	2008	18 to 29	4 responses of 6 presentations	5,38 ms (RE) 4,88 ms (LE)
Presente trabalho	2009	9	4 responses of 6 presentations	4,4 ms (RE) 4,2 ms (LE)

deviation can be used as a normality criterion for this age range. The GIN test can be applied using the same normality criteria for both boys and girls and can be binaurally applied without influencing of the results.

ACKOWLEDGEMENTS

We thank the Foundation for Research Support of São Paulo (Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP) for their support to this study under process number 08/54587- 4.

REFERENCES

1. Musiek FE, Shinn JB, Jirsa R, Bamiou DE, Baran JA, Zaidan E. GIN (Gaps-In-Noise) test performance in subjects with confirmed central auditory nervous system involvement. Ear Hear. 2005;26(6):608–18.
2. Shinn JB. Temporal processing: the basics. Hear J. 2003;56(7):52.
3. Muniz LF, Roazzi A, Schochat E, Teixeira CF, Lucena JA. Avaliação da habilidade de resolução temporal, com uso do tom puro, em crianças com e sem desvio fonológico. Rev CEFAC. 2007;9(4):550-562.
4. Samelli AG. O teste GIN (Gap in Noise): limiares de detecção de *gap* em adultos com audição normal [tese]. São Paulo: Universidade de São Paulo; 2005.
5. Hautus M, Setchell G, Waldie KE, Kirk IJ. Age-related improvements in auditory temporal resolution in reading-impaired children. Dyslexia. 2003;9(1):37-45.
6. Perez AP. Estudo dos limiares de detecção de gap, com o uso do teste GIN, em crianças de 11 e 12 anos [dissertação]. São Paulo: Universidade Federal de São Paulo; 2009.
7. Perez AP, Pereira LD. O teste gap in noise em crianças de 11 e 12 anos. Pro-Fono. 2010;22(1):7-12.
8. Pereira LD, Schochat E. Testes auditivos comportamentais para avaliação do processamento auditivo central. Barueri: Pró-Fono; 2011.
9. Musiek FE. Assessment of central auditory dysfunction: the dichotic digit test revisited. Ear Hear. 1983;4(2):79-83.
10. Musiek FE, Zaidan E, Baran JA, Shinn JB, Jirsa RE. Assessing temporal processes in adults with LD: the GIN test. In: Convention of American Academy of Audiology; 2004; March – April; Salt Lake City, USA. Annals. p. 203.
11. Samelli AG, Schochat E. The gaps-in-noise test: gap detection thresholds in normal-hearing young adults. Int J Audiol. 2008;47(5):238-45.
12. Shinn JB, Chermak GD, Musiek FE. GIN (Gap-In-Noise) Performance in the pediatric population. J Am Acad Audiol. 2009;20(4):229-38.
13. Chermak GD, Lee J. Comparison of children´s performance on four tests of temporal resolution. J Am Acad Audiol. 2005;16(8):554-63.
14. Zaidan E, Garcia AP, Tedesco ML, Baran JA. Desempenho de adultos jovens normais em dois testes de resolução temporal. Pró-Fono. 2008;20(1):19-24.
15. Neves IF, Schochat E. Maturação do processamento auditivo em crianças com e sem dificuldades escolares. Pró-Fono. 2005;17(3):311-20.