CoDAS
ISSN 2317-1782 (Online version)

Original Article
Artigo Original

Phrases in Noise Test (PINT) Brazil: influence of the inter-stimulus interval on the performance of children with hearing impairment

Phrases in Noise Test (PINT) Brasil: influência do intervalo interestímulos no desempenho de crianças com deficiência auditiva

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Keywords

Speech Perception
Noise
Hearing Tests
Child Development
Hearing Aids

ABSTRACT

Purpose: This study aimed to investigate, using the PINT Brasil, the influence of the interstimulus interval on the performance of children with moderate and severe hearing loss fitted with hearing aids. **Methods:** Ten children with normal hearing (CG) and 20 children with hearing loss (SG) participated in the study. Both groups were assessed using the speech perception test called PINT Brasil in PAUSE and NO PAUSE situations. **Results:** When comparing the PAUSE and NO PAUSE situations, only the SG presented a statistically significant difference, indicating that the NO PAUSE situation had the best performance. In this situation, the noise oscillations were smaller, and the noise reduction algorithm, which may cause the loss of message information, was not repeatedly activated. **Conclusion:** The interstimulus interval in the PINT Brasil influenced the performance of children with moderate and severe hearing loss fitted with hearing aids. The NO PAUSE situation presented the best results.

Descritores

Percepção da Fala
Ruído
Testes Auditivos
Desenvolvimento Infantil
Auxiliares da Audição

RESUMO

Objetivo: Investigar a influência do intervalo interestímulos no desempenho de crianças com deficiência auditiva de grau moderado e severo, adaptadas com aparelhos de amplificação sonora individuais (AASI), no teste PINT Brasil. **Método:** Participaram do estudo 10 crianças com audição normal (GC) e 20 crianças com deficiência auditiva (GE). O teste PINT Brasil foi aplicado nas situações SEM pausa e COM pausa para os dois grupos. **Resultados:** Na comparação entre as situações SEM pausa e COM pausa, houve diferença significativa apenas para o GE, indicando a SEM pausa com melhor desempenho. Nesta última condição, as oscilações ruidosas foram menores e não houve o acionamento repetido do redutor de ruído, o que possibilita a perda de informações da mensagem. **Conclusão:** Conclui-se que o intervalo interestímulos no teste de percepção da fala PINT Brasil influenciou o desempenho das crianças com deficiência auditiva de grau moderado e severo, adaptadas com AASI. O melhor resultado foi encontrado na situação SEM PAUSA.

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Received: April 17, 2020
Accepted: November 13, 2020

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Financial support: Programa Institucional de Bolsas de Iniciação Cientifica (PIBIC-FOB-USP) and Programa de Residência Multiprofissional em Saúde Auditiva do HRAC-USP- Bolsa do Ministério de Educação e Cultura (MEC).

Conflict of interests: nothing to declare.

INTRODUCTION

The technological progress of Hearing Aids (HA) and Cochlear Implant (CI) allows individuals with sensorineural hearing loss (HL) to have access to speech sounds. These devices can provide benefits for communication, modifying and enhancing oral language acquisition[1].

For children with hearing loss (HL), accessibility to education must be ensured. With the use of electronic devices applied to deafness, speech perception needs to be favored by improving the signal-to-noise ratio (SNR), especially in the school environment[1]. In Brazil, if the individual fits the criteria indicated by the Brazilian Unified Health System (*Sistema Único de Saúde* - SUS), s/he can acquire such devices free of charge at an accredited Hearing Health Services[2][3].

Most individuals are exposed to undesirable sounds in social environments, impairing speech perception. In children, the classroom is an example of an environment where factors that hinder auditory perception, such as the distance between the speaker and the listener, the number of students per class, acoustic reverberation and excessive noise, can generate educational losses[4].

According to the American National Standard Institute (ANSI/ASA S12.60)[5], the maximum value of noise inside classrooms is 35 dB, SNR must be +15dB, and reverberation time must not exceed 0.6 seconds. According to the Brazilian Association of Technical Standards (*Associação Brasileira de Normas Técnicas* - ABNT)[6], NBR 10.152 of 1987, the noise level in classrooms may vary from 35dB to 45dB. However, acoustic conditions suffer great variations, and noise values are far from ideal for a classroom[7].

To verify and plan the hearing habilitation and rehabilitation process, evaluating the functioning and benefit of HA devices is essential. Thus, the American Academy of Audiology has developed a guide of good practices to evaluate them. The verification protocol of the devices indicates the assessment of speech perception in noise[8].

For this type of assessment, sentences are the most indicated because they represent daily communication situations[9]. The Phrases in Noise Test Brasil (PINT Brasil) is a speech perception test with sentences. This test was considered effective to assess speech perception in noise in different groups of four-year-old and older children with HL[10][11].

Schafer developed PINT in 2005, which was designed originally for children using CI; later, the same author revised and modified the test[11,12]. In 2015 it was adapted and validated in Brazilian Portuguese by Santos[12]. PINT aims to obtain the child's speech recognition threshold in noise without the interference of their vocabulary level or the speaker's speech production intelligibility. The test uses sentences referring to body parts that are considered familiar to the children. To simulate the reality of the school environment, it also uses competitive noise, which is classified as "noise from several classrooms (multiclassroom)"[13]. The PINT Brasil is available for download[14].

The PINT Brasil has a relatively short duration, and it is easily applied by audiologists[12,13]. The sentences can be presented in two situations: In the NO PAUSE situation, the sentences and the noise cease simultaneously during the 8-second intervals, and in the PAUSE situation, the noise is continuous during the 8-second intervals between sentences.

There are no data in the literature that show which situation is the best to obtain the speech recognition threshold in noise. However, tests that use sentences and present competitive noise without interrupting both stimuli, such as the Hearing in Noise Test (HINT), make the assessment closer to reality[7,15].

Thus, this study aims to investigate the influence of the interstimulus interval on the result of the PINT Brasil in children with moderate and severe HL fitted with HA.

METHODS

This cross-sectional study has a quantitative approach. It was developed in the Hearing Health Section of the Hospital for Rehabilitation of Craniofacial Anomalies of the University of São Paulo (HRAC/USP) and approved by the Research Ethics Committee of the same institution with CAEE 62481816.2.0000.5417 and No. 2.451.450.

The parents or guardians of the children who agreed to participate in this study signed the Consent Form, attesting their permission to publish the data. The children were guided through the Assent Form, which explained the procedures they would be submitted and the study objectives.

Ten children participated in the control group (CG). They were aged between 4 years and 4 months to 11 years (mean age 8.3 and SD = 2.40). They underwent the following assessment procedures: inspection of external acoustic meatus, pure tone audiometry and logoaudiometry (audiometer Interacoustics AD229e), acoustic immittance and acoustic reflex measurements (automatic impedance audiometer Interacoustics AT235). The following normality criteria were considered: external acoustic meatus without impediments; audiometric thresholds lower than 15dBHL for frequencies from 500 to 4000Hz in both ears, with corresponding results for logoaudiometry; type A tympanometry; and with ipsilateral and contralateral acoustic reflex in both ears.

Twenty children participated in the study group (SG). They were aged 6 years and 6 months to 11 years and 8 months (mean age 9.08 and SD = 1.48) and were enrolled in the institution hearing care service. They attended the following inclusion criteria: a) to be aged between 6 years and 11 years and 11 months b) to be diagnosed with moderate to severe sensorineural HL according to the four-frequency average adopted by the World Health Organization (WHO)[16], c) to be fitted with hearing aids; and d) to be enrolled in elementary school.

Secondary data were collected from all participants using a protocol form, which contained demographic information, case studies and data regarding the fitting of their hearing devices (Tables 1, 2 and 3). The HAs were previously fitted; therefore, verification procedures were conducted to guarantee audibility of soft sounds, audibility and comfort for medium sounds, and tolerance for loud sounds. Thus, the intensities of the PINT were audible for the SG.

Instruments and procedures

All procedures were performed in an acoustically-treated booth (Vibrasom brand). The test was performed using a two-channel audiometer and a free-field amplification system (both MADSEN Astera products), with two loudspeakers: one presenting speech stimuli (0-degree azimuth) and the other, noise (180-degree azimuth).

Each participant was positioned in the center of the booth. The objects for the test (doll, hairbrush, toothbrush, towel) were placed on a bench in front of the participant (Figure 1).

PINT Brasil[10,12,13] is composed of ten sentences recorded by a female speaker; each sentence is a simple order referring to a body part. For the Brazilian Portuguese version of the test, six lists of sentences were developed, each sentence being repeated twice per list in a pseudo-randomized manner (Figure 2).

Before starting the assessment, the objects (doll, hairbrush, toothbrush and towel) were introduced to the participant, who practiced how to execute the actions requested in the sentences with live-voice training.

For this study, the six randomized lists from PINT Brasil were selected. They were used in the CG and SG and applied in random order, using the Latin square design for the PAUSE and NO PAUSE situations. The Latin square corresponds to an n x n matrix[17]. In this case, the matrix has entries with n distinct lists, and there is no repetition of lists in any row or column.

The test starts with a decreasing signal-to-noise ratio (SNR) from +15 dBSNR to -12 dBSNR, and it ends with an increasing SNR from -12 dBSNR to +15 dBSNR. The speech signal remains at a fixed intensity (65 dB), and the noise varies adaptively in 3 dB for each presentation. This is the default value for the beginning of the test. If the child did not respond correctly three consecutive times, the value of +15 dBSNR, when SNR is increasing, was considered. If the child responded to all test phrases 100% correctly or if s/he responded incorrectly to just one sentence, the value of -12 dBSNR was adopted[11-13].

Correct and incorrect responses were written down on the score sheet (Figure 2). The rules for obtaining the scores were determined in previous studies[11-13]. The threshold in dBSNR was determined by the mean of the following scores: (1) from the decreasing column, the last correct response followed by two incorrect responses and (2) from the increasing column, the first correct response followed by two consecutive correct responses.

Statistical analysis

The statistical analysis was submitted to the Kolmogorov-Smirnov test to analyze the normality criterion. The paired t-test in intergroup comparisons for independent groups was used to compare the groups in the PAUSE and NO PAUSE situations. The significance level of 5% ($p<0.05$) was used for all tests.

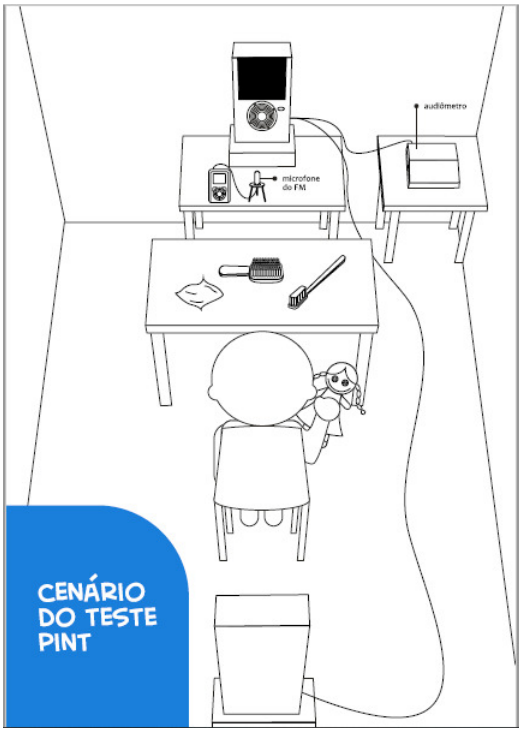
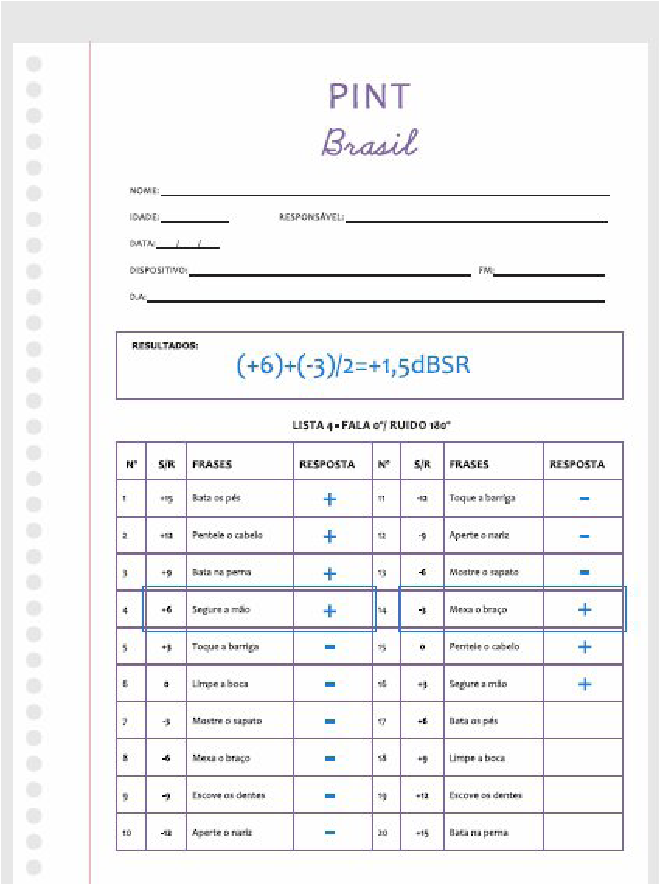


Figure 1. Application scenario of the PINT Brasil. Source: Santos et al.[13]. Reproduced with the permission of the authors



PINT
Brasil

NOME:
IDADE: RESPONSÁVEL:
DATA: / /
DISPOSITIVO: FM:
D.A:

RESULTADOS: (+6)+(-3)/2=+1,5dBSR

LISTA 4 - FALA 0°/ RUIDO 180°

Nº	S/R	FRASES	RESPOSTA	Nº	S/R	FRASES	RESPOSTA
1	+15	Bata os pés	+	11	-12	Toque a barriga	−
2	+12	Penteie o cabelo	+	12	-9	Aperte o nariz	−
3	+9	Bata na perna	+	13	-6	Mostre o sapato	−
4	+6	Segure a mão	+	14	-3	Mexa o braço	+
5	+3	Toque a barriga	−	15	0	Penteie o cabelo	+
6	0	Limpe a boca	−	16	+3	Segure a mão	+
7	-3	Mostre o sapato	−	17	+6	Bata os pés	
8	-6	Mexa o braço	−	18	+9	Limpe a boca	
9	-9	Escove os dentes	−	19	+12	Escove os dentes	
10	-12	Aperte o nariz	−	20	+15	Bata na perna	

Figure 2. Response sheet and scoring example for the PINT Brasil. Source: Santos et al.[13]. Reproduced with the permission of the authors
Caption: CG = Control Group

RESULTS

Table 1 and Table 2 show the demographic data, referring to sex, age, school year, school type (public or private), origin (city/state) and characteristics of the case studies of the control group (Table 1) and the study group (Table 2).

Table 3 shows the data regarding the degree of HL and the fitting of the HA of the study group.

Table 1. Demographic data of the control group (n = 10)

n	Sex	Age	School year	School type	City/State
1	M	9y7m	4th year	Pb	Arealva/SP
2	F	4y4m	Pre-K	Pb	Arealva/SP
3	M	8y8m	4th year	Pt	Bauru/SP
4	M	8y	4th year	Pb	Arealva/SP
5	M	6y8m	2nd year	Pb	Arealva/SP
6	M	4y7m	Pre-K	Pb	Arealva/SP
7	M	9y	4th year	Pb	Arealva/SP
8	M	8y8m	4th year	Pb	Arealva/SP
9	M	11y	6th year	Pt	Bauru/SP
10	F	11y	6th year	Pt	Lençóis Paulista/SP

Caption: F = Female; M = Male; Pb = Public school; Pt = Private school

Table 2. Demographic data of the study group (n = 20)

n	Sex	Age	School year	School type	City/State
1	M	8y	3rd year	Pt	Rio de Janeiro/RJ
2	F	9y2m	4th year	Pb	Dois Córregos/SP
3	M	8y10m	4th year	Pb	Bauru/SP
4	M	10y1m	4th year	Pb	Agudos/SP
5	F	8y3m	3rd year	Pb	Olímpia/SP
6	F	9y10m	5th year	Pb	Dois Córregos/SP
7	M	9y	5th year	Pb	Assis/SP
8	F	9y	4th year	Pt	Bauru/SP
9	M	11y3m	6th year	Pt	Coroados/SP
10	M	8y3m	3rd year	Pb	Santa Gertrudes/SP
11	M	10y7m	5th year	Pb	Bauru/SP
12	F	8y1m	2nd year	Pb	Manduri/SP
13	M	10y3m	4th year	Pt	Marília/SP
14	F	10y3m	4th year	Pb	Ourinhos/SP
15	M	7y1m	1st year	Pb	Araraquara/SP
16	F	7y6m	2nd year	Pb	Londrina/PR
17	F	10y10m	5th year	Pb	Areiópolis/SP
18	F	6y6m	1st year	Pb	Viradouro/SP
19	M	7y1m	1st year	Pb	Itápolis/SP
20	F	11y8m	6th year	Pb	Indaiatuba/SP

Caption: F = Female; M = Male; Pb = Public school; Pt = Private school

S/N ratio

Table 4 shows the descriptive values of the children's performance (dBSNR) for the PINT Brasil. The CG shows better results in both situations (PAUSE and NO PAUSE).

Table 5 shows the intergroup comparison of the mean results of the PINT Brasil.

The box plots show the comparative analyzes of the CG (Figure 3), the SG (Figure 4) and between groups (Figure 5) in PAUSE and NO PAUSE situations. The best performance was observed in the NO PAUSE situation for the SG.

Table 3. Data regarding the degree of HL and HA fitting of the study group (n = 20)

n	Degree of HA	Model/Manufacturer (HA)
1	SV	Ria/Oticon
2	MD/SV	Mosaic 10p/Rexton
3	MD	Mosaic 10p/Rexton
4	SV	Ria/Oticon
5	MD	Ria/Oticon
6	MD	Ria/Oticon
7	MD	Hit/Oticon
8	MD	Mosaic 10p/Rexton
9	MD	Get BTE/Oticon
10	MD	Ria/Oticon
11	SV	Ria/Oticon
12	MD/SV	Get BTE/Oticon
13	SV	Ria/Oticon
14	MD	Hit/Oticon
15	MD	Intro 1200/NuEar
16	MD/SV	Ria/Oticon
17	MD/SV	Chili SP5/Oticon
18	MD	Ria/Oticon
19	MD/SV	Mosaic 10p/Oticon
20	MD	Ria/Oticon

Caption: MD = Moderate; SV = Severe

Table 4. Intragroup comparison of the means of the PINT Brasil results

	n	Mean 1/Mean 2 (dBSNR)	t	p
CG PAUSE x CG NO PAUSE	10/10	-9.60/-10.80	1.714	0.121
SG PAUSE x SG NO PAUSE	20/20	-4.95/-8.93	-4.785	**0.001***

*p<0.05 statistically significant
Caption: CG = Control Group; SG = Study Group; t = t-student test

Table 5. Intergroup comparison of the means of the PINT Brasil results

	n	Mean 1/Mean 2 (dBSNR)	t	p
CG PAUSE x SG PAUSE	10/20	-9.60/-4.95	-3.052	**0.005***
CG NO PAUSE x SG NO PAUSE	10/20	-10.80/-8.93	-1.483	0.149

*p<0.05 statistically significant
Caption: CG = Control Group; SG = Study Group; t = t-student test

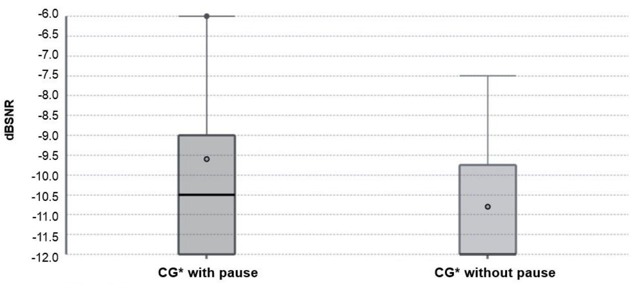
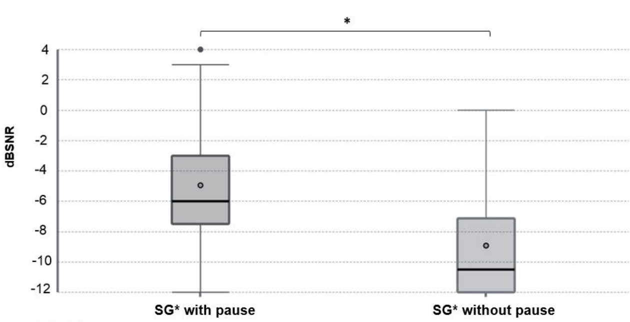
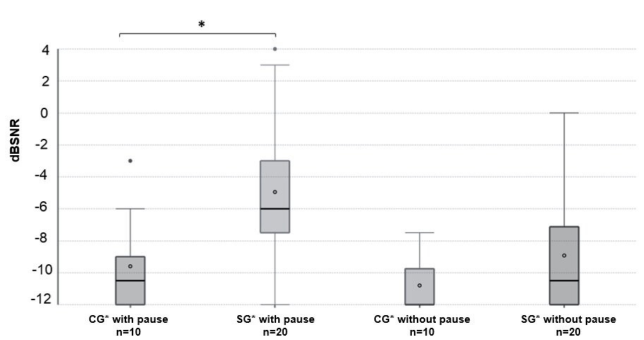


Figure 3. Box-plot of PINT Brasil results for the control group. n = 10 individuals



Caption: SG = Study Group; *Statistically significant difference (p<0.05)
Figure 4. Box-plot of PINT Brasil results for the study group. n = 20 individuals



Caption: CG = Control Group; SG = Study Group; *Statistically significant difference (p<0.05)
Figure 5. Box-plot of the intergroup results of the PINT Brasil

DISCUSSION

The present study aimed to investigate the influence of the interstimulus interval on the results of the PINT Brasil, which assesses children's speech perception in noise. The findings indicated a significant difference in speech perception in noise between children with normal hearing (CG) and children with HL (SG), with the best results obtained by children with normal hearing (CG) (Table 4 and Figure 3). There was no significant difference in the CG for the PAUSE and NO PAUSE situations (Table 4 and Figure 3), revealing that the integrity of the auditory system facilitates speech intelligibility in noise.

When comparing the results for the SG, there was a significant difference between the PAUSE and NO PAUSE situations: the NO PAUSE situation had a better performance (Table 4 and Figure 4).

Given the evaluation conditions and the results, two explanations will be discussed: 1) the possibility that the temporal processing ability is impaired and influenced by sensorineural hearing loss[18] and, 2) the noise-reducing algorithm of the hearing aid interferes with the test performance[19].

The auditory temporal processing is responsible for isolating or resolving acoustic events in a minimum amount of time. It influences speech intelligibility in noise since speech is full of complex characteristics of both spectral and temporal acoustic signals[18].

Some children with HL who use HA and CI can understand speech in quiet environments like their peers with normal hearing[20], but they rarely reach performance levels like their normal hearing peers in noise[21]. For this reason, some authors[22] decided to investigate the influence of auditory, cognitive and linguistic factors on speech recognition in noise in children with HL.

As expected, children with HL performed worse than children with normal hearing in noise, as the results obtained in the present study for the PAUSE situation (Table 4 and Figure 4). In that study, the individual differences observed were partially predicted by language skills, working memory and auditory attention. These aspects were not assessed in this study because they were not part of the methodological objective, but they can be included in future studies.

Those findings had already been presented by other authors[23], who investigated the effects of age and HL on the ability to use the temporal and spectral modulation cues in speech processing, corroborating that children with HL had the worst performance in the proposed tests. Such findings were consistent with the additive effects of HL and its stage of development.

Because of the constant complaint of speech understanding in noise by individuals with HL, HA algorithms were developed to improve speech intelligibility, increase comfort and reduce the auditory effort of the user of electronic devices. One of the most common is the noise reduction algorithm, which aims to improve speech perception when the sound of interest is spatially separated from the noise[24].

The processing of the HAs with noise reduction is digital and aims to provide, in a given area, less amplification for noise than speech. It accurately monitors and analyzes the characteristics of the input signal over a period of time to make sure if it is speech, noise or another signal. When identifying noise, the gain of the HA is changed depending on the noise's intensity[25].

The SG children had the noise reduction algorithm activated on their devices. The best performance in the NO PAUSE situation might be explained because, in this condition, the noise oscillations were smaller; therefore, the noise reduction algorithm was not repeatedly activated. The repeated activation interferes with the frequency gain of the HA, increasing the possibility of a loss of message information, which may hinder speech intelligibility[26].

Studies have shown conflicting results in the evaluation of noise reduction. On the one hand, some authors found an improvement in the clinical assessment of speech recognition in the presence of noise, while others found improvement only in self-assessment questionnaires[27].

On the other hand, studies reveal improvement in the users' responses when the noise reduction is associated with the directional microphone in the speech/noise situation at 0°/180° azimuth. Thus, noise reduction can be a positive strategy to favor the SNR, with an average gain of 3 to 4 dB in environments with low reverberation[23].

In addition, a study investigated the effect of noise reduction on 24 children (aged 7 to 12 years) with normal hearing using hearing aids. The HAs were programmed for 50 dB flat hearing loss and had the noise reduction activated. The study found that the participants' verbal response time was faster with the HA noise reduction active. The authors stated it reduced the listening effort and improved the subjective clarity classifications. Another author found that noise reduction increased the learning of new words for older children and improved children's tolerance to noise[28].

In speech perception tests, the type of noise used in the assessment must also be considered. PINT Brasil uses a mixed noise from four classrooms. The literature indicates that when the noise is similar to the spectra of the speech material itself, the auditory closure is facilitated, increasing the chance of better performance[29].

However, this presents disadvantages since there is a high probability that the speech may be attenuated during the spectral subtraction of the noise reduction[25].

Future studies should investigate the effects of noise reduction on the result of the PINT since the present study did not evaluate situations with the noise reduction deactivated.

CONCLUSION

The interstimulus interval in the speech perception test PINT Brasil influenced the performance of children with moderate and severe hearing loss fitted with hearing aids, and the best result was found in the NO PAUSE situation.

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Author contributions

BCR idealized the study, collected, analyzed and interpreted the data; RTSJ as an advisor, idealized the study, analyzed and interpreted the data; ECMP collected and analyzed the data; COS analyzed the data; ECB collected the data. All authors participated in the writing of the manuscript.