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Software-based digits-in-noise test for Brazilian Portuguese in children with central auditory processing disorder

Teste de dígitos no ruído baseado em software para português brasileiro em crianças com transtorno do processamento auditivo central

Prueba de dígitos en ruido basado en software para portugués brasileño en niños con trastorno del central procesamiento auditivo

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Abstract

Speech recognition on noise is an auditory processing skill, important for children in contexts with competitive noise and reverberation and can test their functional capacity. The Digits-in-Noise (DIN) Test, developed for hearing screening in adults and the elderly, has advantages that make it promising for screening children with central auditory processing disorders (CAPD). **Objective:** Verify the performance of children with central auditory processing disorder in a software-based DIN Test for Brazilian Portuguese. **Methods:** The convenience sample comprised 31 children (8 to 12 years), 23 with CAPD placed in G1, and eight without the disorder that composed G2. All children underwent basic

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TCS: conceived and carried out the data collection and analysis, as well as the writing of the scientific article.
ADSN: contributed in the collection and analysis of data, as well as in the writing of the scientific article.
TRFF and ABS: contributed in the data collection, organization and standardization of the article.
SAB: conceived the study, supervised the collection, performed data analysis, as well as writing the scientific article.
All authors discussed the results and implications of the article, as well as reviewing the final wording of the article.

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audiological assessment and tympanometry, visual and random numerical recognition, use of DIN and auditory processing behavioral assessment to determine the presence or absence of APD. We used the Mann-Whitney test to compare G1 and G2. **Results:** G1 and G2 presented different performances in the filtered speech (right ear), dichotic digits (left ear), binaural fusion and gaps-in-noise tests of both ears and in the frequency pattern test. We observed that the average DIN signal-to-noise ratio (SNR) was -7.29 dB (SD ± 4.76) in G1 subjects, and -8.42 dB (SD ± 2.93) in G2 subjects. There was no statistically significant difference between G1 and G2 in comparison of average final SNR (p = 0.227). **Conclusion:** Considering the average values of the final SNR, we found that the children's performance in the DIN test was similar between both groups.

Keywords: Hearing; Auditory Perceptual Disorders; Mass Screening.

Resumo

Introdução: Nas situações da vida diária, frequentemente, é necessário reconhecer a fala em ambientes com ruído competitivo, sendo que dificuldades neste reconhecimento é uma queixa comum de pessoas com transtornos do processamento auditivo central (TPAC). O Teste de Dígitos no Ruído (TDR), desenvolvido para triagem de perdas auditivas em adultos e idosos, apresenta vantagens que o tornam promissor para triagem em crianças com TPAC. **Objetivo:** Verificar o desempenho de crianças com TPAC no TDR baseado em software para o Português brasileiro. **Método:** A amostra de conveniência foi constituída por 31 crianças (8-12 anos), sendo 23 com TPAC, alocadas no G1, e oito sem o transtorno, que compuseram o G2. Todas realizaram avaliação audiológica básica, timpanometria, reconhecimento numérico visual e aleatório, aplicação do TDR e avaliação comportamental do processamento auditivo central (PAC) para determinar presença ou não do TPAC. Na análise foi utilizado Teste de Mann-Whitney no comparativo entre G1 e G2 e correlação de Sperman entre os testes de PAC e a média da relação S/R (RSR) do TDR. **Resultados:** G1 e G2 apresentaram desempenhos significativamente diferentes nos testes fala filtrada (orelha direita), dicótico de dígitos (orelha esquerda), fusão binaural e *gaps-in-noise* de ambas as orelhas e no teste de padrões de frequência. A média da relação sinal/ruído (RSR) do TDR foi de -7,29 dB (dp ± 4,76) nos sujeitos do G1 e de -8,42 dB (dp ± 2,93) no G2. Não houve diferença estatisticamente significante entre G1 e G2 no comparativo das médias de RSR final (p = 0,227). Não foi evidenciada correlação na maior parte dos testes de PAC e o TDR, exceto correlação negativa no FBOE e DDIOD. **Conclusão:** O desempenho das crianças com TPAC é similar ao de crianças sem TPAC no teste de dígitos no ruído em Português Brasileiro,

Palavras-chave: Audição; Transtornos da Percepção Auditiva; Programas de Rastreamento.

Resumen

Introducción: Reconocimiento de habla en ruido es una habilidad del procesamiento auditivo, importante para chicos en contextos con ruido competitivo y reverberación, y puede ser evaluada para determinar su capacidad funcional. La Prueba de Dígitos en Ruido (PDR), desarrollada para detectar pérdida de audición en adultos y ancianos, presentado ventajas que lo hacen prometedor para detección en niños con trastorno del procesamiento auditivo central (TPAC). **Objetivo:** Verificar el rendimiento de niños conTPAC en PDR basado en software en portugués brasileño. **Metodos:** La muestra de conveniencia consistió en 31 niños entre 8-12 año, 23 chicos con TPAC, asignado en G1, y ocho sin trastorno, que componen G2. Todos realizaron evaluación audiológica básica, timpanometría, reconocimiento numérico visual y aleatorio, aplicación del PDR y evaluación comportamental del procesamiento auditivo, aplicación del PDR e del comportamiento del procesamiento auditivo para determinar la presencia o ausencia de TPAC. Se utilizó la prueba de Mann-Whitney para análisis entre G1 y G2. **Resultados:** G1 y G2 presentaron diferentes rendimientos en pruebas de habla filtrada (oído derecho), dígitos dicóticos (oído izquierdo), fusión binaural y *gaps-in-noise* en ambos oídos y en la prueba del patrón de frecuencia. La Relación Señal/Ruido (S/R) del PDR fue -7.29 dB (sd ± 4.76) en chicos del G1 y -8.42 dB (sd ± 2.93) en G2. No hubo diferencias estadísticamente significativas entre G1 y G2 al comparar las medias finales de RSR (p = 0.227). **Conclusión:** Teniendo en cuenta valores de la media S/R final, hubo similitud de rendimiento en PDR en ambos grupos.

Palabras clave: Pruebas auditivas; Inteligibilidad del habla; Ruido; Pruebas de discriminación del habla; Percepción auditiva

Introduction

In daily life situations, it is often necessary to recognize speech in environments with competitive noise, and difficulties in this recognition are a common complaint of people with central auditory processing disorders (CAPD) [1,2]

Speech recognition in noise can be assessed through tests that seek to replicate real-life situations as a way of determining functional capacity in everyday life[3]. This involves simultaneously presenting speech stimuli and a competitive noise as in the speech in noise test[4], the Speech in Noise + 8 dB sub-test, present in SCAN[5,6]; the Speech Perception in Noise (SPIN) subtest of the ScreeningTest for Auditory Processing (STAP)[7], tool, the Words in Noise subtest of the Münchner Screening of Auditory Perception Disorders (MAUS)[8], test, the Hearing in Noise Test (HINT) [9,10] and the Noise Digit Test (TDR) based on software [3,11- 15].

The use of digits as speech stimuli proves to be an advantageous method because they are high frequency words and very common in the lexical repertoire of most of the population, including children in the school age group[12].

DIN is a test originally developed in the Netherlands [11] as a hearing screening test. People hear triplets of noisy digits (medium speech spectrum) at different signal/noise ratios in both ears simultaneously. To perform the test by telephone, the audio files, previously recorded by a female voice, were played through a computer's sound card, then routed to a modem directly connected to the telephone line. A software was responsible for answering the phone and detecting the keys pressed by the listener on the keyboard. According to the answer given by the listener, the signal-to-noise ratio was calculated for the next presentation, following the proposition of the adaptive process[11]. This involves referring that in an automated way, when the person makes a mistake in the system, the speech signal is increased in intensity in relation to noise and as it hits the speech signal it is lowered. Thus, the speech recognition threshold for noise is established for each person[11].

The DIN was adapted for the English language in an application by researchers from the University of Pretoria, in South Africa [13]. The initial study [13] showed that there was no difference in the use of the application with the smartphone's earphones in relation to the audiometer headphones. 94% sensitivity and 77% specificity were found in the identification of hearing loss with a cut-off point of -9.55 dB[14]. Another study [15] showed 83% sensitivity and 72% specificity with a cut-off point of -9.8 dB. In both studies [14,15] with diotic stimuli.

DIN was applied to children aged 4 to 12 years[16] with the aim of assessing speech recognition in noise under diotic and dichotic conditions. It was observed that with increasing age, there was a significant improvement in the digit recognition threshold in noise. In addition, children aged 10 to 12 years showed similar performances to adults[16].

In Brazil, DIN has been studied in three distinct stages, involving translation, adaptation and validation into Brazilian Portuguese. In the first stage, the protocol of the original study by Potgieter et al was performed[13] covering recording made by a native speaker, processing and equalizing the sound stimulus; insertion of digits in trios in the software already developed; collection of normative data and analysis of different headphones[17]. This step was made possible by the international collaboration between three Higher Education Institutions in Brazil, a University and a company in South Africa. The result of the study of this first step was the test version of the application to be used in research in Brazil, as well as the study of two different types of headphones in normal hearing adults, showing that the performance does not change due to the headphones[17].

The second stage involved the study[18] of the accuracy of DIN in the identification of hearing loss in adolescents, adults and the elderly, evidencing 92.73% sensitivity and 67.11% specificity of DIN in this population, with a cut-off of -6.9 dB[18].

The proposal in the DIN is to assess speech recognition in noise, although it is a procedure developed and studied, predominantly, in hearing loss screening [11-15]. However, its use in audiological diagnosis has been studied in conjunction with pure tone audiometry [19]. It is suggested that it can be a tool that helps in the management and advice of the hearing aid [19].

From the perspective of investigating other applicability of DIN and taking as a reference that speech recognition in noise is commonly inserted in proposals for screening or screening CAPD as in the SCAN test[5,6] the third stage of DIN studies in Brazilian Portuguese was outlined through the study presented in this article, the first involving children with and without CAPD and the DIN in Brazilian Portuguese.

Thus, the aim of this study was to verify the performance of children with CAPD in the digits-in-noise test (DIN) based on software for Brazilian Portuguese.

Method

This study is observational, transversal and prospective. The convenience sample was selected by recruiting children from public schools in Natal, Rio Grande do Norte. This study was approved by the Institution's Research Ethics Committee, under opinion No. 3,232,691. The parents/guardians of the children participating in this study signed the Free and Informed Consent Term (ICF), while the children signed the Free and Informed Consent Term (TALE).

The inclusion criteria for the research were: (1) being within the age range of 8 to 12 years; (2) present auditory responses in up to 25 dB NA[20] or in lower intensity in the frequencies from 250 to 8000 Hz; (3) tympanometry with the peak of maximum compliance in the range of +50 to -100 daPA and with static compliance greater than or equal to 0.2 cc[21]; may or may not have CAPD.

Children who did not meet the inclusion criteria were excluded, as well as those that did not pass the screening of visual recognition of the numbers or did not complete all the research evaluation procedures.

The sample was divided into two groups: G1 consisting of children with a diagnosis of CAPD and G2 with children with normal CAP.

Initially, information was collected for socio-demographic characterization of the sample, when the questionnaire of the Brazilian Economic Classification Criterion of the Brazilian Association of Research Companies[22] was applied with those responsible for the children. Based on the sum of the items informed by them, the socioeconomic classification was established. Based on the results, the A1, A2, B1 and B2 classifications were grouped and classified as high socioeconomic level; C1 and C2 as the average socioeconomic level; and D and E as low socioeconomic status.

The applied procedures were: 1) screening test for visual recognition of numbers; 2) digits-in-noise test (DIN); 3) pure tone audiometry and 4) battery of CAP evaluation tests. These procedures were always carried out in this order by independent researchers who were kept blind to the results of DIN, pure tone audiometry and CAP evaluation throughout the evaluation process.

The screening test for visual recognition of numbers was applied in order to verify whether children were able to correctly recognize the numbers they heard visually. In this way, a board with numbers from zero to nine was randomly distributed and the child was asked to point out each one as the evaluator cited, as well as to nominate each one in the order that was arranged on the board. Knowledge and the ability to visually recognize numbers was a condition for the execution of the DIN task.

The version of the DIN used in the application, in this study, was a test version translated and adapted to Brazilian Portuguese[17] installed on the Motorola smartphone and model Z, with the smartphone's own headphones. The researchers instructed the children and, after registering in the application, headphones were inserted. Before the start of the test, sequences of random numbers were presented from which it was possible for the child to regulate the initial intensity of the stimulus based on his hearing comfort. The average duration of the test was approximately three minutes. The children heard three digits (from 0 to 9) with background noise (speech noise) at 70 dB SPL intensity, in in-phase condition, and they should visually recognize the number heard on the application keyboard.

After starting the test when 23 sequences of 3 digits each were presented and, upon hearing the stimulus, the child typed, through the keyboard that the application has, which digits were heard. Those who could not be identified should be guessed[13]. Based on the assertions or failures, the signal-to-noise (S/N) ratio between stimulus and noise were altered, where it initially presented itself in the S/N ratio of -2 dB (easiest level) and became difficult in an automated way if there was a hit or regress according to the errors, in an adaptive process, based on the following S/N ratios: -2, -4, -6, -8, -10, -12, -14, -16, - 18 and -20 dB. The correct answers were counted when all digits were placed correctly in the presented sequence[13]. At the end, the average of the signal/noise ratios found in the hits between sequences 4 and 23 was calculated. In addition, a table was generated with the results of each sequence presented [18].

The pure tone audiometry by air at frequencies from 250 to 8000 Hz was performed with the Otometrics Madsen Itera II audiometer, in an acoustic booth, with a pure tone using the TDH 39 headphones. Tympanometry was performed with the Interacoustic AT235 device, in order to assess the integrity of the middle ear, ensuring the absence of conductive changes.

The CAP behavioral assessment protocols were applied inside the acoustic booth, using the Pereira and Schochat[4] CD coupled to the audiometer, composed of a band with the recorded percentage of speech recognition (IPRF); Filtered Speech Test (FF) and Binaural Fusion Test (BF) and Dichotic Digit Test (IDD) - binaural integration task. In addition to these, children were assessed using the Standard Pitch Pattern Sequence Test (PPS), in the naming task, and the Gaps in Noise Temporal Resolution Test (GIN)[23]. The methodology for applying each test and the normative values adopted by age group followed those recommended by Pereira and Schochat[4] in the verbal tests and by Auditec [23] in TPF and GIN.

To prove the presence of CAPD, children should present, at least, two tests below the expected for their age in the assessment of central auditory processing [1], being then classified as G1. Children with no changes in the battery of tests were allocated to G2[1,2]. Although this criterion was used for the formation of groups, the analysis and description of the percentage of occurrence of altered G1 performance in each test and ear was also performed to characterize the sample in relation to the CAP behavioral battery tests. The same was not done with the G2 as it showed normal results in the tests of the CAP evaluation battery.

The data were tabulated in a spreadsheet format in the Excel program and imported into the SPSS software (Statistical Package for the Social Sciences) 20.0 for later statistical analysis.

Afterwards, it was verified with the Shapiro-Wilk test that there was no normal distribution of the studied variables, indicating the use of non-parametric tests. In this way, the performance of each group in each test and ear was compared and the comparison of the performance in DIN between the groups using the Mann-Whitney test. Finally, Spearman's correlation was used to analyze whether there was a correlation between each test in the CAP evaluation battery and the DIN results. The level of significance was set at 5%.

Results

63 children were contacted, 40 of whom attended the procedures. Figure 1 shows the exclusion criteria for nine children, with the sample consisting of 31 children, divided into 23 children in G1, with CAPD, and eight children in G2, without CAPD.

As for sex, the distribution was made up of 13 male children in G1 (56.52%) and seven in G2 (87.5%). Regarding socioeconomic level, most children with CPET (47.83%) are at the middle level and, of the children without a disorder, 50% are at the lowest level (Table 1).

When analyzing, through the Mann-Whitney test, the averages of the results of each test of the minimum diagnostic battery of central auditory processing between the groups studied, it was observed that there was no statistically significant difference between the results of the left ear of the Filtered Speech test ($p = 0.054$) and the right ear of the Dichotic Digit Test ($p = 0.082$) (Table 2). In the other tests and ears, G1 had a statistically different performance from G2 in the CAPD battery tests.

It was found when analyzing the percentage of children in G1, that is, in the group with CAPD that presented changes in each test and ear, that the binaural fusion test followed by the filtered speech test in both ears were the tests with the lowest percentage of G1 children with altered performance. In contrast to the dichotic digit test, of ordering and temporal resolution (Table 3).

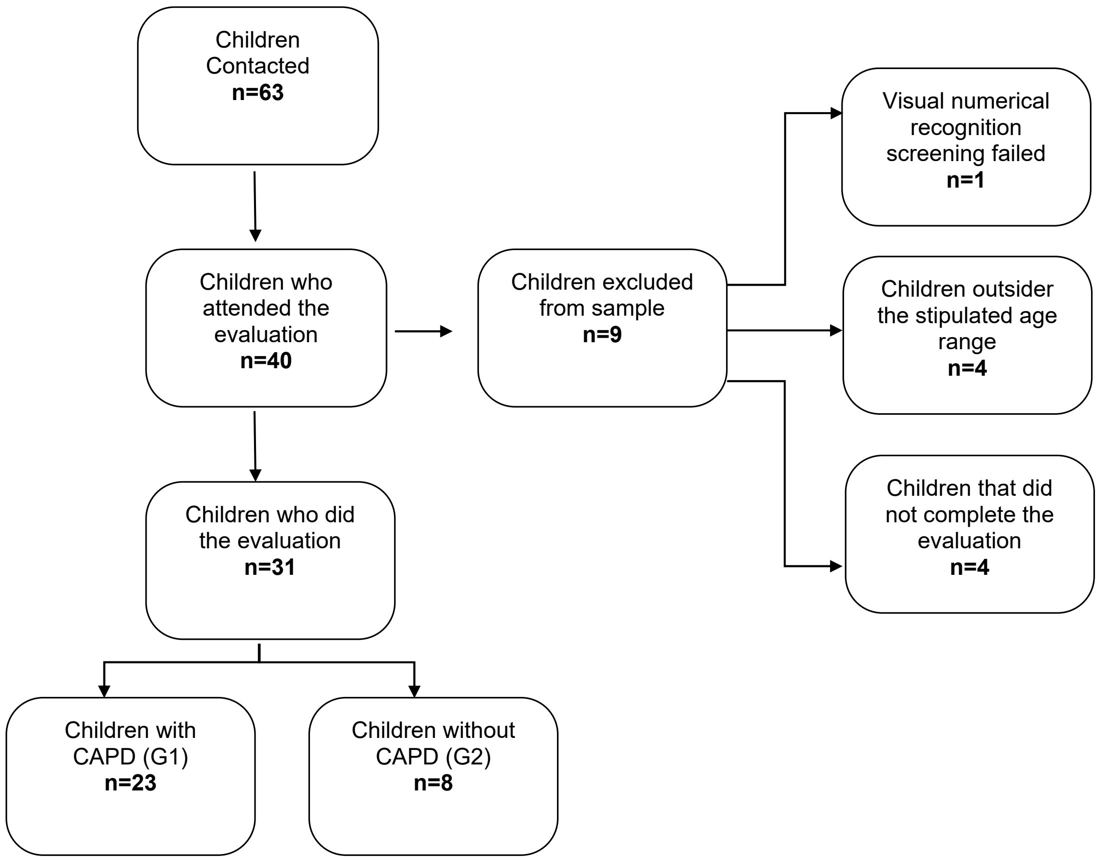

Figure 1. Flowchart of the process of constituting the study sample.

Table 1. Socio-demographic data of the sample studied by group.

	G1 (n=23)	G2 (n=8)	Total (n=31)
Age	10.08±1.12	10.37±0.92	10.16±1.07
Average ± dp			
Minimum-maximum	8-12	9-12	8-12
Sex	13 (56.52%)	7 (87.5%)	20 (64.52%)
Male			
Female	10 (43.48%)	1 (12.5%)	11 (35.48%)
Socio-economic level	7 (21.74%)	4 (50%)	11 (35.48%)
Low			
Average	11 (47.83%)	1 (12.5%)	12 (38.71%)
High	5 (30.43%)	3 (37.5%)	8 (25.81%)

Caption: sd = standard deviation; n = number of subject; % = percentage

Table 2. Descriptive statistics for characterizing the performance of the sample studied in the central auditory processing tests by group.

		G1	G2	p*
FF RE	Average±dp	69.39 ± 11.02	80 ± 9.07	0.016
	Q1	64	77	
	Median	72	84	
	Q3	76	85	
FF LE	Average ±dp	68.78 ± 12.25	77.5 ± 9.30	0.054
	Q1	61	72	
	Median	68	80	
	Q3	76	82	
BF RE	Average ±dp	84.69 ± 7.49	93 ± 4.14	0.007
	Q1	78	91	
	Median	84	92	
	Q3	92	96	
BF LE	Average ±dp	83.91 ± 6.88	92.5 ± 3.96	0.001
	Q1	80	92	
	Median	84	92	
	Q3	88	96	
DDI RE	Average ±dp	88.69 ± 11.42	95 ± 6.05	0.082
	Q1	86.25	95	
	Median	90	98.75	
	Q3	96.25	100	
IDD RE	Average ±dp	80.65 ± 10.79	90.93 ± 13.41	0.048
	Q1	75	83.12	
	Median	87.5	97.5	
	Q3	90	100	
PPS	Average ±dp	68.10 ± 18.33	91.66 ± 0	0.000
	Q1	56.66	90	
	Median	70	90	
	Q3	83.31	94.14	
GIN RE	Average ±dp	7.95 ± 3.41	5.25 ± 0.70	0.024
	Q1	6	5	
	Median	8	5	
	Q3	9.5	6	
GIN LE	Average ±dp	7.72 ± 2.41	5.75 ± 1.03	0.024
	Q1	6	5	
	Median	8	5.5	
	Q3	8	6	

Caption: * Mann-Whitney test; FF = filtered speech test; RE = right ear; LE = left ear; BF = binaural fusion test; IDD = dichotic digit test (integration task); PPS = pitch pattern test; GIN = gaps-in-noise test; sd = standard deviation; Q1 = first quartile; Q3 = third quartile; ** p <0.05

Table 3. Percentage of children in G1 (n = 23) with changes in each test of the CAP evaluation.

		Altered N (%)	Normal N (%)
FF	RE	3 (13.05)	20 (86.95)
	LE	4 (17.40)	19 (82.60)
BF	RE	1 (4.35)	22 (95.65)
	LE	1 (4.34)	22 (95.65)
IDD	RE	15 (65.22)	8 (34.78)
	LE	20 (86.95)	3 (13.05)
PPS		14 (60.87)	8 (39.13)
GIN	RE	13 (56.52)	10 (43.48)
	LE	15 (65.22)	8 (34.78)

Legend: N = number of children; FF = filtered speech test; RE = right ear; LE = left ear; BF = binaural fusion test; IDD = dichotic digit test (integration task); PPS = pitch pattern test; GIN = gaps-in-noise test.

Table 4 shows that there was also no statistically significant difference between G1 and G2 when comparing the mean signal-to-noise ratio (p = 0.227) in the DIN.

Table 4. Descriptive and inferential statistics of the DIN mean result (final S / R) by group studied.

	G1	G2	p*
Average±dp	-7.29±4.76	-8.42±2.93	0.227
Q1	-10.40	-9.80	
Median	-9.20	-9.10	
Q3	-6.00	-7.75	

Caption: * Mann-Whitney test; sd = standard deviation; Q1 = first quartile; Q3 = third quartile; ** p <0.05

When analyzing the correlation between each test of the CAP evaluation with the results of the average signal / noise ratio of the DIN, it can be observed that there was no correlation, or it was negative (Table 5).

Table 5. Spearman's correlation analysis between the average final signal / noise ratio and the performance of G1 subjects in each test that makes up the minimum battery for behavioral assessment of central auditory processing.

	FF RE	FF LE	BF RE	BF LE	IDD RE	IDD LE	PPS	GIN RE	GIN LE
DIN (SNR final)	0.109	-0.096	-0.368	-0.608	-0.504	-0.254	-0.108	0.203	0.152
p*	0.619	0.665	0.084	0.002	0.014	0.241	0.622	0.353	0.488
R^2	0.056	0.025	0.139	0.354	0.432	3.821	4.951	0.002	0.002

Legend: * Spearman's correlation coefficient; FF = filtered speech test; RE = right ear; LE = left ear; BF = binaural fusion test; IDD = dichotic digit test (integration task); PPT = pitch pattern test; GIN = gaps-in-noise test; DIN = digits-in-noise test; SNR = signal / noise ratio; ** p <0.05

Discussion

In this study we show that the performance of children with CAPD is similar to that of children without CAPD in the digits-in-noise test in Brazilian Portuguese, due to the absence of statistical significance between the two groups.

The acoustic signal and the task proposed by DIN involves speech recognition in noise. Children with normal hearing from the age of four are able to perform the test with the task of speech recognition in noise to assess this ability, which depends on the child's ability to dissociate the speech signal from background noise, to benefit from the acoustic fluctuations of noise and binaural tracks[3]. Thus, we sought to verify the applicability of DIN as a screening tool for CAPD, starting from the comparison between a group of children with this disorder and another group that did not have CAPD.

It is worth noting that some controversies permeate the definition and diagnosis of CAPD[24-28]. There is no way to guarantee that it is a deficit with only auditory characteristics[28]. Scientific evidence strengthens the premise that different disorders with top-down modulation such as Specific Language Disorder, Attention Deficit Hyperactivity Disorder, Developmental Dyslexia, Learning Difficulty and CAPD have similar and even coincident manifestations on issues such as intelligence, memory, attention and language[27].

There is also the concept that CAPD and all its symptomatic manifestations go beyond a disorder, and constitute an important marker of Neurodevelopmental Syndrome, which associates several markers in auditory, speech, attention, memory and behavioral difficulties. Depending on the severity and predominance of one or more markers, the child manifests a unique developmental profile with developments that are modulated through genetic makeup, the environment to which the child is exposed, age and academic demands[24]. On the one hand, it is believed that children with a central auditory function disorder cannot be diagnosed with just a combination of tests, which do not seem to follow the same logic as the characteristics presented[25,29].

In contrast, the diagnostic assessment tools available, through a minimum battery of tests, are sensitive to detect central auditory processing dysfunction in specific cortical regions, their nature according to the identified strengths and disabilities, as well as quantifying and qualifying the hearing difficulties, associated with communication, learning and other comorbidities[26,30]. Therefore, a minimal behavioral battery composed of the Filtered Speech tests was used for this study, which assesses the ability of auditory closure; Binaural fusion, to assess the ability of auditory synthesis; Digit dichotic, evaluating binaural integration; Pitch Pattern Sequence Test, responsible for assessing the temporal ordering ability and the Gaps-in-noise test (GIN) to assess temporal resolution[18,19,31].

The lack of correlation between filtered speech, binaural fusion tests, dichotic digit LE, PPS and GIN LE and LE with the results of DIN in children with CAPD shows that DIN does not distinguish children with CAPD from those without CAPD. The negative correlation between the LE binaural fusion test and the dichotic digit RE and the DIN results demonstrate that the higher the performance in these tests, the lower the DIN, since the variables correlate negatively. Therefore, even the filtered speech test that assesses the ability of auditory closure and, in theory, could have a greater correlation with speech recognition in the noise requested in DIN from children.

This result may have been influenced by the low occurrence in the sample of 23 children (46 ears) of results below the expected in the filtered speech test. Low-redundancy monoaural tests are tests that involve reducing the extrinsic redundancy of the speech signal, through stimulus distortion with low-pass filters, time compression, competitive noise and reverberation, capable of assessing the ability of auditory closure , which consists of the ability to recognize auditory information when there is no clarity[2,30]. However, this ability is not the only one within the scope to detect CAPD[2],which can be an important influence in the absence of clinical findings when differentiating G1 from G2 and the comparative of DIN results. It is also pointed out the importance of tests for CAP screening that mainly involve dichotic listening skills, localization, lateralization and other binaural interactions, as they show greater sensitivity in the detection of CAPD and other changes in the Central Auditory Nervous System[2].

Among the limitations faced during the development stages of this study, it is possible to list the difficulty in collecting clinical data and expanding the sample size of the group of children without CAPD, the low adherence of parents or guardians to attend or return to complete clinical procedures, and, finally, the lack of availability of parents' schedules for the outpatient care.

The lack of matching of the namostral in the evaluated groups has repercussions on the results found and leads to hypothesize that the absence of a statistically significant difference when comparing the results of the FF test in the left ear could be elucidated with leveled groups, since the p value is very close of significance. It would also be necessary to correlate DIN with behavioral tests that assess speech recognition in noise with proposals for similar tasks. This is the case, therefore, for HINT[9,10] and the SCAN[5,6].

However, it is noteworthy that in most of the tests and ears evaluated with the CAP evaluation procedures, G1 presented inferior and statistically different performances from G2, which characterizes that, in fact, they are subjects with different spectra in hearing skills, with DIN showing similar results.

Thus, further studies with a higher namostral are needed to confirm the present findings, especially in the unchanged group, in order to enable the accuracy analysis of this instrument. If confirmed, there will be evidence to the fact that DIN in a diotic form as presented in this study may not be a valid test to be used with children with CAPD. It is also suggested to study the dichotic presentation of DIN in future studies, as it may be potentialized to assess the Central Auditory Nervous System.

Conclusion

The performance of children with CAPD is similar to that of children without CAPD in the digits-in-noise test in Brazilian Portuguese.

Thanks

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