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The use of the dichotic digit test as a screening method

O uso do teste dicótico de dígitos como método de triagem

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Keywords

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ABSTRACT

Purpose: To analyze the use of the Dichotic Digit Test (DDT) as a screening method and to compare its performance with a self-perception questionnaire and other Central Auditory Processing (CAP)behavioral tests. **Methods:** Cross-sectional, retrospective study with analysis of medical records. The study analyzed 66 medical records of children aged 8 to 11 years, and divided them into control group (G1), consisting of 34 children who did not show changes in the DDT, and the study group (G2) with 32 children who showed changes in the DDT. The Scale of Auditory Behaviors (SAB) questionnaire was used in addition to behavioral tests that assessed the auditory abilities of localization, closure, figure-ground, temporal ordering and resolution. **Results:** Individuals in G2 showed higher percentages of changes in all instruments, except for the speech-in-noise test. There was a statistically significant association between the DDT performance categories with the categories of the SAB questionnaire (p-value 0.022) and the simplified CAP assessment (p-value<0.001). The DDT showed a significant correlation with the SAB questionnaire and with all CAP tests used in at least one of the analyzed ears. **Conclusion:** In conclusion, the DDT can be used as a screening method for central auditory processing disorder in basic audiological assessment as there was an association in its performance with the self-perception in the SAB questionnaire, in addition to correlation, especially in the left ear, with behavioral tests applied to diagnose CAPD.

Descritores

Percepção Auditiva
Testes Auditivos
Triagem
Transtornos da Audição
Audição

RESUMO

Objetivo: Analisar o uso do teste dicótico de dígitos (TDD) como método de triagem e comparar seu desempenho com questionário de autopercepção e demais testes comportamentais do processamento auditivo central (PAC). **Método:** Estudo do tipo transversal, retrospectivo e com análise de prontuários. Foram analisados 66 prontuários de crianças com idade de 8 a 11 anos, sendo as mesmas divididas em grupo controle (G1), constituído por 34 crianças que não apresentaram alteração no TDD e o grupo estudo (G2), por 32 crianças que apresentaram alteração no TDD. Foi utilizado o questionário Scale of Auditory Behaviors (SAB). Além de testes comportamentais que avaliaram as habilidades auditivas de localização, fechamento, figura-fundo, ordenação e resolução temporal. **Resultados:** Os indivíduos do G2 apresentaram maiores percentuais de alteração em todos os instrumentos, com exceção do teste fala com ruído. Houve associação estatisticamente significante entre as categorias de desempenho do TDD com as categorias do questionário SAB (p-valor 0,022) e da Avaliação simplificada do PAC (p-valor<0,001).O TDD apresentou correlação significante com o questionário SAB e com todos os testes do PAC utilizados, em pelo menos uma das orelhas analisadas. **Conclusão:** Conclui-se o TDD pode ser utilizado como método triagem do transtorno do processamento auditivo central na avaliação audiológica básica, uma vez que houve associação no seu desempenho com o questionário de autopercepção SAB. Além de correlação, especialmente na orelha esquerda, com os testes comportamentais aplicados para realizar o diagnóstico do transtorno do PAC.

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INTRODUCTION

Central Auditory Processing (CAP) concerns the perception and understanding of speech sounds, which interfere with language acquisition and comprehension. According to the American Speech-Language Hearing Association (ASHA), CAP refers to the efficiency and effectiveness in which the Central Nervous System (CNS) uses auditory abilities[1,2].

Central Auditory Processing Disorder (CAPD) can be characterized by changes in one or more auditory abilities which may bring, as consequences, problems of reading and writing, social behavior disorders, changes in speech, memory, sound localization, recognition and speech discrimination[2-4].

The international literature[5] reports that the estimated prevalence of children with CAPD is 6.2%, with an increase in this percentage for more specific populations, such as the elderly. In an attempt to track individuals with CAPD, discussions have been held in order to identify an instrument or battery of sensitive and effective tests to serve as a good screening method for auditory abilities.

Studies and guidelines[5,6] have been carried out with the aim of analyzing which combinations of tests or questionnaires could be able to function as a screening method for CAPD. The guidelines suggest the use of self-perception questionnaires as an affordable and quick way to obtain relevant information on the child's auditory behavior, especially important for the identification and early intervention in children at risk for CAPD[5,6].

Currently, few studies highlight sensitive hearing screening methods to identify changes in CAP[7,8]. The instruments cited as a form of screening to detect possible CAPD are: screening procedures using questionnaires[8,9]; screening through auditory tests, or a combination of both[10].

Among the behavioral auditory tests, investigations that adopted the DDT (Dichotic Digits Test) as a screening protocol are highlighted. The test used in combination was efficient in classifying over 50% of the individuals with CAPD[11]. In addition, a study in individuals with neurological injuries verified the diagnostic value of some CAP tests, and among the studied tests, the research found for DDT values of sensitivity equal to 90% and specificity of 83%, enough to justify its use as a future screening instrument in new research to identify CAPD[12].

The DDT was translated into Brazilian-Portuguese[13] to analyze figure-ground abilities in the integration task and binaural separation for verbal sounds through a dichotic task[14]. However, the literature has observed that DDT has been identified as a test for screening hearing disabilities, and recommended in national forums[15] and international studies[8], due to the low linguistic level, easy and quick application, and for evaluating the precursor skills of the learning process, in addition to being ideal for screening in school settings or in basic audiological assessments, thus facilitating referrals when necessary[7].

In order to complement the investigation of auditory abilities, one of the questionnaires indicated for detecting behavioral characteristics of children in school and social settings is the Scale of Auditory Behaviors (SAB)[16]. The scale, together with a CAP test battery, are able to identify and complement a possible CAPD diagnosis[9,16].

It is known that for the CAPD diagnosis, a complete battery of audiological tests is necessary, as one single instrument does not include all the auditory abilities recommended by ASHA[2,7]. However, this study is justified by the need to promote and prevent early problems in the learning process, as well as the use of procedures that facilitate the clinical routine of professionals and patients, in addition to verifying the use of the DDT as a referral method for formal CAP assessment.

Thus, the present study aimed to analyze the use of the DDT as a screening method and to compare its performance with a self-perception questionnaire and other CAP behavioral tests.

METHODS

This is a cross-sectional, retrospective study with medical records analysis. It was approved by the Research Ethics Committee of the Federal University of Santa Catarina (UFSC), under number 2,008,562. All guardians who agreed to participate signed the Free and Informed Consent Form and were informed about the confidentiality of the information. The research was carried out at the School Clinic of Speech Therapy (Clínica Escola de Fonoaudiologia) at UFSC in Florianópolis, state of Santa Catarina.

In the clinic of infant audiological assessment at the School Clinic of Speech Therapy, the DDT (binaural integration stage) and the SAB questionnaire to assess children with possible demands for CAP assessment are performed on the same day.

Thus, as an inclusion criterion, information was initially collected from the medical records of 66 children, of both sexes, aged 8 to 11 years, who underwent the DDT and the SAB questionnaire on the day of the basic audiological assessment. As exclusion criteria, children did not have cognitive, neurological or psychiatric disorders described in the anamnesis or the basic audiological assessment with changes in hearing thresholds, bilaterally, or conductive problems in the immittance testing.

Information of sociodemographic data (gender, age and education), results from the SAB questionnaire and CAP assessment was collected from the medical records.

After data collection, the children were divided into two groups: control group named G1, and study group named G2. G1 was composed of children who did not show any changes in the DDT, and G2 was composed of children who had changes in the DDT in at least one of the ears.

The SAB questionnaire[16] consists of 12 questions, with 1-to-5 answering options, in which 1 is frequently, and 5 is never. These questions, involving the possible manifestations of CAPD, cover questions about school and social life, to be answered by parents and teachers. The SAB score can vary from 12 to 60 points. To compare with G1 and G2, according to the DDT performance, two cutoff points were adopted in the SAB questionnaire suggested in the study[16]: 46 and 35 points. According to this study with Portuguese children, performance below 46 points is considered risky and the study recommended the children be referred for CAP assessment. With performance below 35 points, the children had changes in more than two

CAP tests and should be referred for auditory ability assessment and training. These two cutoff points were used to assess which would be the most appropriate to be adopted in children as a screening method.

In the outpatient clilnic where the SAB questionnaire was collected, it was always filled out by the guardian without interference from the evaluator.

In the initial assessment, the DDT was performed in the binaural integration stage[14] to assess figure-ground abilities for verbal sounds. A list with 20 pairs of digits presented in dichotic listening was used. The child heard four digits presented in a dichotic manner (four, five, seven, eight or nine) and had to repeat the digits presented orally.

After dividing the groups according to the DDT performance, the SAB performance, the Simplified Assessment of Auditory Processing (SAAP) performance and the tests that assessed the auditory abilities: auditory closure, figure-ground (binaural separation), temporal ordering and resolution were collected in the medical records. In the clinic, the CAP assessment is always scheduled to be carried out on a different day after the completion of the basic audiological assessment and the DDT and SAB applications.

In the SAAP, the following tests were analyzed: sound localization (SL) in five directions, sequential memory for verbal sounds and sequential memory for non-verbal sounds. The assessed auditory abilities were: sound localization and temporal ordering[13,14]. In case of any changes in any of these tests, the individual was considered changed.

The Random Gap Detection Test (RGDT)[17] was used to assess the temporal resolution ability. Children from seven years old who had mean correct answer of four sound frequencies (500, 1000, 2000 and 4000Hz) below or equal to 10 ms were considered within the normal range.

To assess figure-ground (binaural separation), information was collected from the Pediatric Speech Intelligibility (PSI)[13] in monotic test. The performance in the signal/noise ratios of zero and -10dB was analyzed. In case the individual had a change in one of these relationships, he/she was considered changed.

The performance of the speech-in-noise test (SIN) or the filtered speech test (FST) were analyzed in the medical records to assess the auditory closure[14]. Both are monoaural tests of low redundancy, in which patients listen to the monosyllables and repeat them orally.

In children aged 9 to 11 years, the Duration Pattern Test (DPT) in the musical tone[14] was also applied to assess the temporal ordering. This test was presented binaurally and in the naming task. In children, only the DPT was performed to assess the auditory ability of temporal ordering to avoid mental fatigue through the application of special tests, as the behavioral tests are applied all in one session.

Groups G1 and G2 were compared with the SAB questionnaire and with the SAAP results and the CAP special tests.

The data were tabulated in Microsoft Excel spreadsheets, version 2019, and submitted to descriptive and analytical analysis. For the descriptive analysis, the data were represented by frequencies: absolute, relative, means with standard deviation (sd), medians, minimum and maximum values. Data distribution was analyzed using histograms and the Shapiro-Wilk test. After assessment, the Mann-Whitney U non-parametric test was used to verify whether there was an association between the data, and Pearson's chi-square test to analyze differences between the proportions of the groups.

To check whether there was a correlation between the CAP assessment tests and the SAB questionnaire, Spearman's correlation coefficient was used. For data interpretation, the following parameters were considered: 0 to 0.30 negligible; 0.31 to 0.50 weak; 0.51 to 0.70 moderate, 0.71 to 0.90 strong and ≥ 0.91 very strong. The p-value was considered statistically significant for values below 0.05, and was represented with a superscript asterisk (*). The analyzes were conducted using the SPSS 25 software.

RESULTS

The study included 66 children with a mean age of 9.1 years, minimum age of 8 and maximum age of 12, with 40 (60.60%) male and 26 (39.40%) female children. All of them attended between the 2nd and the 6th grade of elementary school.

Table 1 shows the individuals' performance (G1 and G2) in the CAP assessment and in the SAB questionnaire. In relation to the SAB, 34 children performed the same in G1 and 32 children in G2. It is noteworthy that 19 children did not take the DPT because they were 8 years old.

Individuals in G2 showed higher percentages of changes in all instruments, when compared to G1, except for the SIN test. In addition, when observing the SAB questionnaire scores, changes are higher for scores below 45 points in both groups, but with a worse performance in G2.

Table 2 shows the comparison of the SAB cutoff point scores with the number of changed CAP tests.

Table 2 reveals that the majority (57.4%) of the children with a performance below or equal to 45 points had 3 or more changed tests ($p < 0.001$). On the other hand, using a score below or equal to 34 points, it was found that 21 children (65.6%) showed changes in 3 or more tests ($p = 0.001$).

Table 3 shows the comparison of the DDT groups with the performance in the SAB questionnaire according to the different cutoff points.

Table 3 shows that there was an association between the DDT performance categories (G1 and G2) with the SAB questionnaire categories and the Simplified Auditory Processing Assessment.

Table 4 presents the descriptive analysis and comparison of the performance in the SAB questionnaire and CAP tests according to the DDT performance (G1 and G2).

There was a statistically significant difference between the performance of G1 and G2 in both ears in the DDT ($p < 0.001$), in the SAB instrument ($p = 0.014$), in the RGDT ($p = 0.005$), in the DPT ($p = 0.042$), in the PSI and FST (both in the right ear: $p = 0.036$ and $p = 0.013$).

Table 5 shows the correlation between the applied auditory tests and the SAB questionnaire.

Analyzing Table 5, this investigation highlights the statistically significant correlations between: the DDT in both ears with the SAB questionnaire (moderate and directly proportional

Table 1. Descriptive analysis of the number of children according to each test/ questionnaire and percentage of changed results in G1 (n = 34) and G2 (n = 32)

Tests	G1- N	G1-% ofchange	G2 - N	G2 - % ofchange
DDT	34	0 (0)	32	32 (100)
SAB ≤ 34	34	12 (35.3)	32	20 (62.5)
SAB ≤ 45	34	20 (58.8)	32	27 (84.4)
SAAP	34	6 (17.6)	32	24 (75.0)
RDGT	34	18 (52.9)	32	24 (75.0)
PSI	34	5 (14.7)	32	7 (21.8)
SIN	29	5 (17.2)	9	1 (11.1)
FST	09	0 (0)	19	5 (26.3)
DPT	28	9 (32.1)	19	13 (68.4)

Caption: SAB = Scale of Auditory Behaviors; SAAP = Simplified Assessment of Auditory Processing; DDT = Dichotic Digit Test; RGDT = Random Gap Detection Test; PSI = Pediatric Speech Intelligibility Test; SIN = Speech-in-Noise; FST = Filtered Speech Test; DPT = Duration Pattern Test; G1 = Control group; G2 = Study group; N = number of children

Table 2. Comparison between the number of changed auditory tests and the cutoff points of the SAB questionnaire for both groups

	No changed tests n (%)	1 ou 2 changed tests n (%)	3 or more changed tests n (%)	*p
SAB NL ≥ 35	10 (29.4)	16 (47.1)	8 (23.5)	0.001
SAB CHA ≤ 34	1 (3.1)	10 (31.3)	21 (65.6)	
SAB NL ≥ 46	9 (47.4)	8 (42.1)	2 (10.5)	< 0.001
SAB CHA ≤ 45	2 (4.3)	18 (38.3)	27 (57.4)	

*Pearson's chi-square test
Caption: SAB = Scale of Auditory Behaviors; NL = Normal; CHA=Changed

Table 3. Comparison of proportions between G1 and G2 according to the SAB cutoff points and simplified assessment of auditory processing

Test	G1	G2	*p
SAB NL ≥ 35	22	12	0.027*
SAB CHA ≤ 34	12	20	
SAB NL ≥ 46	14	5	0.022*
SAB CHA ≤ 45	20	27	
SAAP NL	28	8	< 0.001*
SAAPCHA	6	24	

*Pearson's chi-square test
Caption: SAB = Scale of Auditory Behaviors; SAAP = Simplified Assessment of Auditory Processing; G1 = Control Group; G2 = Study Group; NL = Normal; CHA = Changed

Table 4. Descriptive analysis and performance comparison of the SAB questionnaire and CAP tests according to groups G1 and G2

	Mean (SD)	Median	Minimum	Maximum	*p
DDT - RE					<0.001*
G1	96.3 (3.6)	97.2	86.2	100	
G2	80.8 (17.7)	86.8	20	100	
DDT - LE					<0.001*
G1	94.4 (5.0)	95.0	82.5	100	
G2	79.5 (17.9)	85.5	10	95	
SAB					0.014*
G1	39.2 (11,9)	42.0	18	58	
G2	31.7 (11,4)	31.5	12	53	
RGDT					0.005*
G1	21.9 (20.2)	11.1	2.7	72.5	
G2	51 (44.4)	38.7	2.7	162.5	
DPT					0.042*
G1	91.3 (18.8)	100	20	100	
G2	78.6 (25.3)	80	10	100	

*Mann-Whitney U test
Caption: DDT = Dichotic Digit Test; SAB = Scale of Auditory Behaviors; RGDT = Random Gap Detection Test; DPT = Duration Pattern Test; PSI = Pediatric Speech Intelligibility Test; SIN = Speech-in-Noise; FST = Filtered Speech Test; RE = Right Ear; LE = Left Ear; G1 = Control Group; G2 = Study Group; SD = Standard Deviation

Table 4. Continued...

	Mean (SD)	Median	Minimum	Maximum	*p
PSI - RE					0.036*
G1	90.8 (10.2)	80	60	100	
G2	85.9 (19.1)	90	30	100	
PSI - LE					0.866
G1	87.5 (16.3)	90	40	100	
G2	85.9 (19.1)	90	30	100	
SIN - RE					0.808
G1	80.1 (18.6)	86	24	100	
G2	82.5 (9.3)	84	68	96	
SIN - LE					0.695
G1	81.2 (13.5)	84	40	96	
G2	81 (10.8)	82	68	96	
FST - RE					0.013*
G1	72.8 (14.5)	68	56	88	
G2	49.6 (15.5)	54	20	68	
FST - LE					0.768
G1	77.6 (14.5)	84	52	88	
G2	76.4 (10.7)	76	60	92	

*Mann-Whitney U test
Caption: DDT = Dichotic Digit Test; SAB = Scale of Auditory Behaviors; RGDT = Random Gap Detection Test; DPT = Duration Pattern Test; PSI = Pediatric Speech Intelligibility Test; SIN = Speech-in-Noise; FST = Filtered Speech Test; RE = Right Ear; LE = Left Ear; G1 = Control Group; G2 = Study Group; SD = Standard Deviation

Table 5. Correlation of the continuous variables of the Dichotic Digit Test, Simplified Assessment of Auditory Processing and Scale of Auditory Behaviors with the special CAP tests

	DDT RE	DDT LE	SAB	RGDT	PSI RE	PSI LE	SIN RE	SIN LE	DPT	FST RE	FST LE
DDT - RE	_____	0.776*	0.565*	-0.317	0.240	0.064	-0.006	-0.072	0.587*	0.258	-0.076
DDT - LE	0.776*	_____	0.655*	-0.564*	0.505*	-0.090	0.217	0.554*	0.674*	0.574	0.894*
SAB	0.565*	0.655*	_____	-0.212	0.066	-0.052	0.087	0.105	0.319	0.083	0.099
RGDT	-0.317	-0.564*	-0.212	_____	-0.257*	-0.100	0.108	-0.131	-0.529*	-0.639*	-0.130
PSI - RE	0.240	0.505*	0.066	-0.257*	_____	0.366*	-0.115	-0.290	-0.055	0.201	-0.477
PSI - LE	0.064	-0.090	-0.052	-0.100	0.336*	_____	0.088	0.223	0.001	0.116	-0.143
SIN - RE	-0.006	0.217	0.087	0.108	-0.115	0.088	_____	0.688*	-0.069	_____	_____
SIN - LE	-0.072	0.554*	0.105	-0.131	-0.290	0.233	0.688*	_____	0.203	_____	_____
DPT	0.587*	0.674*	0.319	-0.529*	-0.055	0.001	-0.069	0.203	_____	0.466	-0.083
FST - RE	0.258	0.574	0.083	-0.639*	0.201	0.116	_____	_____	0.466	_____	0.060
FST - LE	-0.076	0.894*	0.099	-0.130	-0.447	-0.143	_____	_____	-0.083	0.060	_____

*Spearman's correlation coefficient
Caption: DDT = Dichotic Digit Test; SAB = Scale of Auditory Behaviors; RGDT = Random Gap Detection Test; PSI = Pediatric Speech Intelligibility Test; SIN = Speech-in-Noise; DPT = Duration Pattern Test; FST = Filtered Speech Test; RE = Right Ear; LE = Left Ear

correlation), the DDT in both ears with DPT (moderate and directly proportional correlation), and the DDT (LE) with RGDT (moderate and inversely proportional correlation), with the SIN in the LE (moderate and directly proportional correlation) and with the FST in the LE (strong and directly proportional correlation).

DISCUSSION

The present study observed that G1 individuals performed better in the SAB questionnaire and in most of the special CAP tests (Table 1). There was an association between the SAB performance, regardless of the used cutoff point, with the DDT groups (Tables 3 and 4).

The use of questionnaires has been increasingly discussed in the literature as a means of screening for detecting possible changes in CAP. In a study, the potential of selected questionnaires to support the evaluation in 49 children was analyzed. The result showed that all applied questionnaires were sensitive to the presence of changes in CAP, especially related to the DDT and the frequency pattern test[11].

In the present study, it was found that using a cutoff point score of ≤ 45 in the SAB questionnaire, a greater number of individuals with changes in G2 were identified (Table 1).

In addition to the higher occurrence of individuals with changes in three or more CAP tests than if ≤ 34 was used as the cutoff point (Table 2).

The literature reports that the potential of the SAB questionnaire as a screening tool capable of classifying a good percentage of individuals is clear[16]. However, it was observed that many individuals with normal SAB had abnormal auditory tests. The use of the instrument in isolation may not be as efficient to track children who really need a formal CAP assessment. It was possible to verify from Table 3 that using the SAB alone with a cutoff bridge of ≤45, there are 47 children with changes, and using only the DDT there are 32 children. However, using the two instruments together, it was found that there were 27 children with changes, and this association was significant. It should be noted that these 27 children were the ones who present changes in three or more CAP tests (Table 2). Therefore, the use of two instruments together and a cutoff score point of ≤45 in the SAB questionnaire is recommended, as the instruments are easy and quick to apply, they have an association and good correlation, and assist in referral to the formal CAP assessment.

This result is in line with the findings of the literature[16], in which the auditory abilities of Portuguese children were investigated in order to verify the correlation between them and the SAB performance, demonstrating the association of the questionnaire with the DDT test among other researched tests.

In the same study[16], the authors observed that of the 51 assessed children, 33 (64%) had values over 46 points. Of the 18 children who scored below 46 points, 17 presented changes to one or more CAP tests. In the present study, using the cutoff point of 46, it was found that out of the 66 children, 45 (68.18%) presented changes in one or more tests. The authors suggested that children with a score below 46 points in the SAB should be referred for CAP assessment. The findings of the present study reinforce this recommendation due to the expressive number of children who presented this score and had changes in behavioral tests.

It was possible to verify, in the present study, that, the SAB median in G1 was 42 points and in G2, 31.5 points. Studies that used the SAB in children with respiratory and sleep disorders, the mean found ranged from 32.85 to 39.92 points. In turn, in the control group (without complaints), the score ranged from 44.75 to 47.90 points. Results similar to those found in the groups with and without changes in the DDT of the present research[18-20]. A study that used the SAB ≤ 34 cutoff point found that 57.28% of the children in the study had normal SAB, but had changes in other assessment instruments, demonstrating that the questionnaire's perspective alone is not enough to identify children at risk for CAPD, indicating the need for a higher cutoff point and other instruments to complement the screening method[21].

In order to identify and analyze questionnaires and checklists for screening the central auditory processing available in Brazil for the Brazilian-Portuguese language, a study[9] carried out a systematic review in which they found different questionnaires for screening methods, among them, the SAB. When assessing the auditory abilities contemplated by each questionnaire, it was found that the SAB contemplated the abilities of figure-ground, auditory closure, auditory attention, temporal resolution and ordering. The abilities not covered by the questionnaire are interaction, integration and binaural separation. This study reinforces the importance of using questionnaires as a method for understanding the individual's auditory behavior and social life, in addition to the importance of using the DDT as a behavioral test for a more complete screening tool.

Regarding the DDT, in addition to the association with the SAB questionnaire, there was a statistically significant difference between the DDT groups with the SAAP and with most of the CAP auditory tests (Table 1, 3 and 4), except for the speech-in-noise, bilaterally.

In relation to SAAP, individuals from G2 were the ones with most changes in this screening (Table 1). Currently, the SAAP is the only battery validated in the national scenario and is feasible for application in the school setting. However, it consists of tasks that screen for a few auditory mechanisms, not covering all the complexity of the central auditory system[10]. A study that applied the SAB and the SAAP to schoolchildren found that the SAAP alone was not sufficient to detect CAPD, so the SAAP and the use of the SAB questionnaires should be used in a complementary way, as both are important and useful tools, easy to use in the school setting[10].

Dichotic Tests are sensitive to detect changes in CAP. A study reports that when there is low performance in these tests, there is a high chance for CAPD[22]. Some authors[8] comment on the use of this test as a screening method. Thus, G2 was expected to have more individuals with changes in the CAP tests.

Recent studies[11,12] have described CAP test results and suggested the use of the DDT as a screening method for CAP assessment due to its effectiveness and easy application, in addition, its use combined with other tools demonstrated good sensitivity, specificity and efficiency, contributing to the separation of the research subjects.

The literature includes studies with different objectives[23-26] and which use the DDT performance as an inclusion criterion for research, however, few studies report this test as an instrument for screening. Current research indicates the relationship between low performance in this test with environmental factors and CAP[8], highlighting the importance of future research in the area.

When researching the correlation of the DDT results, the results draw attention to the positive and bilateral correlation of the test with the SAB questionnaire, that is, the higher the SAB score, the better the percentage of digit recognition in dichotic listening. When correlating the SAB with the other behavioral tests, no correlation was found with them (Table 5).

The DDT was correlated, mainly in the left ear, with all the behavioral tests researched in at least one ear. The fibers of the corpus callosum are responsible for the integration between the right and left hemispheres, connecting to the central auditory pathways. The dichotic tests are sensitive to assess the corpus callosum using the binaural integration task, and are useful to help identify changes in the transfer of information from the right to the left hemispheres, which results in worsening performance

in the left ear[2-5]. It is also worth noting the interference that the age group up to eight and nine years can cause in the behavioral assessment. Individuals below this age group may present worse performance in the left ear, resulting in a disadvantage of the left ear in relation to the performance in the right ear due to the immaturity of the corpus callosum, which can also be seen in an older group of individuals diagnosed with CAPD[27]. It is believed that this fact may be the reason why some tests in the present study have a higher association with the left ear. These findings reinforce that the SAB questionnaire should not be applied in isolation as a screening method and highlight the potential of using the DDT as a screening method.

In addition to the age group, the individual's development and brain maturation are influenced by external factors, such as socioeconomic conditions, recurrent otitis, lack of stimulation in the environment and poor health conditions. All of these factors interfere with the maturation of the corpus callosum, with consequences on the auditory processing abilities[28]. In a systematic review study, resilience in dichotic listening tasks was investigated in adolescents at social risk; this study showed that the DDT is highlighted by the low performance of subjects with high vulnerability. The result showed that the DDT was the most significant test in subjects with higher social risks, highlighting low performance in integration and binaural separation, confirming the importance of applying this test as a screening instrument[28].

In another study, the application of a CAP battery of tests was analyzed in 30 children aged 5 to 16 years with suspected CAPD. In the results, it was found that among the dichotic tests, the DDT stood out for the number of subjects with low performance, presenting 65% of incorrect answers[29]. Corroborating these findings, another study evaluated the usefulness of the DDT in detecting CAPD in school-aged children and assessed 235,664 children. The authors concluded that the DDT is a test to be considered as a screening method in school-age children, as it is easy to be performed in school settings and requires low linguistic levels from the individuals[30].

In the current study, it was highlighted that there was an association and correlation between the DDT performance with the SAB questionnaire and with most of the researched CAP tests, showing that those who had changed DDT also performed poorly in the questionnaire and in the special CAP tests. This finding is important to contribute to clinical practice, as it reveals the relevance of using the combination of questionnaire and the DDT as a method to identify subjects who may have CAPD.

The findings of the present study strengthen the research that indicates the DDT as a screening method to identify possible individuals with changes in CAP.

Due to the great demand for services, in particular, school clinics that carry out CAP assessment, it is suggested that, in addition to the behavioral complaints analyzed in the anamnesis, the results of the DDT (auditory integration task) and the SAB questionnaire should be added in the basic audiological assessment to refer children for formal CAP assessment. It is believed that the concomitant use of the SAB questionnaire and the DDT will assist in the early diagnosis of CAPD, in addition to preventing future learning problems.

CONCLUSION

It is concluded that the DDT can be used as a screening method for CAPD in the basic audiological assessment, as there was an association in the performance of the test with the SAAP and the SAB questionnaire; in addition to DDT correlation, especially in the left ear, with the behavioral tests applied to perform the CAPD diagnosis.

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Author contributions

JOB was responsible for recruiting study participants, for data collection, tabulation and analysis and also for the research and production of the scientific article; FYOMMP participated in the recruitment of study participants, through data collection, tabulation and analysis and also participated in the writing of the manuscript; JBJ participated in the data analysis and the writing of the manuscript; MMCP outlined the manuscript investigation, data analysis, article production and was responsible for advising the study.