Original Article

Artigo Original

Scale of Auditory Behaviors and auditory behavior tests for auditory processing assessment in Portuguese children

Scale of Auditory Behaviors e testes auditivos comportamentais para avaliação do processamento auditivo em crianças falantes do português europeu

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Keywords

Questionnaires
Hearing
Auditory perception
Hearing tests
Child

ABSTRACT

Purpose: The objective of this research was to assess the auditory abilities of Portuguese children and compare such abilities to the score of the Scale of Auditory Behaviors (SAB). **Methods:** Fifty-one children were evaluated with audiometry, speech audiometry, acoustic immittance measures, and eight behavioral tests involving dichotic listening, monotic listening, temporal processing, and sound localization. Their parents filled in the SAB questionnaire adapted to European A. SAB scores and auditory tests scores were submitted to Pearson's correlation coefficient. **Results:** There is significant correlation between the score on SAB questionnaire and the auditory processing tests. The greatest coefficient was observed in temporal processing test (p=0.000). **Conclusion:** There was correlation between the score of SAB and the performance in auditory processing tests, suggesting that the SAB may be used for auditory processing screening.

Descritores

Questionários
Audição
Percepção auditiva
Testes auditivos
Criança

RESUMO

Objetivo: Investigar as habilidades auditivas de crianças portuguesas e verificar se há correlação entre aquelas e o escore do *Scale of Auditory Behaviors* (SAB). **Métodos:** Todas as crianças foram submetidas a audiometria tonal, logoaudiometria, medidas de imitância acústica e oito testes comportamentais do processamento auditivo, envolvendo tarefas de escuta dicótica, escuta monótica, processamento temporal e localização sonora. Os pais das 51 crianças portuguesas avaliadas preencheram o questionário SAB adaptado ao português europeu. Foram calculados os valores do coeficiente de correlação de Pearson entre os escores obtidos no questionário e os dos testes do processamento auditivo. **Resultados:** Observou-se correlação significativa entre o escore do questionário e o dos testes comportamentais, tendo a maior sido observada nos testes relacionados ao processamento temporal (p=0,000). **Conclusão:** Houve correlação entre o escore da SAB e os resultados obtidos nos testes auditivos comportamentais em crianças portuguesas, sugerindo que este questionário pode ser utilizado em triagem do processamento auditivo.

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INTRODUCTION

Auditory processing (AP) has been studied for more than five decades, especially in North America, and its evaluation as well as intervention strategies have become areas of study in speech and language pathology.

In Brazil, there are already studies that approach this area of inquiry since the 1990s. In Portugal, the evaluation of AP skills has been implemented gradually. Up to the present, there are no tests or questionnaires universally accepted to perform such evaluations.

The use of information from the clients and their families is valuable for the diagnostic process and is recommended by the Speech-Language-Hearing Association. The information may be gathered using questionnaires developed for such ends or during interviews with open-ended questions. Presently, a review of the literature has verified the existence of checklists in the area of AP. These questionnaires are used with this population, since they inform us about daily living situations related to the function of the auditory system.

The procedures of these questionnaires help to obtain qualitative information that can be related to auditory processing disorders (APD) and address day-to-day experiences. Various questionnaires are cited in the literature and are used with children with audiological complaints, of which are included the Children's Auditory Performance Scale (CHAPS), the Children's Home Inventory of Listening Difficulties (CHILD), the Fisher's Auditory Problems Checklist (FISHER), the Listening Inventory for Education (LIFE), the Screening Instrument for Targeting Educational Risk (SIFTER), and the.

The Scale of Auditory Behaviors (SAB) questionnaire, chosen for this study, has a version that may be used by parents or professionals. It is normed with a sample of 96 children ranging in age from 4 to 6 years. The instrument was improved after studying the most relevant items, following the Conference of Bruton recommendations, during which time the 12 questions most relevant to AP were defined. The questionnaire is easily administered since it contains a small number of questions and answer options, which are easily understood. The authors of the study state that children between 8 and 12 years average a score of 46 points and that lower values may indicate an at-risk situation for APD.

The present study is an extension of a larger research project in the Centro de Estudos da Crianca (Research Center for Child Studies) in the Universidade do Minho and is part of the first study which is norming a set of tests related to AP in Portuguese children aged 10–13 years. This way, the values found in this study are used as norms for gauging the performance of the auditory tests, and subsequently, these are compared with scores obtained in the SAB.

The objective of this study was to investigate the auditory abilities of Portuguese children and verify if there is a correlation between these abilities and the SAB scores.

METHODS

This study was approved by the Centro de Investigacao em Estudos da Crianca (CIEC) (Research Center for Child Studies) in the *Universidade do Minho*, in Portugal, conforming to local legislation, with approval from the Conselho Cientifico (Scientific Board). Parents or guardians of the participants signed a consent form (Termo de Consentimento Livre e Esclaredio), authorizing the inclusion of the children in the study.

The sample size included 51 Portuguese children between the ages of 10 and 13.11 years and comprised 18 (35%) females and 33 (65%) males. All the children were enrolled in the fourth or fifth grades in a public school in the Northern region of Portugal. Inclusion criteria were the absence of middle-ear problems and auditory thresholds within normal limits at 500, 1K, and 2K Hz.

The parents or guardians of the children responded to a case history, and the children participated in pure-tone audiometry threshold audiometry, speech audiometry, and immittance audiometry, in order to select those children with auditory thresholds within normal limits and good tympanic mobility. The parents also informed the researchers about the child's academic performance and of any presence of a communication disorder. Children with communication disorders also sent a summary from the school speech and language pathologist, indicating the diagnosis.

The parents responded to the SAB questionnaire that had been adapted to European Portuguese (Appendix 1). The questionnaire comprises 12 questions related to daily events. Those events that occur more frequently are given a score of 1.0; those occurring most of the time are given a score of 2.0; those occurring sometimes are scored as 3.0; sporadic events are valued at 4.0; and those that never occur are given a score of 5.0. The sum of all values resulted in final scores ranging between 12 and 60 points. The authors of the questionnaire identify the mean score around 46 points, which indicates the normal auditory behavior expected for the age range between 8 and 11 years. Scores lower than 35 points — one standard deviation below the mean — indicate a need for AP testing. Scores lower than 30 — one and a half standard deviations below the mean — suggest APDs, needing long-range monitoring.

The children participated in the following testing: sound localization (SL), verbal sequential memory (VSM), nonverbal sequencing memory (NSM), speech in noise (SIN), dichotic digits (DDs), harmonic pattern with dichotic digits (HPDDs), duration pattern recognition (DPR), and gaps-in-noise (GIN). Three tests, (SL, VSM, and NSM) were presented binaurally free field. The rest of the tests (SIN, DD, HPDD, DPR, and GIN) were presented in an audiology booth, using the portable equipment Eee PC series ASUS connected to an AA-222 (Interacoustics) audiometer.

Evaluation Tests

- Sound Localization (SL): Its purpose is to evaluate the ability to localize binaural sound/interaction. The test was applied with the presence of the sound of a rattle in five directions in reference to the head (top, front, behind, right side, and left side), at a distance of 20 cm during each presentation. The results were analyzed with respect to the

total correct responses in identifying the five directions. One error was deemed as within normal limits.

- Nonverbal Sequential Memory (NSM): Its purpose is to evaluate auditory memory ability for brief nonverbal sounds and successive temporal processing. The test was presented with the presence of four musical instruments (guizo, agogo, sino, and coco) in three different sequences. One error was deemed as within normal limits.
- Verbal Sequential Memory (VSM): Its purpose is to evaluate the auditory memory abilities for verbal sounds that are brief and successive temporal processing. The test presentation required the use of four verbal sound stimuli — the syllables "pa," "ta," "ca," "fa" — in three different sequences. One error was deemed as within normal limits.
- Speech In Noise (SIN): The purpose of this test is to evaluate the ability for selective closure/attention. In this study, white noise that was continuous, ipsilateral, competitive, with a speech/sound ratio of +5dB was used. The stimulus list was previously pre-recorded and validated in European Portuguese. The results in this test consisted of the quantity of correct responses when repeating the word heard and obtaining a percentage. Those values equal to 74% or higher for the right ear and 79% or higher for the left ear were considered within normal limits for the Portuguese population.
- Dichotic Digit (DD): The purpose of this test is to evaluate the ability of figure-ground integration and selective binaural attention. Two words were presented in each ear simultaneously. Just as in the SIN test, the stimuli list had been previously recorded and validated in European Portuguese. The DD test was used addressing binaural integration, which required the children to listen to four digits. Those values equal to or higher than 95.2% in the right ear and 91.5% or higher in the left ear were considered within normal limits for the Portuguese population.
- Harmonic Pattern with Dichotic Digits (HPDDs): The purpose of this test is to evaluate the ability of figure-ground integration and selective binaural attention. The difference between the DD and HPDD tests is that in the HPDD the digits are hummed and, therefore, comprises a differentiated prosodic component. The analysis followed the same procedures as those with the DD test. Those values equal to or higher than 93.3% in the right ear and 81.3% or higher in the left ear were considered within normal limits for the Portuguese population.
- Duration Pattern Recognition (DPR): This test evaluates the auditory ability for temporal ordering and integration. In this study, the first three initial sequence tracks of the test compact disk (CD) were used for training, and the next 30 sequences were used to collect the data binaurally. The children were to identify the duration of three sounds heard (ranging between 250 ms and 500 ms), in order of presentation. The value of 47.5% or higher in both ears was considered within normal limits for the Portuguese population.
- Gaps-In-Noise (GIN): The purpose of this test is to evaluate the auditory skill of temporal resolution and processing. Two tracks of the GIN were selected — list 1 and list 2 — to be presented in each one of the ears separately, since recent studies have demonstrated no differences in responses between using four and only two tracks. Intervals up to 5.5 ms were considered within the normal limits for the Portuguese population.

The statistical measures used compare the results of the SAB questionnaire with the AP evaluations results. For this analysis, a Pearson correlation coefficient was used with a 95% level of significance and, therefore, values of $p<0.05$ signaled the presence of significant differences.

Scatterplots were used to illustrate the rate of progression between the SAB questionnaire scores and the results of the AP testing.

RESULTS

In the statistical analysis, a positive correlation between the SAB scores and the results of the following tests VSM, NSM, SIN (left ear), DD (right ear), HPDD (both ears), and DPR were observed. A statistically significant negative correlation was observed between the SAB and the GIN (threshold) (Table 1). Therefore, the better the results of the AP evaluation, the better the scores of the SAB questionnaire.

To complete the analysis, an inquiry was made as to how many children, from the total sample, obtained an average score of less than 46 points (Appendix 1). This helped to verify that

Table 1. Results of the scores of the Scale of Auditory Behaviors (SAB) and hearing processing tests

Tests	r	p
SL	0.27	0.056
VSM	0.64	0.000*
NSM	0.41	0.003*
SIN RE	0.20	0.169
SIN LE	0.36	0.010*
DD RE	0.47	0.001*
DD LE	0.21	0.147
HPDDs RE	0.50	<0.001*
HPDDs LE	0.29	0.041*
DP	0.50	<0.001*
GIN RE	-0.47	<0.001*
GIN LE	-0.38	0.006*

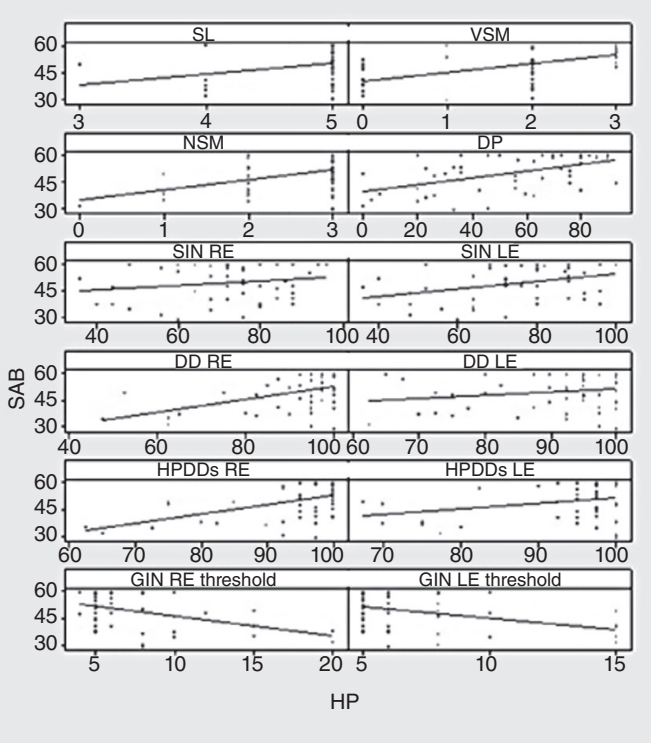
* Statistically significant values ($p<0.05$*) – Pearson's correlation
Caption: SL = sound localization; VSM = verbal sequential memory; NSM - nonverbal sequential memory; SIN RE = speech in noise right ear; DD RE = dichotic digit right ear; DD LE = dichotic digit left ear; HPDDs RE = harmonic pattern with dichotic digits right ear; HPDD LE = harmonic pattern with dichotic digits left ear; DP = padrão de duração; GIN RE = gaps-in-noise right ear; GIN LE = gaps-in-noise left ear

of the 51 children who were evaluated, 33 (64%) presented with scores equal to or higher than 47 points. Of these, 39% (13 children) obtained optimum thresholds in eight tests that evaluated processing and 20 children (61%) presented with difficulties in at least one test of AP. For the 13 children with optimum thresholds in the AP tests, the average SAB score was 56 points.

With regard to the number of children presenting with average SAB scores less than 46 points, it was verified that 18 children fell within this condition. Of these children, 17 (94.4%) presented with difficulties in one or more AP tests.

It was also observed that three children presented with final SAB scores lower than 35 points and concurrent problems in two or more AP tests. With this perspective, it was verified that a low score in the SAB questionnaire indicates difficulties in AP. As per the families, these children demonstrated low academic performance and communication disorders, which suggest comorbidity between language and auditory difficulties.

The positive correlation between the SAB scores and the AP evaluation results can be observed in the 12 scatterplots presented in Figure 1. It may be observed that the higher the SAB score (observed in the vertical), the better the performance in the auditory tests (observed in the horizontal). The only scatterplots presenting descending rates were from the GIN, since for this test, the lower the threshold, the better the skill for temporal resolution. Therefore, a descending rate in this diagram represents a good correlation.



Legends: Caption: SL = sound localization; VSM = verbal sequential memory; NSM - non-verbal sequential memory; SIN RE = speech in noise right ear; DD RE = dichotic digit right ear; DD LE = dichotic digit left ear; HPDDs RE = harmonic pattern with dichotic digits right ear; HPDD LE = harmonic pattern with dichotic digits left ear; DP= padrão de duração; GIN RE = gaps-in-noise right ear; GIN LE = gaps-in-noise left ear; SAB: Scale of Auditory Behaviors

Figure 1. Dispersion diagrams of the Scale of Auditory Behaviors (SAB) score per hearing processing test

In Table 1, we present the results obtained from the Pearson correlation coefficient (r), in which a linear association was verified between the variables studied. Values of r between 0.4 and 0.6 found in the VSM, NSM, DD (right ear), HPDD (right ear), DPR, and GIN (right ear) tests suggest a moderate association between their obtained values and SAB scores.

In the third column of Table 1, the p values of the VSM, NSM, SIN (left ear), DD (right ear), HPDD (both ears), DPR, and GIN (both ears) tests indicate that a low score in the SAB probably co-occurs with low AP tests results. With these methods, it is possible to determine, not a causal but, a strong relationship between the variables studied.

DISCUSSION

The evaluation of AP is important in children with communication disorders, since, based on this evaluation it is possible to better understand the difficulties presented and offer more appropriate therapy strategies. Understanding the neural mechanisms' sound paths that reach the brain helps with speech pathology procedures, especially for children with difficulties in acquiring auditory skills and/or learning the language rules they are exposed to since birth. AP may be understood as the detection of an acoustic event and its codification into a pattern of neural information that is transmitted as a conscientious mental image, which passes through the selection, organization, classification, and storing of sounds, leading to the assimilation and/or the transformation of knowledge (gnosia).

The evaluation of AP may be done by using behavioral or electrophysiological auditory tests — using specialized equipment and settings requires the analysis of individuals' performances on specific auditory tests and should always be done by an audiologist.

The professional role of audiologists is increasing every day, concentrating not only on the clinical settings but also on the educational settings, searching for improved quality of services and the well-being of their clients. The guidelines and the application of checklists to screen for auditory disorders have been deemed as important prevention work.

In this study, an evaluation questionnaire addressing auditory performance was elaborated in European Portuguese to be used with educators or parents in the schools as screeners to identify those individuals who need to be referred for evaluation of the auditory neural mechanisms involved with AP.

To compare the results obtained in the questionnaire with the neural mechanism function involved when identifying stimuli, AP test procedures were used, based on Brazilian and American literature. The SL, VSM, NSM, SIN, and DD tests were used and analyzed following the Evaluation Manual of Central Auditory Processing, published in 1997 by Professors Liliane Desgualdo Pereira and Elaine Schochat, and the HPDD, DPR, and GIN tests were used and analyzed following the studies presented in the tests proper. For the verbal tests, sound stimuli lists were previously recorded and validated in European Portuguese.

When possible, our results were compared with the professional literature. Finding studies became quite difficult, especially with regard to the SAB questionnaire used, which would compare the test procedure results with the SAB questionnaire scores.

Our study verified that, the higher the SAB score, the better the responses obtained in the AP performance evaluation. Therefore, we may infer that it is possible to predict the AP test performance with the SAB scores obtained. Through the results presented, it is established that the use of the SAB questionnaire can contribute to AP screening. This evidence is very important, since the use of the SAB scale can help speech and language pathologists, educators, professors, and health and education aides effectively participate in the screening of AP. Furthermore, it may be possible to arrive at early diagnosis and effective interventions.

This study also confirmed that the majority of the children with performances below a score of 46 in the SAB presented difficulties in one or more AP tests. Thus, this value may be judged as an expected measure that may serve as a starting point toward a more comprehensive evaluation. It was also verified that this instrument is not appropriate for diagnosing APDs, but rather may be used for screenings. It was also verified that the children with difficulties in more than two AP tests presented with scores below 35 in the SAB and that children with the best performances in auditory skills obtained high averages (close to 56 points). Consequently, we suggest that children who present with scores below 46 points should be referred for AP evaluations, since they are considered at risk for APDs, and that those with scores below 35 points (half of the average score) should be referred for evaluation and treatment of auditory skills. Chart 1 presents the recommendations from this study, which takes into consideration the values analyzed.

Future research is necessary to verify the use of this scale with younger children, especially those between 7 and 9 years of age, which is the age recommended for identifying APDs, and remembering that our study reveals data regarding children between the ages of 10 and 13 years.

In Portugal, there are few settings performing AP evaluations and, generally, its cost is high. The use of this questionnaire, during routine pediatric consultations, helps prevent future AP difficulties.

The results of the present work suggest that, the higher the SAB score, the higher the performance in the auditory tests, and less the temporal threshold, which indicate adequate neurological processing of acoustic stimuli.

Using the results of this study, it is suggested that the parents/guardians complete the SAB questionnaire during a simplified evaluation of AP. The use of the SAB questionnaire may help during AP screening activities in the schools and help elaborate a plan of action with strategies for the enhancing auditory skills.

Keeping in mind the established scientific relationship between learning disabilities and APDs, the speech and language pathologist/audiologist should function beyond clinical diagnosis restricted to tests, but must also address prevention and the global well-being of individuals and society at large.

Chart 1. Recommendations for the analysis of the questionnaire Scale of Auditory Behaviors (SAB)

Age	Parents' response (final score)	Indication
10-13 years	Mean=56/SD=3.5	Passed the screening
	Mean=46 points	Failed the screening. Analyze together with other screening tests of the hearing processing
	Mean=31-45 points	Failed the screening. Risk of APD - indicate formal evaluation
	Mean=less than 30 points	High risk of APD - indicate formal evaluation and training of hearing skills

Caption: SD = standard deviation; APD = Auditory Processing Disorder

Since the SAB questionnaire demonstrated to be a screening tool valid for Portuguese children between the ages of 10 and 13 years, it is suggested that it be used with children within the same age range who speak Portuguese in other countries.

CONCLUSION

The SAB questionnaire results in children aged 10–13 years demonstrated strong relationships with the results of their AP performance evaluation, especially with the temporal processing tests.

** CLN was responsible for the collection and preparation of the data, as well as the editorial staff of the manuscript; LDP orientated in the delineation of the study, in the analysis of data, and in the interpretation of the obtained results; GSC was responsible for the project and general direction of the stages of execution and preparation of the manuscript.*

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Appendix 1. Questionnaire Scale of Auditory Behaviors (SAB) adapted to Portuguese and reference value[5]

SCALE OF AUDITORY BEHAVIORS (SAB)

Orientação: Por favor, meça proporcionalmente cada item, circulando o número que melhor representa o comportamento da criança que está analisando. No topo da coluna dos números é possível verificar o termo para cada frequência que está sendo observada. Por favor, considere estes termos cuidadosamente quando for medir cada possibilidade de comportamento. Uma criança pode, ou não, mostrar um ou mais destes comportamentos. Uma medida elevada numa ou mais áreas não indicará nenhum padrão particular de funcionamento. Se não conseguir decidir sobre uma pontuação para determinado item, use o seu melhor julgamento.

Valor de referência para o questionário SAB[5]

Idade	Resposta dos pais (escore)	Resposta dos professores (escore)
8-9 anos	Média=45,6	Média=43,5
	DP=9,6	DP=10,7
10-11 anos	Média=46,8	Média=47,4
	DP=11,5	DP=9,6
8-11 anos	Média=46,1	Média=45,3
	DP=10,4	DP=10,3
	-1,0 DP=35	-1,0 DP=35
	-1,5 DP=30	-1,5 DP=30

Legends: DP = desvio-padrão

Data: ____/_____/_____.

Nome:
Idade atual: _____ Data de nascimento: ___/___/___

Ciclo escolar:
Escola:
Professor(a):

Itens do comportamento	Frequente	Quase sempre	Algumas vezes	Esporádico	Nunca
1. Dificuldade para escutar ou entender em ambiente ruidoso	1	2	3	4	5
2. Não entender bem quando alguém fala rápido ou "abafado"	1	2	3	4	5
3. Dificuldade de seguir instruções orais	1	2	3	4	5
4. Dificuldade na identificação e discriminação dos sons de fala	1	2	3	4	5
5. Inconsistência de respostas para informações auditivas	1	2	3	4	5
6. Fraca habilidade de leitura	1	2	3	4	5
7. Pede para repetir as coisas	1	2	3	4	5
8. Facilmente distraído	1	2	3	4	5
9. Dificuldades acadêmicas ou de aprendizagem	1	2	3	4	5
10. Período de atenção curto	1	2	3	4	5
11. Sonha acordado, parece desatento	1	2	3	4	5
12. Desorganizado	1	2	3	4	5

Escore: _____ (soma dos itens circulados)