Utility of the 'Screening Checklist for Auditory Processing (SCAP)' in Detecting (C)APD in Children

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Abstract

Chermak and Musiek (1997) reported that 2 % to 5% of school-going children have central auditory processing disorder [(C)APD]. Since, the prevalence of (C)APD is high in school-going children, there is a need for an efficient tool to screen and to refer them for further evaluation. The aim of the present study was to use Screening checklist for auditory processing (SCAP) to identify children with symptoms of central auditory processing and find the agreement of the checklist with a battery of diagnostic (C)APD tests. The study also aimed to determine an appropriate cut-off score for the SCAP and check its sensitivity and specificity. A total of 3120 children were screened using the SCAP. Forty-two of them, who had varying score on the SCAP, were evaluated using a test-battery consisting of 5 different diagnostic tests speech-in-noise (SPIN),Gap detection test (GDT), masking level difference (MLD), Dichotic CV (DCV), and Auditory memory and sequencing Test (AMT). These tests were selected to evaluate auditory separation / closure, temporal processing, auditory interaction, auditory integration and auditory memory. The analyses of the data revealed that there was no agreement between a single symptom on the SCAP and the presence of (C)APD. A Kappa measurement of agreement of various cut-off scores of SCAP with the (C)APD diagnostic test findings indicated that a cut-off score of 6 yielded a good agreement with the results of SPIN and AMT as well as with the overall diagnosis of (C)APD. With a cut-off score of 6, the sensitivity of the checklist was71% and specificity was 68%, the prevalence of suspected (C)APD in school-going children was 3.2%. Among the diagnostic tests used, most of the participant failed in the AMT and DCV tests, followed by SPIN and GDT. Hence, it is important to include theses test in a diagnostic test battery. All the participants who had (C)APD did not demonstrate similar auditory processing difficulties. Thus, a test battery approach should be employed while assessing children with suspected (C)APD. It is evident from study that the SCAP could be used as a simple and practical measure to screen for the presence of (C)APD.

Introduction

Screening to detect the presence or absence of any problem is a necessity. Musiek, Gollegly, Lamb and Lamb (1990) listed several reasons as why screening for (C)APD should be carried out. A major reason was to enable early identification, thus paving the way to plan effective management and educational strategies. They noted that screening also helped in identifying conditions leading to (C)APD that may require medical attention. It was also noted that screening promoted increased awareness about (C)APD among educators and parents. Further, they reported that it helped in easily determining the cause of a particular child's listening and learning difficulties and hence, minimized the psychological factors like anxiety and stress in the child. Bellis (2003) added that screening for (C)APD could help in

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providing direction to special educators, speech language pathologists, rehabilitative audiologists, and others entrusted in the task of developing remedial programs and hence help in managing the disorders of children more effectively.

Screening for (C)APD has been carried out using checklists and / or tests. Both procedures have been reported to have their own advantages and disadvantages. However, checklists have the advantage of not being affected by a regional language. In a multi-linguistic country like India, it is far easier to just translate a checklist into different languages without influencing the outcome of the findings, instead of developing screening tests in various languages.

Some of the checklists reported in the literature are Children's Auditory Processing Performance Scale (CHAAPS) developed (Smoski, 1987, cited in Smoski, Brunt and Tannahill, 1992), Screening Checklist for Auditory Processing (SCAP) by Yathiraj and Mascarenhas (2002, 2004) and 'Fisher's auditory performance checklist' (Fisher, 1976, cited in Willeford & Burleigh, 1985). CHAPPS was designed to be administered on parents and teachers to assess the listening ability of a child. It has six listening conditions included perception in quiet, in the presence of noise and multiple inputs as well as auditory memory/sequencing and auditory attention span. Smoski (1990) recommended using CHAPPS as an objective tool to find out the effectiveness of therapy. Purdy and Jonstone (2000) found a significant correlation between the Dichotic digit test and the memory rating with CHAPPS. However, the studies also found that CHAPPS lead to either over or under referral and that it could not be used as an isolated tool for referral (Drake et al., 2006; Cameron, Dillon & Newali, 2005).

In India, the SCAP (Yathiraj & Mascarenhas, 2002, 2004) has been utilized to detect the presence or absence of (C)APD in children effectively (Yathiraj & Mascarenhas, 2003; Priya & Yathiraj, 2007; Devi, Sujitha & Yathiraj, 2008; Maggu & Yathiraj, in press). Yathiraj and Mascarenhas (2003) found no significant difference in the results obtained between SCAP and (C)APD diagnostic tests. The others (Priya & Yathiraj, 2007; Devi & Sujitha & Yathiraj, 2008; Maggu & Yathiraj, in press) also found SCAP to be effective in detecting the presence of (C)APD in children. However, these studies used an arbitrarily cut-off criteria of six to suspect children to have (C)APD. This value was chosen to increase the sensitivity of SCAP. However, it was not confirmed that children who passed the screening checklist did not have (C)APD. Hence, there is a need to confirm whether those children who did not exhibit symptoms of (C)APD on screening checklist, also passed diagnostic tests.

The validity and reliability of a screening procedure needs to be studied to know how effectively it can be used in a clinical set-up. The ASHA task force (2005) recommended that a test battery approach should be used to check for the efficiency of screening checklists and tests. Although, a variety of methods to assess the Central Auditory Nervous System (CANS) are available, behavioural tests have been recommended to be used for the diagnosis of (C)APD in children or adults (Chermak & Musiek, 1992). Chermak and Musiek (1997) reported that it is valuable to select tests that assess different processes rather than evaluate the same process to get a better idea of the processing deficits of a client.

There is a need for a tool with fairly high sensitivity and specificity considering the number of children having possible (C)APD. According to Repp and Stockdell (1978), 15% to 20% of a school-age population have some type of language / learning disorder, out of which, 70% have some form of auditory impairment. However, Lewis (1986, cited in Bellis, 1996) estimated that only 3 to 7% of all school-age children exhibit some form of learning disability. Similar to the findings of Lewis, it was found by Cherry (1987) that 6.5% of children in the age range 3 to 17 years have learning disabilities, with a high proposition of these children having (C)APD. In India, it has been found that 3% of school-going children have dyslexia (Rama, 1985). A direct estimate of the number of school aged children with (C)APD was obtained by Chermak and Musiek (1997) who found it to be 2% to 5%.

From the above information, it can be construed that the first stage in identifying the presence of a (C)APD is screening. It is also essential that a screening tool should be efficient with clear cut-off criteria to decide whether an individual should be referred for further evaluation or not. The aim of the present study was to use SCAP to identify children with symptoms of central auditory processing and find the agreement of the checklist with a battery of diagnostic (C)APD tests. The study also aimed to determine an appropriate cut-off score for the SCAP and check its sensitivity and specificity.

Method

The study was carried out in two stages. In the first stage, SCAP was used to detect children with the presence or absence of symptoms of (C)APD. In the second stage, SCAP results were compared with the results of a diagnostic (C)APD test battery. The participants for the second stage of the study were randomly selected from those included in the first stage.

Participants

A total of 3120 children in the age range of 8 to 15 years were screened using the SCAP. These children were selected from four different schools with English as the medium of instruction. They had studied English for at least two years. Among them, 80 children were randomly selected for further diagnostic evaluation, ensuring that they had varying score on the SCAP. Only 42 children could finally be evaluated, since the remaining declined to be evaluated further. The mean age of these 42 children was 10.93 years.

It was ensured that all the children who were selected for suspected to diagnostic evaluation had normal IQ, as determined through Raven's Progressive coloured/standard Matrices (Raven, 1952). In addition, they had normal hearing. Their pure-tone AC and BC thresholds were less than 15 dB HL in the octave frequencies 250 Hz to 8 kHz and 250 Hz to 4 kHz, respectively. Normal middle ear function was confirmed with the presence of 'A' type tympanograms and both ipsilateral and contralateral acoustic reflex being present for the frequencies 500 Hz, 1 kHz and 2 kHz. In addition, all the participants had a speech identification score that was greater than 85% in quiet, which was determined using the 'Common Speech Discrimination Test for Indians' (Mayadevi, 1974). Further, the teacher and the caregivers reported that none of these children had any history of a speech and hearing problem.

Equipment

A calibrated dual channel diagnostic audiometer OB 922 (version 2) with AC (TDH-39) and BC (B-71) transducers was used to carry out pure-tone audiometry, speech audiometry and the (C)APD tests. A calibrated immittance meter (GSI Tympstar) was used to ensure the presence of normal middle ear function. The CD version of the test material was played through a Compaq Presario laptop with Intel dual core processor. An Interacoustics AC-40 clinical audiometer was utilized to administer the Masking Level Difference (MLD) test.

Test Environment

Part of stage I of the study was carried out in a quiet room, free from distraction. This included administrating the screening checklist and IQ testing. All the audiological tests of stage I and stage II were carried out in a two-room situation with permissible noise limits as per ANSI standards (S3.1-1991).

Procedure

Stage I

Procedure for selection of participants

Screening for the presence of (C)APD was carried out on school-going children from four different schools. Sixty-one teachers who had taught the children for at least one year were asked to identify those with a suspected (C)APD using the SCAP. The checklist was scored on a two point rating scale. Each answer marked 'Yes' was scored '1' and each 'No' was scored '0'.

Eighty children with varying scores on the checklist were randomly selected from four different schools. It was ensured that the score ranged from 0-12. Though, 80 children were selected for further evaluation, only 42 of them reported. Of them, 22 had scores less than 50% and 20 had scores 50% and above. The former group had a mean age of 11.22 years and the latter a mean age of 10.65 years.

It was ensured that all the children met the participant selection criteria which included normal peripheral hearing; normal speech identification in quiet; and normal IQ. Only those participants who met the above criteria were subjected to further (C)APD evaluation in stage II of the study.

Stage II

Procedure for (C)APD evaluation

In stage II, the diagnostic tests were administered. All the participants were evaluated using five different (C)APD tests. The tests included SPIN, Dichotic CV test, Masking Level Difference (MLD), the Gap Detection Test (GDT) and Auditory Memory and Sequencing Test (AMST).

The Speech-in-Noise (SPIN) test was administered using the recorded version of 'Monosyllabic speech identification test in English for Indian children' (Rout, 1996) in the presence of speech noise. The signal was presented monaurally to each ear at 0 dB SNR at 40 dB SL (ref. SRT). Verbal responses of the participants were noted. A correct response was given a score of '1' and an incorrect response a score of '0'.

The Dichotic CV test was played using the CD version of the test (Yathiraj, 1999) at 40 dB SL (ref. SRT). The participants were asked to repeat the syllables which were heard through headphones. Their double correct responses were noted and compared with norms given by Krishna (2001).

Masking level difference (MLD) was evaluated using a 500 Hz tone at 50 dB HL. The stimuli were presented binaurally through headphones in both homophasic and antiphasic conditions. The noise level was increased until the participants were unable to hear the signal. MLD was calculated by subtracting the $S_{\pi}N_{o}$ (antiphasic) threshold from that of the $S_{o}N_{o}$ (homophasic) threshold. The responses were compared with norms provided by Wilson, Zizz, and Sperry (1994).

Gap detection test (GDT) was obtained with the CD version of the test. The signals were presented monaurally to each ear at 40 dB SL (ref. PTA) through head phones. The participants were required to indicate as to which set of noise bursts in a triad contained a gap. The minimum gap duration which the participants were able to detect was compared with norms given by Chermak and Lee (2005).

The Auditory Memory and Sequencing Test (AMST) developed by Yathiraj and Mascarenhas (2003) was presented using the CD version of the test. The recorded material [at 40 dB SL (ref. SRT)] was routed through an audiometer and was heard through the loudspeaker. The loudspeaker was placed at a 45^0 azimuth at a distance of one meter from the head of each participant. The participants were asked to repeat the words heard by them. A score of '1' was given for each correctly repeated word to calculate the auditory memory score. The responses were compared with age appropriate norms developed by Devi, Sujitha and Yathiraj (2008).

Test-retest reliability

Test-retest reliability was done for responses got in stage I and stage II. To check for the test-retests reliability of SCAP, the questionnaire was re-administered on 606 children

(20%) after a gap of three months. This was done by eight teachers who had answered the checklist earlier. Further, in stage II, two of the 42 participants were randomly selected to check for the test-retest reliability of the diagnostic tests after a gap of three months. All five (C)APD tests were re-administered on these two participants. None of the clients who were selected for retesting underwent any remedial help.

Scoring

All the tests administered were scored according to the norms provided for each of the tests. The participants were considered to have a problem in a specific process, if his/her score on the particular test were below the age appropriate normative data.

Participants were diagnosed as having an auditory processing disorder if they failed in two or more of the five diagnostic (C)APD tests used in the present study. If they failed only one test, they were considered to have (C)APD if the score on that test was at least three standard deviations below the mean performance of the normative score. This diagnosis was done in keeping with the recommendations of Chermak and Musiek (1997).

Analyses

The obtained score were tabulated and analyzed using SPSS (Statistical Package for Social Sciences version 10). Kappa measurement of agreement was used to find the agreement of each question of SCAP with the (C)APD tests findings. To find the correlation of SCAP scores with the (C)APD tests, a Pearson product moment correlation was utilized. Further, the sensitivity and specificity of different SCAP cut-off scores was determined through a decision matrix**.** Finally, the α tests of reliability was used to find a test-retest reliability of SCAP.

Results and Discussion

Initially, the data were analysed to detect children with symptoms of (C)APD as well as identify those with confirmed (C)APD. The former was done using the SCAP findings and the latter was done utilizing a diagnostic test battery.

Presence of (C)APD symptoms as per the SCAP checklist

The analysis of the SCAP findings on the 3120 school-going children revealed that 216 (6.9%) of the children had symptoms of (C)APD. The symptoms that occurred most frequently were ‘Requires repeated instruction’ (4.9%) and ‘Short attention span’ (4.2%). The other symptoms that were present fairly frequently were ‘Poor academic performance’ (3.7%) , ‘Forgets what is said in a few minutes’(3.6%) , ‘Easily distracted by background noise’ (3.4%) and ‘Delayed response to verbal instruction or questions’ (3.1%). The symptoms that occurred the least (0.99%) were questions which dealt with the discrimination of phonemes. It is possible that the teachers did not understand these questions rather than the symptom really not being present. It is suggested that the question should be accompanied with examples, to make the questions clearer.

Symptoms which occurred more frequently could probably act as greater indicators of (C)APD. In the present study, it was found that the occurrence of attention and memory related symptoms were more followed by poor academics. Similar findings were obtained by Smoski, Brunt and Tannahill (1992). They too observed, based on the findings of CHAPPS, that 'affected memory' was a common symptoms seen in children with (C)APD. However, a more common symptom noticed by them was 'difficulty in hearing in the presence of noise'. This was also a common symptom seen in the present study as well as by Musiek, Guerkink, Kietel and Hannover (1982).

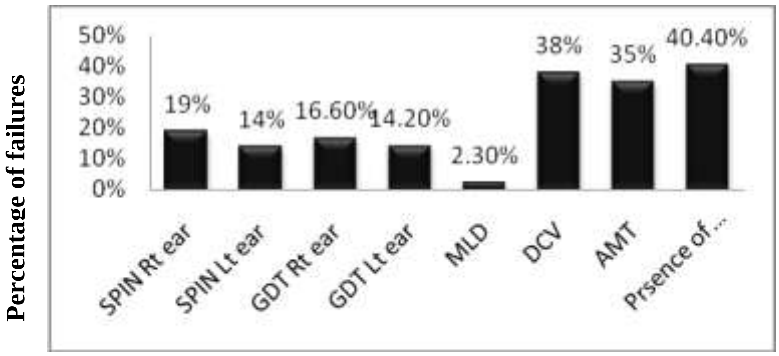
In contrast, Sanger, Freed and Decker (1985) reported that the symptoms that were least seen in their group of children with suspected auditory processing disorder was 'auditory memory'. They noticed this finding using a 23-item informal checklist.

The variation seen across the studies, including the present study could be due to the heterogeneity seen in children with suspected (C)APD. Yet another reason for the variation in the finding may have due to an observer bias. It is possible that teachers varied in terms of the symptoms to which they were more observant. This could have also resulted in the variation seen across the studies.

Presence of (C)APD as per the diagnostic tests

The findings of the diagnostic tests, carried out on 42 of the participants, are provided in Figure 1. The figure provides information regarding the number of children who failed each of the diagnostic tests as well as the number of children diagnosed to have (C)APD, as per the recommendation of Chermak and Musiek (1997).

Among the diagnostic tests, the tests with maximum failure was DCV (38%) followed by AMT (35%), SPIN (average of both ears being 16.5%) and GDT (average of both ear being 15.5%). Only one participant failed the MLD test. Using the criteria suggested by Chermak and Musiek (1997), 40.4 % (17) of the participants were diagnosed to have (C)APD.



(C)APD tests

Figure 1: Percentage of children who failed each diagnostic test and those who were diagnosed to have (C)APD.

From the finding it can be construed that children with (C)APD have varied performance on the (C)APD diagnostic tests, with a greater number of them have difficulty in auditory integration and auditory memory. Further, on the SPIN and GDT, a larger number of participants failed when tested in the right ear, when compared to the left ear.

The findings of Musiek et al. (1982) are in consensus with that of the present study. They too noted that their children with (C)APD failed most often on different diagnostic tests, including the presence of an auditory integration problem. However, they too reported of a larger number of their participants having temporal processing problems, as assessed by the frequency pattern test.

Agreement of each question of SCAP with (C)APD

To find out the agreement between the SCAP results and (C)APD findings, further analysis was done. The agreement was checked between each question of the SCAP and the diagnostic tests, as well as between each question with the overall diagnosis of (C)APD. This was analysed using the Kappa measure of agreement.

There was a significant agreement ($p < 0.05$) found between some of the questions of SCAP with the SPIN results of both the ears. However, the agreement between these questions and SPIN results was only moderate. There was no agreement observed for other questions with any of the (C)APD tests. In addition, the results of the Kappa revealed that there was no statistically significant ($p > 0.05$) agreement between any question of SCAP and presence / absence of (C)APD, using the criteria given by Chermak and Musiek (1997)

The above findings substantiates that isolated symptoms cannot be used to suspect the presence / absence of (C)APD and make a judgment as to whether a client is to be referred or not for further evaluation. As the agreement between the each SCAP questions and presence and absence of (C)APD was poor, it was considered better to use groups of questions to suspect the presence / absence of (C)APD, instead of individual questions.

None of the checklists for (C)APD, reported in the literature, have recommended making referrals based on only one symptoms of (C)APD. Smoski et al. (1992) also reported that the symptoms of (C)APD vary from child-to-child as well as situation-to-situation. Due to this heterogeneity, they too recommended that it would be better to use groups of questions to refer a child for further diagnostic assessment. Thus, the findings of present study are in consensus with the recommendation of Smoski et al. (1992).

Further, the correlation between the total score obtained on SCAP with the diagnostic test results was determined. This was done for five different diagnostic tests that had being administered.

Correlation between overall SCAP scores and each (C)APD diagnostic test

The correlation between the overall scores obtained on the SCAP checklist with the results of the (C)APD test battery (SPIN, GDT, MLD, DCV, AMT) are depicted in Table 1. This correlation was checked using Pearson moment product correlation.

It is apparent from Table 1 that there was a significant negative correlation between the SCAP scores and the SPIN scores for the right ear ($r = -0.439$, $p < 0.05$), SPIN scores for the left ear ($r = -0.536$, $p < 0.05$), and the auditory memory test ($r = -0.464$, $p < 0.05$). This indicates that as the SCAP score increased the score of these diagnostic tests decreased. However, this correlation was only moderate. There was no correlation between the SCAP scores and any of the other diagnostic tests of (C)APD.

Table 1: Correlation between SCAP scores and each of the (C)APD tests.

(C)APD tests	Ear	r
SPIN	Right ear	-0.439*
	Left ear	-0.536*
GDT	Right ear	0.108
	Left ear	0.030
MLD	Both ears	-0.021
DCV	Both ears	-0.286
AMT	Both ears	-0.464*

* Significant at $p < 0.05$ level

The findings of the present study are unlike that reported by Purdy and Johnstone (2000). They correlated the subsection of CHAPPS with the Dichotic Digit Test (DDT) and the Frequency Pattern Test (FPT). They found scores obtained from the Dichotic Digit Test correlated significantly with the CHAPPS memory rating but not with the other subsection (attention span, listening in noise etc.). In addition, the authors did not find a correlation between the frequency pattern tests and CHAPPS.

The variation in finding between the present study and that of Purdy and Johnstone (2000) could be due to the differences in the design of the checklists. The CHAPPS used a larger number of questions and a more complex way of scoring when compared to the SCAP. The subtle differences between the questions and the rating used in the CHAPPS could have affected the scores obtained on their checklist. This in turn could have affected the correlation between the checklist and the diagnostic tests used by Purdy and Johnstone (2000). Another reason for the differences in findings across the studies could be due to the heterogenic nature of (C)APD. The variation in the participants could have also resulted in the difference in findings between study by Purdy and Johnstone (2000) and the present study.

Agreement between various cut-off scores of SCAP and the diagnostic tests

The agreement between various cut-off scores of SCAP and the diagnosis of the presence of (C)APD was also ascertained using the Kappa measure of agreement. This agreement was done to find which score of SCAP could serve as the best cut-off criteria to indicate the presence / absence of (C)APD. The number of the participants at each cut-off included those with as wells as those having scores above the particular cut-off score.

The results revealed that there was a significant moderate agreement for a SCAP cut-off score of five [k = 0.26 ($p < 0.05$)] and six [(k = 0.37 ($p < 0.05$)] with the presence/absence of (C)APD. The agreement was slightly greater for the cut-off scores of six. The other cut-off scores demonstrated no such agreement. This finding indicates that the score of six was the best cut-off score to define a pass / refer criteria. Probably when the SCAP cut-off score were set lower than six, the over referral rate was high. On the other hand, with a higher SCAP cut-off score, the under referral rate was high.

Additionally, the agreements between the SCAP findings and each of the (C)APD test results were also carried out using the Kappa measures of agreement. This was done with the SCAP cut-off score of 5 as well as 6. These two cut-off scores were selected since they had a significant agreement with the presence/absence of (C)APD. The results revealed that there was a moderate, yet significant agreement with the SPIN findings for the both ear as well as AMT for the cut-off score of six. However, for the cut-off score of five, there was no such agreement found with any of the (C)APD tests.

Further, the sensitivity and specificity of the SCAP was determined for different cut-off criteria. This was done to confirm the most appropriate cut-off score.

Sensitivity and specificity of SCAP using different cut-off scores

The sensitivity and specificity for each cut-off score of SCAP was calculated and tabulated. The number of the true positive [number of participants identified as having (C)APD by SCAP] and number of true negatives [number of participants identified as not having (C)APD by SCAP] were calculated. This was obtained for different cut-off scores of SCAP. Using this information, the sensitivity and specificity was calculated.

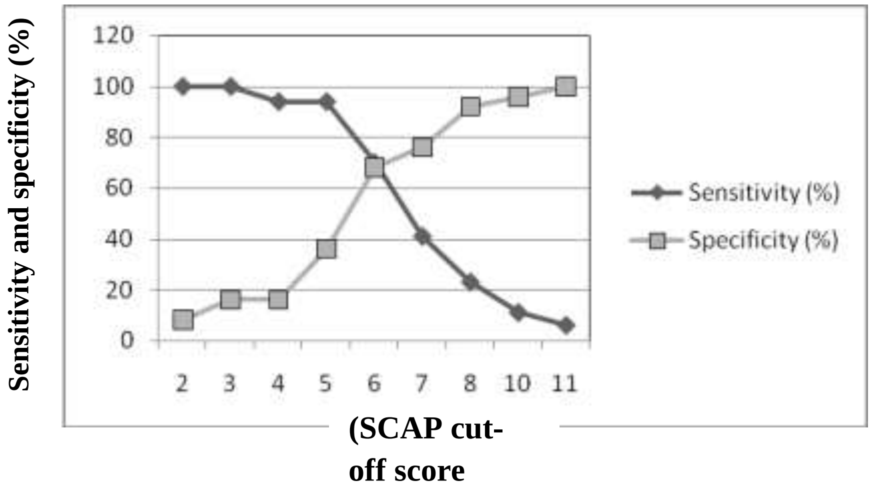


Figure 2: Sensitivity and Specificity for various SCAP cut-off scores.

It is evident from Figure 2 that as the cut-off score of SCAP increased, the sensitivity decreased and specificity increased. With the cut-off score of six, the sensitivity and specificity values were comparable, and with other cut-off scores either the sensitivity was lower or the specificity was lower. Based on the above finding of the study and the results of the Kappa measures of agreement, the cut-off score of six for the SCAP is recommended to decide whether a child is suspected to have or not have (C)APD. At this cut-off, the sensitivity was good without compromising on the specificity.

A few studies have provided the sensitivity and specificity of published screening checklists. Drakes et al. (2006) found that the CHAPPS had a sensitivity of 75% but a specificity of just 25%. They observed this finding when using a stringent diagnostic criterion, wherein a child was labeled as having (C)APD if he/she failed in two tests at least in one ear for the same process. However, the authors reported that the findings could have been different if they used a lax criterion, as recommended by Bellis (2003).

Cameron et al. (2005) also noted that CHAPPS results lead to over-referral. Further, they observed that the CHAPPS scores did not shed light on the magnitude of deficits demonstrated in diagnostic tests. However, it provided information in assessing the overall auditory function. It can be seen that though the SCAP had a sensitivity that is comparable to that of CHAPPS, its specificity was far higher. While the specificity of CHAPPS was just 25%, that of SCAP was 68% indicating that the latter checklist was more efficient.

The screening tests reported in the literature have sensitivities and specificities that differ from that of the present study. Domiz and Schow (2000) found the SCAN developed by Keith (1986) to have a sensitivity of only 45% and a specificity of 95%. Thus, this test has considerably poorer sensitivity compare to the SCAP but a much higher specificity. Using the SCAP would result in a lesser chance of under referral, when compared to the SCAN. On the other hand, MAPA developed by Domitz and Schow (2000) has been found to have a high sensitivity and specificity (83% and 85% respectively). Though this screening test would be more efficient in referring / passing children with suspected (C)APD, it would be far more time consuming when compared to SCAP. Schow, Seikal, Brockett and Whitaker (2007) reported that the MAPA took around 21 minutes to administer on a child. In contrast, teachers took approximately 10 minutes to answer the SCAP and provide information about the entire class having a strength of 40 to 50 students.

Thus, it can be inferred that the SCAP is a practical and fairly efficient method to screen school-going child to detect (C)APD. Though, it is not as efficient as some other screening tests, it is far more time and cost effective.

Prevalence of (C)APD in school-going children

From the SCAP scores obtained from the 3120 children, it was found that 216 (6.9%) of them had one or more symptoms of the (C)APD. However, using the cut-off score of 6, only 83 (2.6%) children were suspected to have (C)APD. On the other hand, the remaining 133 (4.2%) of them had some symptoms of (C)APD but they passed as per this cut-off score. Thus, based on the SCAP results, it can be construed that the possible prevalence of (C)APD, in the population studied was just 2.6% without accounting for the false negatives and false positives.

However, the SCAP was noted to have a false negative of 29%. After correcting for the false negatives by subtracting this group, the number of true positive who were referred as per SCAP was 59 (1.9%). Further, SCAP had a false positives of 32% wherein 43 (1.3%) of the children would have been missed. Thus, by adding this group, it can be inferred that the number of children with (C)APD would have been 102 (59 + 43), resulting in 3.2% truly having a suspected (C)APD.

The prevalence observed in present study is in agreement with the findings of Chermak and Musiek (1997). They too observed that 2% to 5% of school-aged children have (C)APD, which is not very different from the average 3.2% found in the present study.

Profiling of (C)APD Test findings

The 42 children who were subjected to diagnostic tests, were categorized as pass or refer using their SCAP findings (using a cut-off score of 6). Twenty participants obtained scores of six and greater on the SCAP, while 22 obtained scores below six. The results of each of the diagnostic tests as well as the overall diagnosis of the (C)APD are provided in Figure 3. The diagnostic tests that demarked the two groups (pass, refer) were SPIN, AMT and DCV. However, equal number of participant failed in GDT. Out of the 20 participants who were suspected to have (C)APD and were referred based on the SCAP results, 13 (65%) had (C)APD. On the other hand, five (22%) of the 22 participants, who passed the SCAP checklist, were diagnosed to have (C)APD .

In general, the maximum failure was observed for the DCV and AMT tests, followed by SPIN and GDT. However, only one participant failed the MLD test. Thus, while administering the (C)APD tests, it is necessary to include DCV, AMT, SPIN, and GDT. Higher preference should be given to DCV and AMT during the assessment of (C)APD, as larger number of children failed these tests. It can be deduced from the findings of the study that children generally have greater problems with auditory integration and auditory memory, followed by auditory separation / closure and temporal processing.

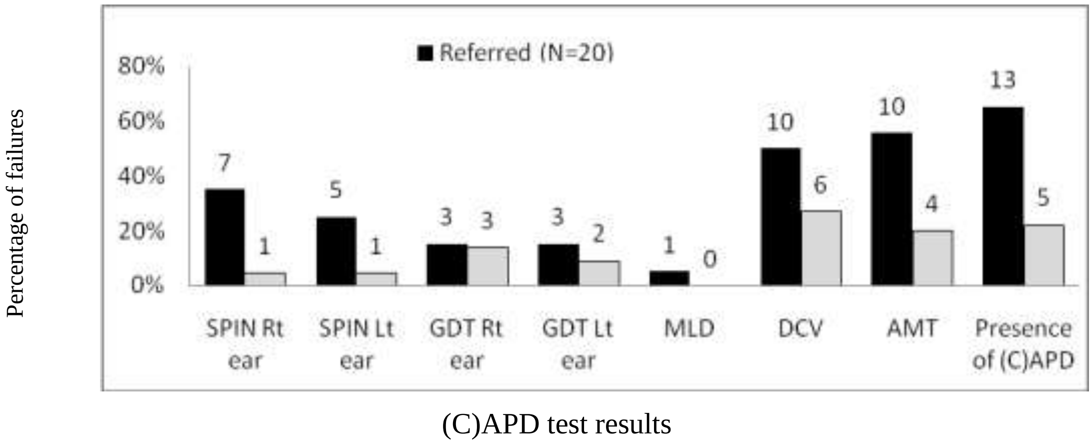


Figure 3: Percentage of participants who passed / referred based on the SCAP as well as those who failed the diagnostic tests. The numbers provided above each bar indicate the actual number of participants.

Further, it was observed that different children failed different tests indicating that all the children did not exhibit the same kind of auditory processing difficulties. Therefore, it is important to include a battery of tests that assess different auditory processes. It is recommended to profile each client to determine the exact deficit which in-turn would help in better management.

It is difficult to be compared the above finding of the present study with reports in literature. The tests / process that have been assessed in different studies vary. Though there exists variance across studies, a few similarities in choice of tests / process can be observed. Musiek et al. (1982) also observed that their participants had more difficulty in auditory integration and temporal processing similar to that found in the present study.

However, Musiek et al. (1982) rated temporal processing to be the second highest deficits unlike the findings of present study where it was found to be considerably less prevalent. Likewise, the order of processes that were deficient in the present study differs from that reported by Ferry and Wilber (1986). However, they too noted that auditory closure and integration problems were present in their participants. Variation across the studies could be attributed to the variations in the tests administered. Though these studies tap similar process, the actual tests used varied. However, the heterogeneity of the condition could have also contributed to the differences observed across the studies.

Reliability measures

In addition to the measures of sensitivity and specificity, the test-retest reliability was checked. It was done separately for the checklist and for the diagnostic tests. While the reliability of SCAP was tested approximately on 20% of the participants, the reliability of the diagnostic tests was done on approximately 5% of the participants.

The reliability of the SCAP was found to be good as per the findings of the alpha reliability co-efficient. The coefficient was greater than 0.6 [$a = 0.77$, ($p < 0.05$)] indicating that the test-retest reliability of SCAP was good.

The reliability of the (C)APD test battery was done on two children showed that the overall diagnosis of the presence / absence of (C)APD and the results of each of the tests of (C)APD remained same. Though there were some differences in the raw scores obtained, the diagnosis continued to be the same.

Summary and Conclusions

The present study was undertaken to check the utility of the ‘Screening Checklist for Auditory Processing’ (SCAP) developed by Yathiraj and Mascarenhas (2002) in identifying children with symptoms of (C)APD. The study also aimed at finding the agreement of the SCAP scores with a battery of (C)APD tests. To determine an appropriate cut-off score for SCAP, the sensitivity and specificity of the checklist was studied.

The analysis of the data revealed that a single symptom on the SCAP was not a good indicator of the presence of (C)APD. Hence, the need to use a group of symptoms was felt necessary. It was found that attention span related symptoms were more prevalent in school-going children with suspected (C)APD. This was followed by memory problems and difficulty in hearing in noisy situations.

Further, a comparison of various cut-off scores of SCAP with the (C)APD diagnostic test findings indicated that a SCAP cut-off score of 6 yielded a good correlation with the results of SPIN and AMT as well as with the overall diagnosis of (C)APD. Additionally, the cut-off score of 6 on SCAP resulted in a fairly high sensitivity without compromising on the specificity. A sensitivity of 71% and specificity of 68% was obtained for the SCAP when a cut-off criterion of 6 was used. The sensitivity and specificity of the SCAP was comparable with other checklist / tests reported in the literature (Domitz & Schow, 2000; Drakes et al., 2006; Schow et al., 2007).

Using cut-off criteria of six on the SCAP, the prevalence of suspected (C)APD in school-going children was 3.2%. This value was obtained after making corrections for the false positives and false negatives. The overall results revealed that the SCAP could be used as a simple and practical measure to screen for the presence of (C)APD.

Among the diagnostic tests used, most of the participant failed in the AMT and DCV tests, followed by SPIN and GDT. Hence, it is important to include theses test in a diagnostic test battery. It is more essential to include the first two tests as the participants failed them more frequently. All the participants who had (C)APD did not demonstrate similar auditory processing difficulties. Thus, a test battery approach should be employed while assessing children with suspected (C)APD.

Acknowledgement

Thanks are to the Director AIISH for permitting to carry out the study. Thanks are also due to the HOD Audiology for permitting to use the equipment. We thank all our participants for their co-operation.

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