A SURVEY ON SCREENING AND DIAGNOSTIC CRITERIA OF AUDITORY PROCESSING DISORDER IN INDIA

(Dissertation in Audiological Evaluation)

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AUGUST, 2022

CERTIFICATE

This is to certify that this dissertation entitled "**A Survey On Screening And Diagnostic Criteria Of Auditory Processing Disorder In India"** is a bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student Registration Number: 20AUD030. This has been carried out under the guidance of a faculty of this institute. It has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
August 2022

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CERTIFICATE

This is to certify that this dissertation entitled" **A Survey On Screening And Diagnostic Criteria Of Auditory Processing Disorder In India"** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled "**A Survey On Screening And Diagnostic Criteria Of Auditory Processing Disorder In India"** is the result of my study under the guidance of a faculty at All India Institute of Speech and Hearing, Mysuru. It has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru,
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Registration No. 20AUD030

This Dissertation is dedicated to my Family

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Abstract

The current study aimed to determine the criteria used for screening and diagnosing cases with central auditory processing disorders (CAPD) in India. A cross-sectional questionnaire-based survey design was used in the present study. A questionnaire was developed to determine the criteria used for screening and diagnosing CAPD across clinics in India. Responses were obtained from 83 participants from all over India. Results indicated that 78% of respondents were currently doing CAPD evaluation. In that, the majority of respondents (63%) had a predetermined minimum battery that was relatively adaptable depending on the case history and age of the patient. In screening, most respondents used a screening questionnaire (SCAP, 75%) and a screening test (STAP, 60%). In the diagnostic protocol, the most used tests by the respondents were masking level difference (MLD), repetition of words (RW), gap detection test (GDT), pitch pattern test (PPT), speech perception in noise (SPIN), digit span test (DST), dichotic digit test (DDT), binaural fusion test (BFT), auditory brainstem response (ABR), dichotic CV test (DCVT), and duration pattern test (DPT). The current study's result will help professionals choose the minimum test battery for diagnosing CAPD.

Key Words: Central auditory processing, Central auditory processing disorder, CAPD test battery

Chapter 1

Introduction

A defect in the perceptual (i.e., neural) processing of auditory information and the neurobiological activity that underlies that processing is referred to as central auditory processing disorder (CAPD) (American Speech-Language-Hearing Association [ASHA], 2005). The central nervous system's (CNS) capacity to process auditory data is known as auditory processing (AP). CAPD can result in difficulties with attention, speech production, and reading and can manifest diverse approaches along with problems localizing sound sources, processing rapid auditory inputs, and difficulty hearing in difficult listening situations. CAPD can affect an individual's listening, spoken language comprehension, and learning (Catts et al., 1996; ASHA, 1996). CAPD regularly coexists with different issues with comparable traits, including attention deficit disorder, learning disabilities, speech and language problems, and poor listening abilities (Jerger & Musiek, 2000).

Difficulties in speech perception seen in individuals with CAPD could be because of the dysfunction in the central auditory nervous system, or it could be a dysfunction at the level of the cochlea. Hence the prefix 'central' is removed from CAPD, and it is preferred to use the term APD or (C)APD. This is a symbolic recognition that the possible role of the peripheral ear is not ruled out in APD (Moore, 2011). The diagnosis of CAPD is only confirmed when the individual has speech perception difficulties which are seen even with normal peripheral hearing and deficits in one or several central auditory processing skill areas (Munguia,2014).

Studies have shown that children with CAPD have various co-morbid conditions. Catts et al.(1996) reported that 30% of the children with CAPD also had writing and reading difficulties, 90% had speech and language problems, and 10% had attention deficit hyperactive disorder. It was also reported in the same study that 60% of the children had two or more associated problems. Sharma et al.(2009) studied the co-morbidity of auditory processing, language, and reading disorders. They used auditory, language, reading, attention, and memory tests on 68 children with CAPD and normal nonverbal IQ scores of 80 or higher. The findings demonstrated that reading disorder and linguistic impairment frequently coexisted with CAPD. A few auditory processing tasks are related to performance in terms of attention and memory, although these relationships only partially account for the variation in results. The study states that a comprehensive assessment is needed across the age range to know the difficulties experienced by children with CAPD. Skarzynski et al.(2015)examined the efficacy of the dichotic digit test in identifying central hearing impairments in children of school age. A screening test was done on 76429 children between the ages of 7 and 12. According to the study, these authors claimed to have a right ear advantage and a higher prevalence of other conditions, including dyslexia. Thus it can be concluded from the above studies that CAPD individuals present with various co-morbid conditions, and the most common include reading and writing difficulties.

The prevalence of CAPD has been reported in multiple studies (Muthuselvi & Yathiraj, 2009; Hind et al., 2011; Yathiraj & Maggu, 2013). According to Chermak and Musiek (1997), the prevalence of CAPD ranged from 2 to 5 %, whereas Nagao et al. discovered that it was just 0.19 % in the Delaware Valley (2016). The prevalence of

CAPD was determined to be 0.5 % to 10% in the United Kingdom, and it was 5.1 % among children who had problems hearing speech over background noise (Chermak et al., 1997; Bamiou et al., 2001; Hind et al., 2011). However, in the Indian scenario, the incidence of CAPD in school-age children was reported to be3.2% (Muthuselvi & Yathiraj, 2009). Thus, the prevalence of CAPD differed across studies.

To correctly identify school-going children who exhibit problems in auditory processing and to start the intervention untimely, there is a need to identify necessary tests that should be included in the CAPD test battery. The use of a test battery that detects specific auditory processing problems has been encouraged because of the heterogeneity in individuals with CAPD (Baran, 2007*).* Numerous studies have noted deficiency in one or more auditory processes in individuals with CAPD (Katz et al., 1992; Musiek et al., 1982; Muthuselvi & Yathiraj, 2009; Welsh et al., 1980). A test battery method is best than any single testing to diagnose CAPD, and there are versions concerning the selection of tests to be integrated into a test battery (BSA 2011; ASHA, 1996 & 2005; Bellis & Ferre, 1999; Yathiraj & Vanaja, 2018). However, there is no gold standard for the selection of tests to be included in a test battery for CAPD (Yathiraj & Vanaja, 2018). The Bruton Conference, as it is more commonly known, recommended including the following CAPD tests in the minimum test battery: a dichotic task, a duration pattern sequence test, a temporal gap detection test, and electrophysiological tests like the auditory brainstem response (ABR) and middle latency response (MLR) (Jerger & Musick, 2000).

Specific auditory processes have been reported in the literature to be often disrupted in children with CAPD, despite the lack of a gold standard battery of tests.

The processes often affected in children with CAPD include auditory separation/closure (Katz,1992; Muthuselvi & Yathiraj, 2009; Welsh et al., 1980), binaural integration (Katz et al., 1992; Musiek et al., 1982; Muthuselvi & Yathiraj, 2009) and temporal processing (Musiek et al., 1982; Muthuselvi & Yathiraj, 2009). In addition, auditory memory has been observed to be often deviant in children "at risk" for CAPD (Muthuselvi & Yathiraj, 2009; Yathiraj & Maggu, 2013).

1.1 Need for the study

The lack of normative data on several of the most regularly used behavioral CAPD tests complicates the diagnosis of CAPD (Emanuel, 2002). No 'gold standard test' or a series of tests can be used to diagnose CAPD. Even though numerous publications and guidelines for evaluating CAPD have been published, there doesn't seem to be agreement among academics and medical professionals over the tests that should make up a primary CAPD battery. ASHA(1996) has stated that CAPD must be considered multidisciplinary if performing a differential diagnosis. For the differential diagnosis of CAPD, a minimum test battery should be performed. But the tests that should be included in the CAPD test battery were not specified. A gathering of audiologists took place in 2000 to review the state of CAPD assessment at the time. Hence there is a need to determine the different criteria used to diagnose CAPD in India, as there is minimal literature suggesting tests to be included in primary CAPD diagnosis.

Further, more than 55 universities provide undergraduate (UG) and post-graduate (PG) programs in speech pathology and audiology, according to the

Rehabilitation Council of India, a statutory agency under the Indian government (Yathiraj et al., 2020). Also, many private speech and hearing centers across India carry CAPD assessment and management. Although CAPD is regularly diagnosed in India, it is not included in widely used diagnostic classifications like the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). Understanding the various screening and diagnostic methods used in India is crucial. Thus, this survey will help understand different test batteries used across different setups in India and arrive at a conclusion about the test battery that can be most efficient.

1.2 Aim of the study

The present study surveyed the screening and diagnostic protocol of CAPD used across clinics in India.

1.3 Objectives of the study

1. To develop a questionnaire for the survey of screening and diagnosis of CAPD used across clinics in India.
2. To survey the CAPD screening protocol used across clinics in India.
3. To survey the CAPD diagnostic protocol used across clinics in India.
4. To compare different screening and diagnostic protocols used across clinics in India.

Chapter 2

Review of Literature

The term "difficulties in the perceptual processing of information in the central auditory nervous system (CANS) and the neurobiological activity that underlies that processing and generates the electrophysiological auditory potentials" refers to central auditory processing disorder (CAPD) (American Speech and Hearing Association [ASHA], 2005). According to ASHA (1990), CAPD refers to difficulties in processing audio information not caused by diminished hearing sensitivity or mental disability.

The prevalence and demographic characteristics of pediatric CAPD have been reported by various authors (Chermak & Musiek, 1997; Obuchi et al., 2017). In school-going children, the prevalence of CAPD has been reported as 2–3% (Chermak &Musiek, 1997). However, in the Indian scenario, the incidence of CAPD in school-age children was reported to be 3.2% (Muthuselvi & Yathiraj, 2009). To create suitable infrastructure and intervention strategies for CAPD, it is, therefore, crucial to understand the assessment of CAPD, like any other condition.

2.1 Assessment of CAPD

The evaluation of peripheral and central hearing is part of the CAPD assessment. The gold standard for assessing hearing is still the pure tone audiogram (Iliadou et al., 2019). The audiogram is the main instrument for identifying the kind, severity, and configuration of hearing loss; however, it only tells you how sensitive your ears are to certain frequencies. It does not demonstrate the complete physiological state of the cochlea or the entire (peripheral and central) auditory system. Despite having normal

pure tone audiograms, adults with central auditory nervous system (CANS) pathology (such as stroke, traumatic brain injury, or degenerative illness) and children with CAPD and learning issues have trouble processing speech in noisy or competing message contexts. The audiogram explains a small portion of speech understanding performance and self-reported hearing ability variation. So, a single test is insufficient to diagnose CAPD because it is linked to other co-morbid diseases. Because of this, a test battery approach and a multidisciplinary team is required to diagnose CAPD.

ASHA published a position paper in 1996 that stated a minimal set of tests that should be carried out for the differential diagnosis of CAPD and that CAPD should be considered from a multidisciplinary perspective when reaching a diagnosis. Which CAPD test should be a part of the minimum battery, though, was not stated. Chermak and Musiek(1997) also stated that the assessment of CAPD involves a test battery to identify the lesion and define the functional auditory deficits in the central auditory nervous system.

Baran (2007) also recommended using a test battery to detect different auditory processing problems due to the heterogeneity seen in children with CAPD. CAPD deficiency has been noted in one or more processes in children with CAPD (Katz et al., 1992; Muthuselvi & Yathiraj, 2009; Welsh et al., 1980; ASHA, 2005; Bellis & Ferre, 1999). It has long been established that in the CAPD population, a test battery approach is preferable to standalone assessments. However, there are differences in the tests that should be included in a test battery. Yathiraj and Vanaja (2018) reported that the sensitivity and specificity of a test battery depend upon the tests used in the evaluation

process. However, there is currently no gold standard for the tests that should be included in a test battery for CAPD.

The test battery includes various behavioral and physiological tests. Behavioral CAPD tests that assess central auditory processing abilities include; dichotic tests to assess binaural integration and separation, temporal processing tests to assess temporal resolution and temporal patterning, binaural interaction tests, and monaural low redundancy speech tests to assess auditory closure (Emanuel et al., 2011; Chermak et al., 2007).

ASHA (2005) and the American Academy of Audiology [AAA] (2010) state that instead of using a limited test battery, the test battery for CAPD assessment should be dependent on the patient's case history and other information provided to the audiologist. These two professional organizations suggested a few test principles that should be used when deciding which tests should be included in a CAPD test battery. These recommendations cover topics like (a) multidisciplinary assessments for CAPD should be used; (b) the case history and diagnostic results should be used to determine the diagnosis and course of therapy for CAPD; behavioral CAPD tests and any screening tools (including questionnaires) should be well validated, have good test-retest reliability, and demonstrate high sensitivity and specificity; (c) diagnostic CAPD test batteries should include both verbal and nonverbal stimuli to assess different levels of the CANS; (d) the CAPD test battery should examine different processes, regions, and levels of the CANS; (e) CAPD testing should be completed in a reasonable amount of time, such as an hour, as recommended by AAA (2010); (f) the audiologist needs to be aware of subject-related characteristics of the patient that may affect their test performance, such as

chronological and mental age, attention to task, fatigability, and native language; and (g) CAPD testing should not be test driven but rather motivated based on the referring complaint.

Jerger and Musiek (2000) suggested incorporating electrophysiological and electro-acoustical tests into a test battery for CAPD. However, the authors acknowledge that the time and expense required to use such procedures is a drawback. Furthermore, according to Katz et al. (2002), there is insufficient evidence to support the use of these tests as part of a CAPD exam battery, besides the fact that they are not the time or cost-effective. Maciej Serda (2013) also stated that electrophysiological tests should not, due to a lack of evidence, be a part of a clinical test battery for CAPD.

The screening of CAPD may also be a part of the CAPD test battery. The screening can be done using various questionnaires: Auditory processing domain questionnaire(O'Hara & Mealings, 2018); Buffalo Model Questionnaire-Revised, BMQ-R (Katz & Zalewski, 2011), Scale of Auditory Behaviors (Show et al., 2007); Screening Instrument for Targeting Educational Risk, SIFTER (Anderson & Matkin., 1989) and Screening checklist for Auditory processing, SCAP (Yathiraj & Mascarenhas., 2003). The screening tests available to screen CAPD are; A screening test for auditory processing disorders, SCAN (Keith, 1986); a screening test for auditory processing, STAP (Yathiraj & Maggu, 2013). SCAN is used to identify children (3-11 yrs) at risk for auditory language processing problems and educational difficulties. The different versions of SCAN are; SCAN – a Screening test for CAPD (Keith, 1986), SCAN – A for adults (Keith, 1994), SCAN – C for children (Keith, 2000), SCAN – 3: A test of auditory processing disorders in adolescent and adults (Keith, 2009). Studies have been done in

the past to report that CAPD screening can be a part of the CAPD test battery as it will reduce the referrals for detailed diagnostic evaluation (Emanuel et al., 2011).

3.2 CAPD Assessment according to various guidelines

The criteria utilized for diagnoses of CAPDare a crucial part of any diagnostic test battery. The measures employed in research(Bellis & Ferre, 1999; Chermak et al., 2007; Jerger & Musiek, 2000; Keith, 2000) and reports of various monitoring organizations/associations (Alles et al., 2011; ASHA 1996 &2005; Musiek et al., 2010) to classify people as having CAPD differ. If a child performed differently on one or more of the processes included in the ASHA task force on central auditory processing consensus development's description, they were classified as having CAPD (ASHA, 1996).

Some of these processes were sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal characteristics of the audition, auditory performance decrements with competing acoustic signals, and auditory performance decrements with degraded acoustic signals. On the other hand, it was suggested by Chermak and Musiek (1997) that a person should be given a CAPD diagnosis if their performance on two or more tests in the battery fell at least two standard deviations (SDs) below the mean. Additionally, they advised that a person could be diagnosed with CAPD based on a single test if their performance is at least 3 SDs below the mean or if the finding is followed by significant functional problems in auditory behaviours dependent on the process tested. Further, to validate the preliminary conclusions, the audiologist was advised to perform the one test that failed again and a different test that is analogous and evaluates the same process.

Likewise, the AAA task force (2010) declared that "the use of cutoff scores that are based on suitable normative data can be used(Musiek et al., 2005; Shinn & Musiek, 2007; Spaulding et al., 2006; Turner & Hurley, 2009). Musiek et al. (2010) reported that the cutoff scores are established at performance levels, such as 2SD below the mean, to achieve the optimal balance between sensitivity and specificity. Therefore, no clear prescription is made to distinguish between persons who have and do not have CAPD; only examples of possible cutoff values are given.

The British Society of Audiology's position statement on CAPD did not provide any specific criteria that might be used to identify someone as having the disorder(Alles et al., 2011). The standard confirms what has already been stated in the literature: no gold-standard tests to diagnose CAPD. Nevertheless, it advises "to concentrate on a core symptom or symptoms; features of auditory perception that reflect and can be demonstrated to contribute to the clinical presentation, and that help to give information to the entire evaluation of a kid with listening issues."

Wilson and Arnott (2013) stated that the rates of prospective CAPD diagnoses ranged from 7.3% (ASHA, 2005 advised performing at least one test mono-aurally within one auditory processing domain)for the most rigid criteria to 96.0% for the most lenient criteria. The criteria used should be explicitly described before making a CAPD diagnosis. The study underlines the necessity of reaching a consensus on the diagnostic criteria for CAPD. Wilson and Arnott (2013)suggest that the condition be diagnosed with specificity by mentioning the criteria used rather than utilizing the term "central auditory processing disorder" as a general diagnosis. But some criteria used to categorize children with CAPD lacked empirical support for their recommendations.

Dillon et al. (2012) proposed three distinct methods to diagnose CAPD. For each of their recommendations, they also listed the challenges that were most likely to be encountered. Their initial recommendation to tighten the pass-fail criteria for each test was rejected since a test failure would have required exceptionally poor performance. Their second suggestion states that a person cannot be diagnosed with CAPD if they fail more than one test out of the battery. It was believed that this would require putting the subject through several tests, raising statistical and fatigue difficulties. The third recommendation was to have a failed test subject retake it; however, someone was only considered to have failed if they received poor marks on both tests. The extra time needed for the person's evaluation, the authors did note, was the biggest disadvantage of their third recommendation. It was also pointed out that a shortage of knowledge on the degree of impairment will truly cause a person to encounter difficulty in real life. The authors emphasized the requirement for an impartial evaluation of the degree of listening difficulties experienced.

Shaikh et al. (2016) tried to offer empirical support for two distinct criteria for diagnosing CAPD in kids. They assessed the effects of using a 1 SD and 2 SDs below the mean criterion on 98 children who had taken a battery of three Katz (1992) recommended CAPD tests. They found that 20% more children failed the tests with a 1 SD threshold than with a 2 SD criterion after analyzing the data of the 68 children who failed two or more examinations. They discovered that children's performance with scores between one and two SD was "close to a normal distribution," hence they suggested utilizing the one SD criterion.

3.3 Assessment of CAPD- Indian Scenario

In India, for the assessment of CAPD, screening (SCAP, Yathiraj & Mascarenhas, 2003; STAP, Yathiraj & Maggu, 2014)and diagnostic tests are available. For diagnostic, a minimum test battery should be conducted to diagnose CAPD. But the tests that should be included in the CAPD test battery are not well understood.

SCAP has two varieties and each with 12 questions and 2 point rating. The subsection includes auditory perceptual processing, auditory memory, and other miscellaneous symptoms. On SCAP, it was discovered that the suggested cutoff criteria (children who scored more than 50% considered at risk for CAPD) were useful in correctly diagnosing most children with CAPD symptoms. Yathiraj and Maggu (2013) showed that 12.3% of children were at-risk for CAPD on the SCAP.

STAP is the only screening tool available in the Indian scenario. STAP has three components, speech perception in noise and auditory memory combined to form a single component, while dichotic CV and gap detection created two separate components. This tool is effective and economical in terms of time; the total time taken by STAP was only 12 min (Yathiraj & Maggu, 2012). The diagnostic tests for CAPD and the STAP subsections showed a strong and substantial association. The STAP's sensitivity and specificity were 76.6 % and 72 % compared to diagnostic tests. It was discovered that the sensitivity and specificity of the screening increased when SCAP and STAP were combined.

Yathiraj and Vanaja (2018) stated that for children aged seven and older, it is advised that the test battery for CAPD should include the SPIN-IE (Speech-in-Noise Test in Indian English), DCV (Dichotic Consonant–Vowel), DPT (Duration Pattern

Test), and RAMST-IE (Revised Auditory Memory and Sequencing Test in Indian English). Furthermore, diagnosing CAPD in kids who failed to perform poorly in one of the diagnostic tests, the diagnosis can be made using 2 SDs below the mean criteria. It is recommended to apply a cutoff criterion of one SD below the mean for children who perform poorly on multiple tests on the CAPD test battery.

Chapter 3

Methods

The current study determined India's screening and diagnostic protocol used for central auditory processing disorders (CAPD). A cross-sectional questionnaire-based survey design was used in the present study. The study was planned in three stages:

Stage 1: Development and verification of the questionnaire

Stage 2: Administration of the developed questionnaire

Stage 3: Analysis of response and its implications

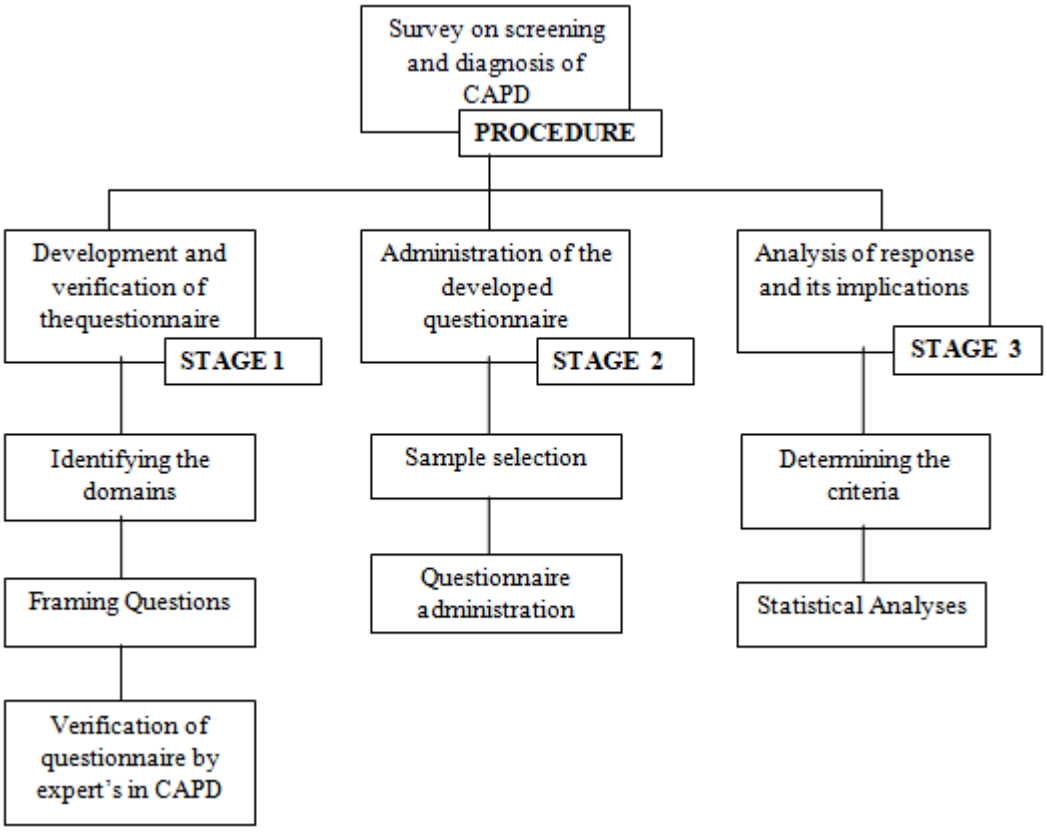

Figure 3.1*The framework of the survey procedure*

Stage 1: Development of the Questionnaire

Identifying domains

The survey aimed to know what protocols are used for screening and diagnosing cases with CAPD in India. Based on the literature review and relevance to the purpose of the study, four major domains were considered for framing the questions, and they were:

- Demographic details and background information
- Specific factors
- Screening protocol
- Diagnosis test battery protocol

Framing questions

The questions were prepared in English based on the pool of potential surveys; (Chermak et al., 2007; Emanuel et al., 2011). Five expert audiologists conducted the content analysis of the framed questions in English for content validity. The questions were modified based on the feedback from the experts, and the final questionnaire was prepared. The final questionnaire was prepared in English. The final questionnaire consisted of 23 questions and included a multiple-choice and four-point scale (always, often, sometimes, and never) and short answer-based questions (Appendix I). Table 3.1 provides the details of the number of questions under each domain in the final questionnaire.

Table 3.1

Total number of questions under each domain of the questionnaire

Sl.No.	Domains	No. of Questions
1	Demographic details and background information	6
2	Specific factors	3
3	Screening protocol	2
4	Diagnosis test battery protocol	12
	Total	23

Stage 2: Administration of the developed questionnaire

The questionnaires were sent to the participants as Google forms via email and social media platforms. An explanation preceded the survey form regarding the purpose of the survey. The confidentiality of the data was ensured to the participants. All study participants provided their informed consent before the survey. A follow-up procedure was followed to ensure maximum participation.

Responses were collected from clinical audiologists working in academic and clinical setups or other setups in the CAPD area. Responses obtained included participants from all over India.

Stage 3: Analysis of response and its implications

Determining the criteria

The obtained responses were analyzed qualitatively. The response percentage was calculated to determine the protocol used for screening and diagnosing cases with CAPD in India.

Chapter 4

Results

The current study aimed to determine the protocol used for screening and diagnosing cases with central auditory processing disorders (CAPD) in India. A total of 83 responses were received online (G-mail, WhatApp). Responses were received from 83 professionals, out of which 65 were currently working in the field of CAPD. The responses were qualitatively analyzed, and response percentages were calculated to determine the criteria for screening and diagnosing CAPD. The results of the data are represented under the following headings:

- **Demographic details and background information**
- **Specific factors**
- **Screening protocol used across India**
- **Diagnosis test battery protocol used across India**

4.1 Demographic details and background information

The first section of the questionnaire consisted of six questions intended to collect particulars on the participants' demographic details and background information. All participants agreed that their participation in this survey was voluntary and knew that participation does not fetch any direct benefit. Responses were received from all over India. Figure 4.1 illustrates the qualification distribution of the professionals; most participants (57%) reported possessing a post-graduate degree as their highest educational qualification, followed by undergraduate and Doctor of Philosophy.

Figure 4.2 provides the details of professionals' experience in practicing CAPD; the majority had an experience of < 2 years (34%). Figure 4.3 illustrates the type of setup in which the professionals are currently employed and practicing. The data showed that most professionals were employed in academic institutions (46%). For the question: "Do you currently screen and diagnose CAPD at your facility?", Sixty-five professionals (78%) out of 83 said: "Yes" (Figure 4.4 depicts the percentage of professionals currently screening and diagnosing CAPD).

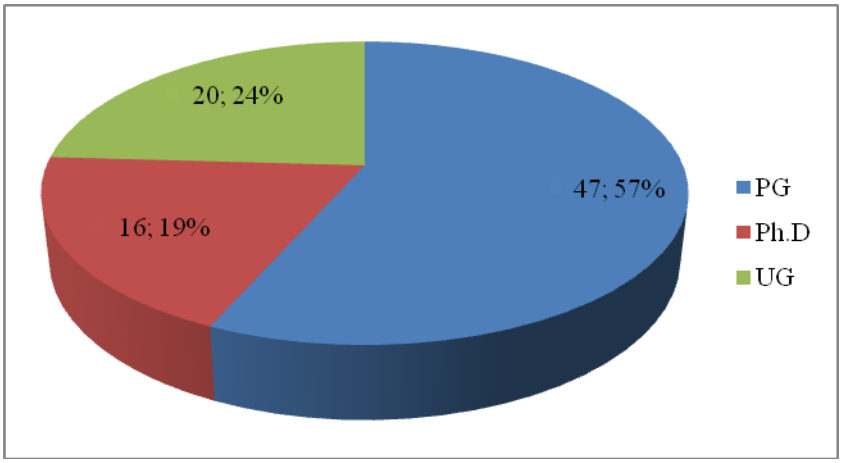

Figure 4.1: *Pie chart depicting the number and percentage of participants with various academic qualifications.*

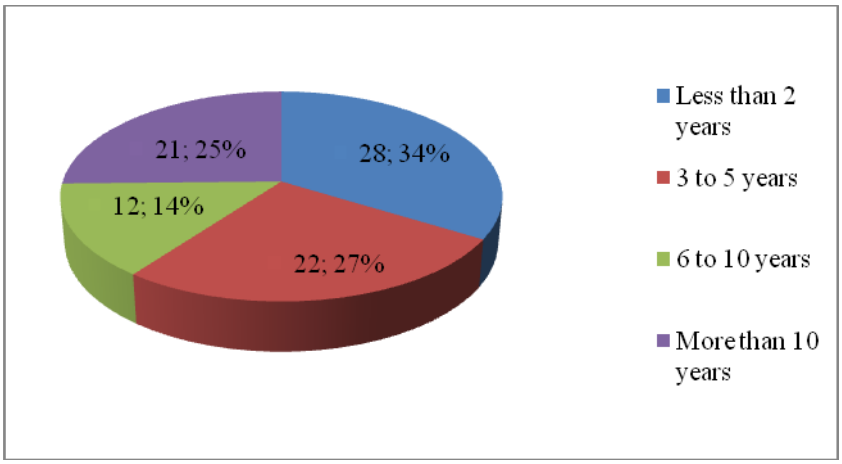

Figure 4.2*: Pie chart depicting the number and percentage of participants with different years of experience in practicing Audiology.*

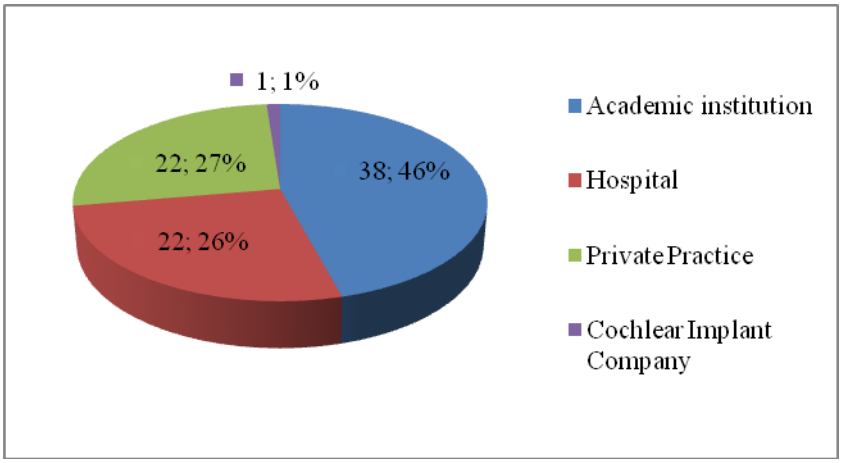

Figure 4.3*: Pie chart depicting the number and percentage of type of setup in which the participants were currently working.*

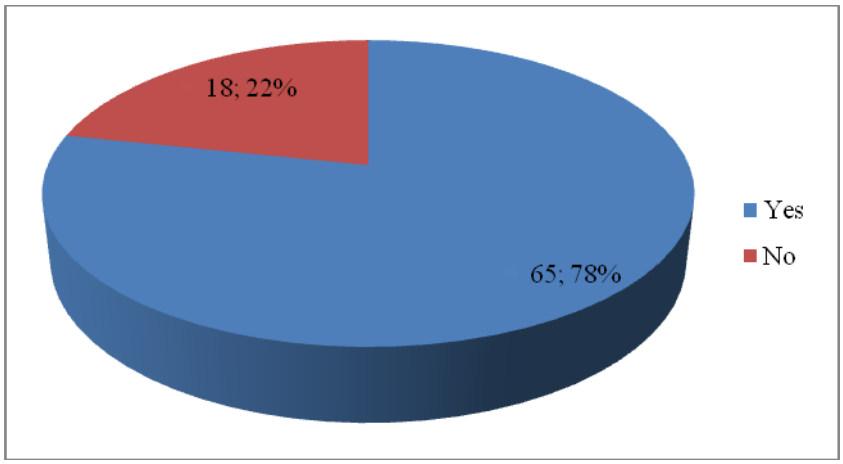

Figure 4.4*: Pie chart depicting the number and percentage of participants currently screening and diagnosing CAPD.*

4.2 Specific factors

Respondents were asked whether they were diagnosing CAPD, and 78% (n = 65 of the 83 who answered the question) indicated they did. Respondents who answered yes were then asked what specific factors (i.e., case history and age) determined the test battery protocol they used to diagnose CAPD. The types of test batteries that respondents rated are depicted in Table 4.1. Table 4.1 shows that most respondents (51%) never used preset CAPD battery for all patients regardless of age or case history. Table 4.1 shows that independent of case history, 34% of respondents never used a unique CAPD battery for each distinct age range (e.g., all children over the age of 10. It can also be seen that most respondents (40%) used the test battery entirely based on case history considerations and age. As a result, most respondents had a predetermined minimum battery that could be adjusted based on each patient's age and medical history.

Table 4.1

Distribution of professionals who rated how often their test batteries were based on specific factors.

	Always		Often		Sometimes		Never	
	n	%	n	%	n	%	n	%
Preset (C)APD battery for all patients regardless of age or Case history	4	6	15	23	13	20	**33**	**51**
Separate (C)APD battery for each specific age range (e.g., all children aged above 10-year-old) regardless of case history.	14	21	14	22	15	23	**22**	**34**
Battery customized based on case history considerations and age	**26**	**40**	15	23	14	22	10	15

4.3 Screening protocol used across India

The screening protocol used across various clinics in India was also probed upon. It was noted that most professionals used screening questionnaires and tests to screen CAPD. Figure 4.5 shows that 55% of professionals used the SCAP questionnaire to screen CAPD, and 20% used SCAP often. Thus, most respondents (75%) used SCAP as a regular screening tool.

Further, Figure 4.6 shows the data on screening tests used by the professionals for screening CAPD. It can be noted from the Figure 4.6that 51 % of professionals used STAP always, and 19 % of them used it often. Thus, most respondents (70%) used STAP as a regular screening tool.

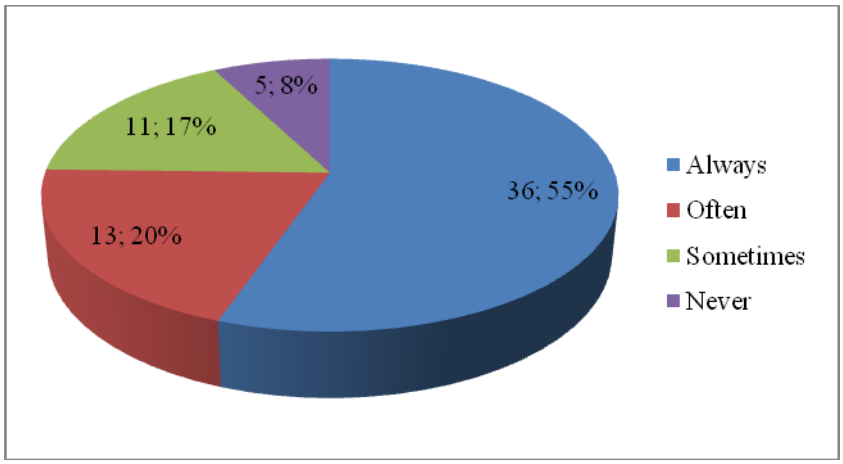

Figure 4.5: *Pie chart depicting the number and percentage of participants using SCAP as a screening questionnaire.*

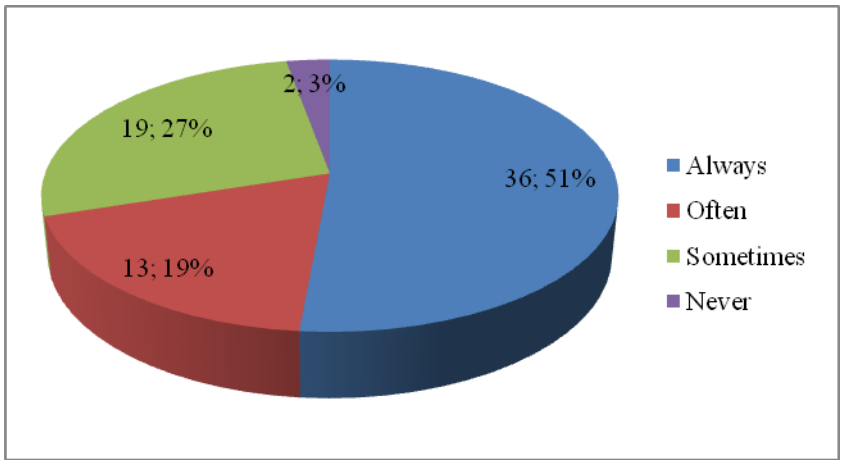

Figure 4.6: *Pie chart depicting the number and percentage of participants using STAP as a screening tool.*

4.4 Diagnostic test battery protocol used across India

The questionnaire had a section to probe the diagnosis protocol used across various clinics in India. The professionals were asked to rate the tests they use for specific assessments of dichotic listening, auditory closure, temporal processing, binaural interaction, working memory, and electrophysiology. Table 4.2 shows the results of the

various tests professionals use for diagnosing CAPD across India. It can be noted from Table 4.2 that the most often used tests under dichotic listening were the DCVT (54%) and DDT (74%). SPIN (70%) was the most used test under monaural low-redundancy speech tests. The professionals often used PPT (86%) and GDT (88%) to assess temporal processing. Also, BFT (61%) and MLD (89%) were the most often used test by professionals for the diagnosis of binaural interaction deficits.

The results also showed that the professionals used the repetition of the words (88%) and digit span test (75%) most often to assess working memory. Among the electrophysiological tests to diagnose CAPD, ABR was the only test reported to be used "Always." Figure 4.7depicts the percentage of professionals who selected each CAPD test from maximum to minimum usage. From Figure 4.7, it can be noted that the MLD is the most used test, followed by GDT and SPIN. It can also be noted that SSW is the least used test for the diagnosis of CAPD.

Table 4.2

The number and percentage of participants utilizing various CAPD tests in the diagnostic test battery.

	TEST	Always		Often		Sometimes		Never	
		n	%	n	%	n	%	n	%
Dichotic test	**DCVT**	**28**	**43**	7	11	19	29	11	17
	DDT	**33**	**51**	**15**	**23**	13	20	4	6
	DWT	9	11	28	36	**38**	**48**	4	5
	DST	8	12	4	6	24	38	**28**	**44**
	DRT	6	9	2	3	19	29	**38**	**59**
	SSW	1	2	2	3	19	29	**43**	**66**
	SSI-CCM	3	5	6	9	19	29	**37**	**57**
	CST	3	4	5	8	20	31	**37**	**57**
Monaural low-redundancy speech tests	HPF SP T	1	2	9	14	18	28	**37**	**57**
	LPF SP T	1	2	8	12	22	34	**34**	**54**
	SSI-CCM	2	3	4	6	21	32	**38**	**59**
	SPIN	**36**	**55**	**16**	**25**	9	14	4	6
	TCST	3	5	11	17	**28**	**49**	**23**	**41**
Temporal processing tests	**PPT**	**36**	**55**	**20**	**31**	6	9	3	5
	DPT	10	15	**24**	**37**	**28**	**43**	3	5
	RGDT	3	4	8	12	17	24	**42**	**60**
	GIN	16	25	10	15	**24**	**37**	15	23
	TMTF	3	5	4	6	**39**	**60**	19	29
	TIT	1	2	3	5	23	35	**38**	**58**
	GDT	**36**	**55**	**22**	**33**	4	6	3	5
Binaural interaction tests	RASP	3	4	3	5	16	25	**43**	**66**
	BFT	**19**	**29**	**21**	**32**	20	31	5	8
	MLD	**43**	**66**	15	23	4	6	3	5
Working Memory tests	R of NW	2	3	6	9	20	31	**37**	**57**
	R of W	**39**	**60**	18	28	5	8	3	4
	D Span T	**32**	**49**	17	26	8	12	8	13
Electrophysiology tests	**ABR**	**28**	**32**	**26**	**29**	9	10	26	29
	MLR	5	8	8	12	**32**	**49**	20	31
	BioMARK	2	3	10	16	**32**	**49**	21	32
	LLR	3	5	9	14	26	40	**27**	**41**
	ABR-BIC	2	3	3	5	21	32	**39**	**60**
	P300	2	3	9	14	**33**	**51**	21	32
	MMN	0	0	13	20	13	20	**39**	**60**

Note. Boldface denotes the test rating that appears the most frequently. DCVT = dichotic consonant vowel test; DDT = dichotic digits test; DWT= dichotic word test; DST= dichotic sentence test; DRT= dichotic rhyme test; SSW = staggered spondaic word test;

SSI-CCM = synthetic sentence identification (SSI) with contralateral competing message test; CST = competing sentences test; HPFS = high pass filtered speech test; LPFS = low-pass filtered speech test; SSI-ICM = SSI with ipsi-lateral competing message test; SPIN = speech-in-noise test; TCST= time-compressed speech test; PPT = pitch pattern test; DPT = duration pattern test; RGDT= random gap detection Test; GIN = gaps-in-noise; TMTF= temporal modulation transfer function; TIT= temporal integration test; GDT= gap detection test; RASP = rapidly alternating speech perception; BFT = binaural fusion test; MLD = masking level difference; RNSW repetition of non-sense words; RW= repetition of words; DSPT= digit span test; ABR = auditory brainstem response; MLR = mid-latency response; ABR-BIC= ABR- binaural interaction component; LLR= late latency response; MMN= miss-match negativity; P300= positive 300 cortical evoked potentials.

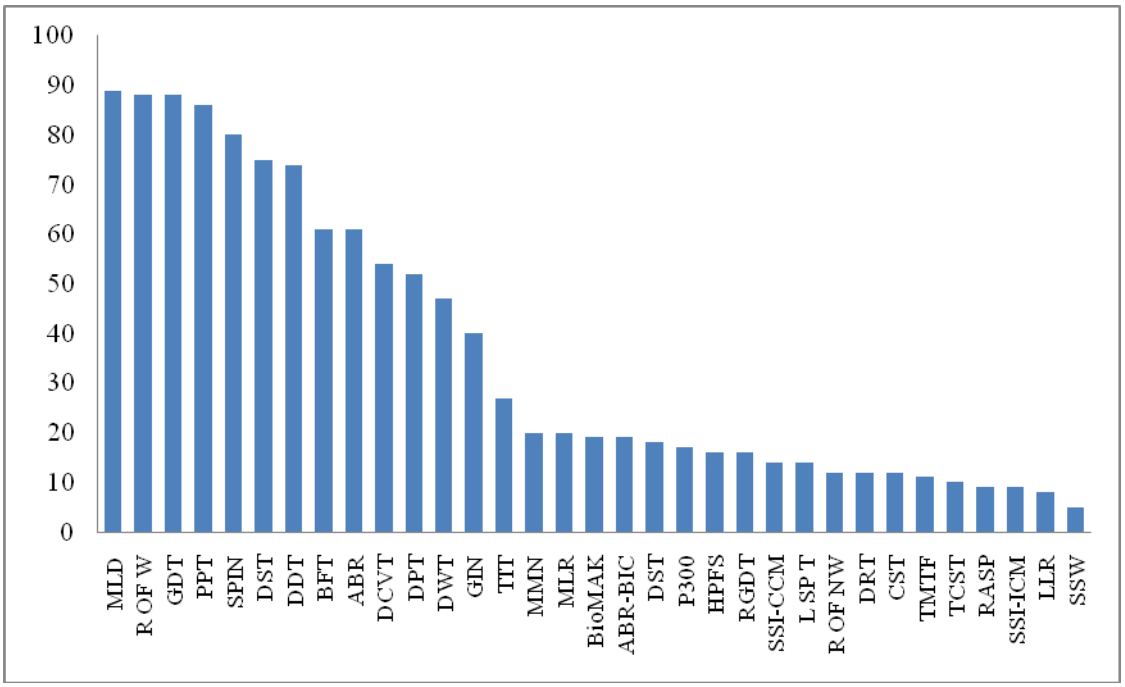

Figure 4.7 *Bar graph depicting the percentage of participants selected for each CAPD test. The X-axis shows CAPD tests, and Y-axis shows the number of participants.*

Chapter 5

Discussion

The current study aimed to determine the criteria used for screening and diagnosing cases with central auditory processing disorders (CAPD) across India. The questionnaire was developed for this purpose. The developed questionnaire consisted of 23 questions and responses from 83 participants working in the field of speech and hearing responded across the country. Qualitative data analysis was carried out using descriptive statistics, and the criteria for screening and diagnosing cases with CAPD were determined. The results of the study are discussed below:

- **Demographic details and background information**
- **Specific factors in deciding the test battery for the diagnosis of CAPD**
- **Screening protocol used across India**
- **Diagnosis test battery protocol used across India**

5.1 Demographic details and background information

The current survey results show that most professionals (57%) possess a post-graduate degree as their highest educational qualification. Similarly, in Chermak et al.(2007) survey, most participants were also post-graduate, and most carried out CAPD assessments frequently. In the current study, most professionals had experience in the field of CAPD (73%), demonstrating that coursework and professional education have

improved in this field of practice during the decade. Significant flaws do, however, still exist, particularly in clinical training.

In the present study, most respondents were employed in academic institutions, followed by a hospital setup and a few in private practices. It is understood that India is a vast country; there are few educational/ academic institutions, i.e. present in the urban area. In contrast, most patients with CAPD come from rural areas and mostly consult private clinics. Where often CAPD facility is unavailable or less popular, professionals don't carry out the assessment frequently.

5.2 Specific factors in deciding the test battery for the diagnosis of CAPD

Most respondents used a test battery technique while conducting CAPD testing (78 %). Most respondents also stated that they "always" or "often" utilize a standard minimum battery for all patients and add batteries based on age and specific case histories. As a result, they have a core set of tests that they administer to each patient while retaining the adaptability required to personalize the assessment for the patient, a recommendation made in the most recent guidelines by both ASHA (2005) and AAA (2010). Most of the time, the CAPD test battery is chosen based on clinical experience and/or a literature review, indicating that audiologists use best practices and good medical judgment (Emanuel et al., 2011). Similarly, Emanuel et al. (2011) survey results stated that audiologists do not rely on a suggested test battery; most prefer their test battery based on various sources, including clinical experience, CAPD seminars, and a literature review. Based on the current survey, audiologists also had a set minimum battery that was quite flexible based on the individual patient's case history and age.

5.3 Screening protocol used across India

The current survey results showed that the SCAP questionnaire (75%) (Yathiraj & Mascarenhas, 2003) was one of the most popular screening tests used across clinics in India. The questions in SCAP assess auditory perceptual processing, auditory memory, and other miscellaneous symptoms. Yathiraj & Maggu (2013) showed that 12.3% of children were at-risk for CAPD on the SCAP. Muthuselvi and Yathiraj (2009) checked the sensitivity and specificity of SCAP in school-going children, and they found that SCAP had 71% sensitivity and 68% specificity. The use of questionnaires by audiologists for screening, diagnosis, or intervention is still not fully understood. However, professionals may use them in conjunction with the case history to create a battery of feasible tests under the new recommendations for that person. Clinical practice guidelines published by the AAA in 2010 suggest that screening questionnaires "typically have low specificity, tend to over-refer, and have not been validated". Future studies should look into how audiologists give questionnaires to CAPD patients.

The current survey found that STAP (60%) was one of the most popular screening CAPD tests used across clinics in India. STAP is the only screening tool available in the Indian scenario. STAP was created by combining three components, speech perception in noise and auditory memory combined, to form a single component. In comparison, dichotic CV and gap detection created two separate components. Thus, STAP can identify three distinct auditory processing components(Yathiraj & Maggu, 2012). The diagnostic tests for CAPD and the STAP subsections also showed a strong and substantial association (Yathiraj & Maggu, 2014). The STAP's sensitivity and specificity were reported to be 76.6 % and 72 % compared to diagnostic tests (Yathiraj &

Maggu, 2014). It was reported that the sensitivity and specificity of the screening could be increased when SCAP and STAP are combined(Yathiraj & Maggu, 2014).

Lessler (1972) emphasized that a screening procedure is helpful if it is economical in terms of time. The total time taken by STAP was only 12 minutes, as Yathiraj and Maggu (2012) found. Compared to screening tests like the SCAN, which takes 20 minutes (Lampe, 2011), and MAPA, which takes 30 minutes, the STAP's feature gives it an advantage (Domitz & Schow, 2000). However, it is advised that a test for peripheral hearing issues be done in addition to performing the STAP.

5.4 Diagnosis test battery protocol used across India

The current survey showed that among the diagnostic tests, dichotic, monaural low-redundancy, and temporal processing tests were the most frequently used test types. Across all categories, the most popular tests were the MLD, RW, GDT, PPT, SPIN, DST, DDT, BFT, ABR, DCVT, and DPT, as shown in Fig. 4.7. Table 5.1compares the results of the current study with the two previous surveys (Emanuel et al., 2011; Chermak et al., 2007). For each CAPD category, the figures in bold indicate the most common tests utilized by at least 50% of the study participants.

Table 5.1 shows that the current study's highest ranked tests were among the highest for the two prior surveys. The most ranked were the DDT (74%), the MLD (89%), the PPT (86%), the SPIN (88%), the GDT (88%), the RW (88%), and DPT (75%). The MLD was the highest ranked test (89%) in the current study. However, this test was only used by 20% and 12% of the respondents in the Emanuel et al.(2011) and Chermak et al. (2007) studies. GDT was the highest ranked test in the present study;

however, GDT was not included in Emanuel et al. (2011) and Chermak et al. (2007) studies. The SPIN test was used by 77% of respondents in the Emanuel et al. (2011) survey, and the SPIN test was not included in the study of Chermak et al. (2007).

The DST, the DRT, the SSI-ICM, the CST, the HPFS, the LPFS, the SSI-ICM, the TCST test, the RGDT, the GIN, the TMTF, the TIT test, and SSW tests were the lowest rated tests in the current study. These tests were also lower-rated in the Chermak et al. (2007) study. Whereas CST (59%), SSW (80%), LPFS (50%), and RGDT (48%) were highly rated tests in the survey of Emanuel et al. (2011). In the binaural interaction tests, the RASP test was the lowest-rated test in the current study and the study of Emanuel et al. (2011) and Chermak et al.(1998).

The working memory (WM) tests were not used in previous surveys (Emanuel et al., 2011; Chermak et al., 2007). In the present survey, the repetition of words (88%) and the digit span test (75%) were highly rated tests, whereas the repetition of a nonsense word (12%) was the least rated test in this category. The working memory section was added in the present survey as studies have shown evidence for the association between WM/attention and auditory processing test performance (Baddeley & Hitch, 1974) and CAPD (Buffalo model provided by Katz 1992; Magimairaj & Nagaraj, 2018). So it's more likely that CAPD patients may also have working memory deficits. Thus, WM should be accounted for during assessment and intervention for auditory processing difficulties.

Table 5.1

Comparison of diagnostic tests survey results of the current study with other survey results

	TEST	Current Study (Always & Often)	Emanuel (2011)	Chermak et al. (2007)
		%	%	%
Dichotic test	DCVT	**54**	8	0
	DDT	**74**	**65**	**12**
	DWT	47	-	-
	DST	18	-	-
	DRT	12	7	0
	SSW	5	**80**	**12**
	SSI-CCM	14	17	-
	CST	12	**59**	**12**
Monaural low-redundancy speech tests	HPFS	16	14	0
	LPFS	14	**50**	**12**
	SSI-ICM	9	17	0
	SPIN	**80**	**77**	-
	TCST	10	30	0
Temporal processing tests	PPT	**86**	**82**	**12**
	DPT	**52**	40	6
	RGDT	16	48	6
	GIN	40	16	0
	TMTF	11	-	-
	TIT	27	-	-
	GDT	**88**	-	-
Binaural interaction tests	RASP	9	30	6
	BFT	**61**	28	6
	MLD	**89**	20	0
Working Memory tests	RNSW	12	-	-
	RW	**88**	-	-
	DSPT	**75**	-	-
Electrophysiology tests	ABR	**61**	15	0
	MLR	20	5	0
	BioMARK	19	-	-
	ABR-BIC	19	-	-
	LLR	8		
	P300	17	5	
	MMN	20		0

Table 5.1 also compares results related to the usage of electrophysiological tests in the current study with the other two surveys. In the present study, ABR was most often used to assess CAPD (61%), which correlated with the Chermak et al. (1998) survey. In this survey, the importance of physiological measurements was particularly noticeable, with the acoustic reflex, auditory brainstem response, and SCAN being the three most often utilized evaluation tests and procedures. The author reported that 59% of their participants used ABR testing. Although it was unclear from their survey and current survey that ABR was used for CAPD assessment or other purposes. The exception to this study was Emanuel et al.(2011), who reported only a few participants (30% or fewer) used any auditory electrophysiological measures as part of their CAPD assessment. We can infer that the CAPD test batteries include behavioral and electrophysiological measurements.

In an Indian study, Yathiraj and Vanaja (2018) stated that for children aged seven and older, the test battery for CAPD should include the SPIN-IE (Speech perception in noise in Indian English), DCV (Dichotic CV test), DPT (Duration pattern test) and RAMST (Revised auditory memory and sequencing test in Indian English). In the present survey, it can be noted that most clinics utilized these tests. Hence, a standardized CAPD battery should be recommended to include screening and diagnostic tests. Screening tests may include SCAP and STAP. Diagnostic tests which may be included are SPIN (auditory closure), DVCT and DDT (binaural integration), GDT and DPT (temporal processing), MLD (binaural interaction), and repetition of words (RW) and digit span test (DST) for working memory.

Finally, according to Table 5.1, several tests in each popular CAPD test category are only occasionally taken, as seen by responder rates ranging from 5% to 40%. Both the results of the current study and the preceding survey studies follow this pattern. The following are some potential explanations for why these tests are not widely used:

1. Since many of these tests come in numerous versions, clinicians ordering them from different manufacturers frequently lack information on the correct normative data for each version.

2. Some audiologists and clinics produce normative data, which may or may not be in line with reliable psychometric principles.

3. The clinician frequently lacks information about the methods used to construct the stimuli, the populations sampled to develop the norms, and the size of these samples. The clinician may become confused due to these practices about adequately using and interpreting the test results.

4. The test needs to be developed and validated in India for each language and dialect.

Chapter 6

Summary and Conclusions

The current study aimed to determine the protocol used for screening and diagnosing cases with central auditory processing disorders (CAPD) across various clinics in India. A cross-sectional questionnaire-based survey design was used in the present study. The study was conducted in three stages: the development and validation of the questionnaire, the administration of the developed questionnaire, and the analyses. The newly developed questionnaire consisted of 23 questions under four subsections: demographic details and background information, specific factors to decide the test battery, screening protocol, and diagnosis test battery protocol. Responses were obtained from 83 participants from all over India. The qualitative data analysis was conducted, and the criteria used for screening and diagnosing were determined.

The results of the current study showed that:

- A total of 78% of respondents were involved in CAPD evaluation.
- The majority of respondents (63 %) had a predetermined minimum battery that was relatively adaptable depending on the case history and age of the particular patient.
- Most respondents used a screening questionnaire SCAP (75%), and the screening test STAP (60%)
- The most used diagnostic CAPD tests in the battery were masking level difference (MLD) and binaural fusion test (BFT) for binaural interaction;

gap detection test (GDT) for temporal resolution, pitch pattern test (PPT), and duration pattern test (DPT) for temporal ordering; speech perception in noise (SPIN) for binaural separation, dichotic digit test (DDT) and dichotic CV test (DCVT) for binaural integration; repetition of words (RW) and digit span test (DST) for working memory; auditory brainstem response (ABR) to check brainstem lesion.

Implications of the Study

- The present study's findings help create awareness among audiologists about different screening and diagnostic tests used across India.
- The findings provide details to the audiologist about the most efficient tests included in the test battery for primary CAPD assessment.

Future Directions

- It is possible to undertake a similar study with more participants.
- A survey on the management of CAPD used across clinics in India can be done in the future.
- It is possible to conduct a similar study among active professionals in different fields.
- A comparable study can be carried out among other CAPD practitioners in the workforce.

Limitations of the Study

- The study's sample size could have been expanded.

Chapter 7

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Appendix 1

A Survey on the Screening and Diagnostic criteria of Central Auditory Processing Disorder in India.

Dear Sir/ Madam,

I'm Sandeep Kumar, II M.Sc. (Audiology), from All India Institute of Speech and Hearing, Mysore. As part of my dissertation, I'm conducting "A Survey on the Screening, Diagnostic and Management criteria of Auditory Processing Disorder in India" under the guidance of Dr. Chandni Jain, Associate Professor in Audiology, AIISH Mysore. Participants: Practicing audiologists & graduates who have experience in screening and diagnostic of central auditory processing disorder (CAPD) are requested to participate. The survey aims to know the different criteria used for the screening and diagnosis of APD across India. This questionnaire has a total of 15 questions and a few sub-sections in it, and it will take 5-10 minutes to complete the survey.

We will be very grateful if you could complete the following questionnaire. Your participation is voluntary, and all the data you provide will be utilised for research purposes only and will be kept confidential and anonymous.

Thank you for your valuable time!!

Thank you!!

I agree that my participation in this survey is voluntary, and I am aware

that my participation does not fetch me any direct benefit.

i) Yes
ii) No

I. DEMOGRAPHIC DETAILS & BACKGROUNDINFORMATION

1. Name:
2. Email address

3. What is the highest degree you currently hold in the field of audiology?

- Undergraduate
- Postgraduate
- Ph.D

4. How many years of practice do you have in the field of audiology?

- Less than 2 years
- 3 to 5 years
- 6 to 10 years
- More than 10 years

5. The type of setup in which you are currently employed?

- Private Practice
- Hospital
- Academic institution
- Ear, Nose, and Throat Clinic
- Cochlear Implant Company
- Other (Specify)

6. Do you currently Screen and diagnose CAPD at your facility?

- Yes
- No

II. SPECIFIC FACTORS FOR CONSIDERING DIAGNOSTIC TEST BATTERY.

1. If yes, how often do you use the test battery approach to diagnose?

Factor	Always	Often	Sometimes	Never	Remarks
Preset (C)APD battery for all patients regardless of age or Case history.					
Separate (C)APD battery for each specific age range (e.g., all children above 10-year-old) regardless of case history.					
Battery customized based on case history considerations					

III. SCREENING PROTOCOLS

1. How frequently do you utilize the screening questionnaire and screening test in your screening protocol for CAPD?

Screening questionnaire	Always	Often	Sometimes	Never	Remarks
Screening checklist for auditory processing (SCAP)					
Other (Specify)					
Screening tests					
Screening Test for Auditory Processing (STAP)					
Other (Specify)					

IV. DIAGNOSTIC PROTOCOLS

1. Which of the following do you utilize in your diagnostic test battery protocol for CAPD?

Diagnostic Tests	Always	Often	Sometimes	Never	Remarks
Dichotic tests • Dichotic CV test • Dichotic digits test (DD) • Dichotic Word Test • Dichotic sentence test • Dichotic Rhyme Test (DRT) • Staggered Spondaic Word test (SSW) • Synthetic Sentence Identification with Contralateral Competing Message test (SSI-CCM) • Competing Sentences Test (CST) • Other (Specify)					
Monaural low-redundancy speech tests • High pass filtered speech test • Low pass filtered speech test • Synthetic Sentence Identification with Ipsilateral Competing Message test(SSI-ICM) • Speech-In-Noise test (SIN) • Time compressed speech test • Other (Specify)					
Temporal processing tests • Pitch pattern test (PPT) • Duration pattern test (DPT)					

- Gap Detection Test (GDT)
- Gaps-In-Noise test (GIN)
- Temporal modulation transfer function test
- Temporal integration test
- Other (Specify)

Binaural interaction tests

- Rapidly alternating speech perception (RASP)
- Binaural fusion test (BFT)
- Masking level difference (MLD)
- Other (Specify)

Working Memory tests

- Nonverbal intelligence test (NVIQ)
- Repetition of nonsense words
- Digit span test
- Test of word reading efficiency
- Other (Specify)

Electrophysiology tests

- Auditory brainstem response (ABR)
- Middle latency response (MLR)
- Cortical evoked potentials
- BioMARK
- Binaural component of ABR-Clicks & Speech
- Late Latency response (LLR)
- Mismatch negativity (MMN)
- P300
- Other (Specify)