



A Survey on Screening and Diagnostic Criteria of Auditory Processing Disorders in India

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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.

Keywords Central auditory processing · Central auditory processing disorder · CAPD test battery

Introduction

A defect in the perceptual (i.e., neural) processing of acoustic information and the neurobiological activity that causes that processing is referred to as central auditory processing disorder (CAPD) [3]. The central nervous system's (CNS) capacity to process auditory data is called 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 impair listening, spoken language comprehension, and learning of an individual [5] (American Speech and Hearing Association, ASHA [2]). CAPD regularly coexists with issues with comparable traits, including attention deficit disorder, learning disabilities, speech and language problems, and poor listening abilities [12].

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 [11, 17]. The diagnosis of CAPD is only confirmed when the individual has speech perception difficulties seen even with normal peripheral hearing and deficits in one or several central auditory processing skill areas [3].

To correctly identify school-going children who exhibit auditory processing problems and 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 to detect specific auditory processing problems is required in individuals with CAPD. Numerous studies have noted deficiency in one or more auditory processes in individuals with CAPD [13, 18–20]. A test battery method is best than any single test to diagnose CAPD, and there are versions concerning the selection of tests to be integrated into a test battery [3, 27]. Still, there is no gold standard for the selection of tests to be included in a test battery for

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CAPD [27]. The Bruton Conference 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) [12].

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 closure [13, 19], binaural integration [13, 19] and temporal processing [18, 19]. In addition, auditory memory is often affected in children “at risk” for CAPD [19, 22, 23].

The lack of normative data on several of the most regularly used behavioral CAPD tests complicates the diagnosis of CAPD [9]. 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 [2] 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. Hence, there is a need to determine the different criteria used to diagnose CAPD in

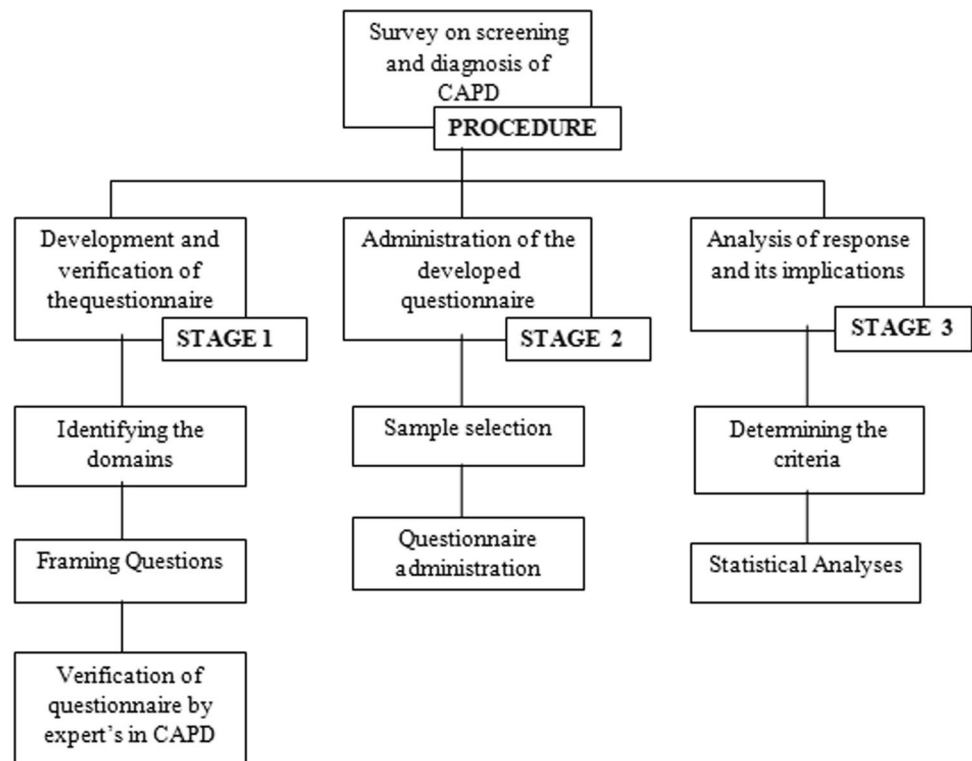
India, as minimal literature suggests tests to be included in primary CAPD diagnosis.

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 [26]. 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.

Methods

The current study determined India’s screening and diagnostic protocol used for CAPD. A cross-sectional questionnaire-based survey design was used in the present study. The study adhered to the institutional ethical guidelines. The study was planned in three stages (Fig. 1):

Fig. 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 [7, 10]. 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. Table 1 provides the details of the number of questions under each domain in the final questionnaire.

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.

Results

The current study aimed to determine the protocol used for screening and diagnosing cases with CAPD in India. A total of 83 responses were received online (G-mail, WhatsApp). 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.

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 2 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 3 provides the details of professionals' experience in practicing CAPD; the majority had an experience of < 2 years (34%). Figure 4 illustrates the type of setup the professionals are currently employed and practicing. The data showed that most professionals were employed in academic institutions (46%). For the question: "Do you

Table 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

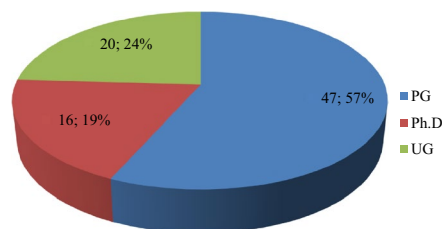


Fig. 2 Pie chart depicting the number and percentage of participants with various academic qualifications

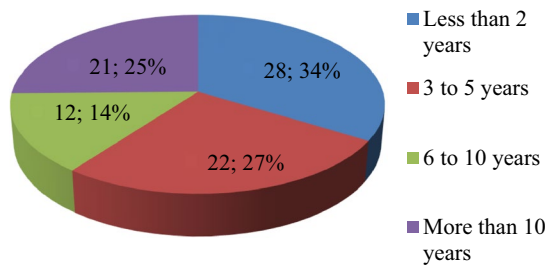


Fig. 3 Pie chart depicting the number and percentage of participants with different years of experience in practicing audiology

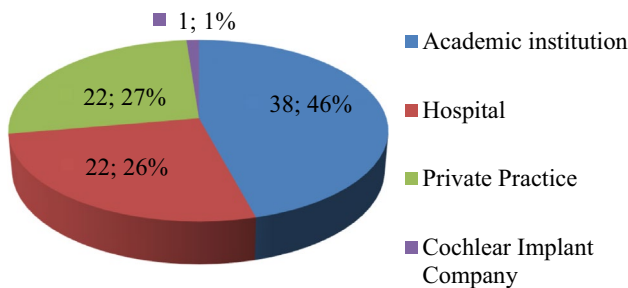


Fig. 4 Pie chart depicting the number and percentage of type of setup in which the participants were currently working

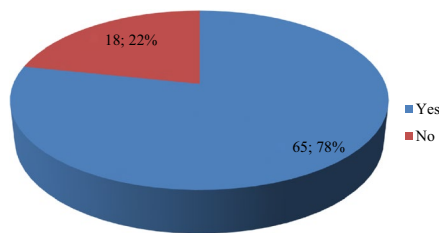


Fig. 5 Pie chart depicting the number and percentage of participants currently screening and diagnosing CAPD

currently screen and diagnose CAPD at your facility?”, Sixty-five professionals (78%) out of 83 said: “Yes” (Fig. 5 depicts the percentage of professionals currently screening and diagnosing CAPD).

Specific Factors

Respondents were asked whether they were diagnosing CAPD, and 78% 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 2. Table 2 shows that most respondents (51%) never used preset CAPD batteries for all patients, regardless of age or case history. Table 2 also 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 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.

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 for CAPD. Figure 6 shows that 55% of professionals used the screening checklist for auditory processing (SCAP) questionnaire to screen CAPD, and 20% used SCAP often. Thus, most respondents (75%) used SCAP as a regular screening tool.

Further, Fig. 7 shows the data on screening tests used by the professions for screening CAPD. It can be noted from Fig. 7 that 51% of professionals used screening test for auditory processing (STAP) always, and 19% of them used it often. Thus, most respondents (70%) used STAP as a regular screening tool.

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,

Table 2 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

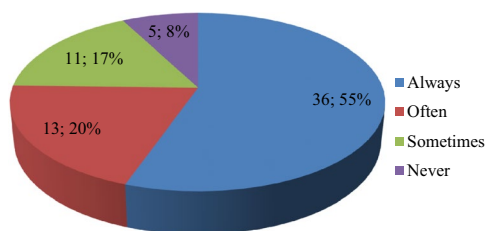


Fig. 6 Pie chart depicting the number and percentage of participants using SCAP as a screening questionnaire

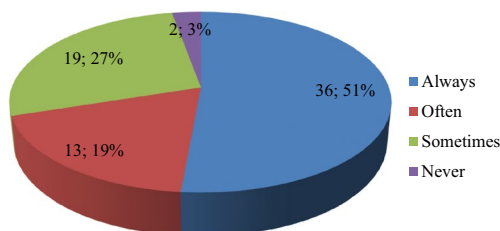


Fig. 7 Pie chart depicting the number and percentage of participants using STAP as a screening tool

binaural interaction, working memory, and electrophysiology. Table 3 shows the results of the various tests professionals use for diagnosing CAPD across India. It can be noted from Table 3 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” Fig. 8 depicts the percentage of professionals who selected each CAPD test from maximum to minimum usage. From Fig. 8, 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.

Discussion

The current study aimed to determine the criteria used for screening and diagnosing cases with CAPD across India. The current survey results show that most professionals (57%) possess a post-graduate degree as their highest educational qualification. Similarly, in Chermak et al. [7] survey,

most participants were post-graduate, and most carried out CAPD assessments frequently. In the current study, most professionals had experience in CAPD screening and assessment (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 conduct the assessment frequently.

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 [3] and American Academy of Audiology, AAA [1]. The CAPD test battery is often chosen based on clinical experience and/or a literature review, indicating that audiologists use best practices and good medical judgment [10]. Similarly, Emanuel et al. [10] 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.

The current survey results showed that the SCAP questionnaire (75%) [25] 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 and Maggu [22, 23] showed that 12.3% of children were at-risk for CAPD on the SCAP. Muthuselvi and Yathiraj [19] 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 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.

Table 3 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

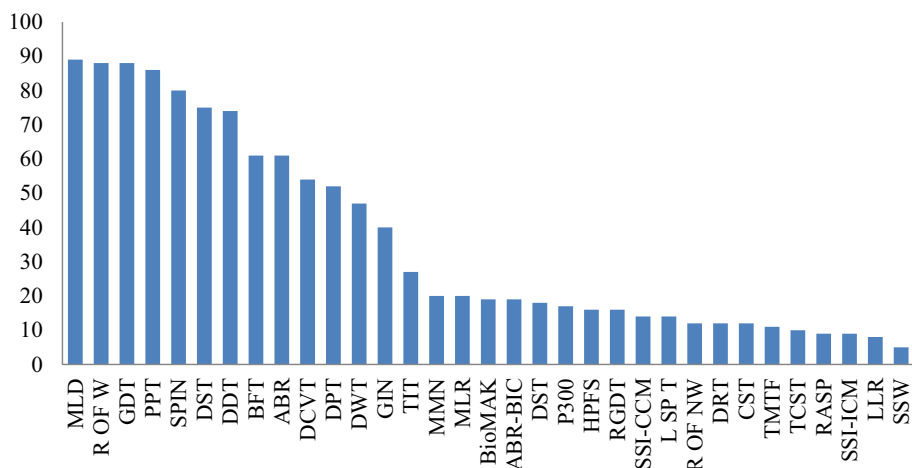
Bold face denotes the test rating that appears the most frequently

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, auditorybrainstem 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

The current survey found that STAP (60%) was one of the most popular screening CAPD tests used across clinics in India. As per authors knowledge, 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, 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 [21].The diagnostic tests for CAPD and the STAP subsections also showed a strong

Fig. 8 Bar graph depicting the percentage of participants using each CAPD test for diagnosis. The X-axis shows CAPD tests, and Y-axis shows the percentage of participants



and substantial association [24]. The STAP's sensitivity and specificity were reported to be 76.6% and 72% compared to diagnostic tests [24]. It was reported that the sensitivity and specificity of the screening could be increased when SCAP and STAP are combined [24].

Lessler [15] emphasized that a screening procedure is helpful if it is economical in terms of time. The total time required to perform STAP was reported to be around 12 min, [21]. Compared to screening tests like the SCAN, which takes 20 min [14], and MAPA, which takes 30 min, the STAP's feature gives it an advantage [8]. However, it is advised that a test for peripheral hearing issues be done in addition to performing the STAP.

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. 8. Table 4 compares the results of the current study with the two previous surveys [7, 10]. For each CAPD category, the figures in bold indicate the most common tests utilized by at least 50% of the study participants.

Table 4 shows that the current study's highest-ranked tests were among the highest for the two prior surveys also. The most ranked were the DDT (74%), the MLD (89%), the PPT (86%), the SPIN (88%), the GDT (88%), and the RW (88%). The MLD was the highest-ranked test (89%) in the current study. However, this test was only used by 20% of the respondents in the Emanuel [7, 10] study. GDT was also one of the highest-ranked test in the present study; however, GDT was not included in both the previous surveys [7, 10]. The SPIN test was used by 77% of respondents in the Emanuel [10] survey, and the SPIN test was not included in the study of Chermak et al. [7].

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. [7] study. Whereas CST (59%), SSW (80%), LPFS (50%), RGDT (48%) were highly rated tests in the survey of Emanuel [10]. In the binaural interaction tests, the RASP test was the lowest-rated test in the current study as well as in the previous two surveys [6, 10].

The working memory (WM) tests were not used in previous surveys [7, 10]. 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 [4] and CAPD (Buffalo model provided by Katz [13] Magimairaj and Nagaraj [16]. 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 4 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. [6] 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. [10], who reported that only a few participants (30% or fewer) used auditory electrophysiological measures as part of their CAPD assessment. We can infer that the CAPD test batteries majorly includes behavioral measurements.

In an Indian study, Yathiraj and Vanaja [27] stated that for children aged seven and older, the test battery for

Table 4 Comparison of diagnostic tests survey results of the current study with other survey results

	TEST	Current Study (Always & Often) %	Emanuel [10] %	Chermak et al. [7] Aggregated Rating
Dichotic test	DCVT	54	8	0
	DDT	74	65	10
	DWT	47	–	–
	DST	18	–	–
	DRT	12	7	0
	SSW	5	80	10
	SSI-CCM	14	17	–
	CST	12	59	12
Monaural low-redundancy speech tests	HPFS	16	14	0
	LPFS	14	50	8
	SSI-ICM	9	17	0
	SPIN	80	77	15
	TCST	22	30	0
Temporal processing tests	PPT	86	82	11
	DPT	52	40	9
	RGDT	16	48	6
	GIN	40	16	0
	TMTF	11	–	–
	TIT	7	–	–
	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	9
	MLR	20	5	8
	BioMARK	19	–	–
	ABR-BIC	19	–	–
	LLR	8	5	0
	P300	17		
	MMN	20		

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 to screen CAPD may include SCAP and STAP. Diagnostic tests to diagnose CAPD may include SPIN (auditory closure), DCVT 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.

Conclusion

To conclude, based on the present survey several tests in each popular CAPD test category are only occasionally taken, as seen by responder rates ranging from 5 to 40% (Table 4). 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 align with reliable psychometric principles.
3. The test needs to be developed and validated in India for each language and dialect.

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Author Contributions SK was involved in concept development, study design, questionnaire preparation, analysis of the results, interpretation, and manuscript writing; CJ was involved in concept development and study design, questionnaire preparation, and manuscript writing.

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Declarations

Conflict of interest There is no conflict of interest to disclose.

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