

## RESEARCH ARTICLE

# Estimation of the referral rate of suspected cases of central auditory processing disorders in children aged 8-12 years old in Oshnavieh, Western Iran, based on auditory processing domain questionnaire and speech in noise and dichotic digit tests

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## Abstract

**Background and Aim:** Studies have shown that central auditory processing disorder is a sensory processing deficit which has five percent prevalence among school-aged children that results in speech, language and learning problems in children. The aim of the current study was investigating the referral rate of children suspected to central auditory processing disorder (CAPD) by using auditory processing domain questionnaire (APDQ), speech in noise test, and dichotic digit test.

**Methods:** Three hundred and ninety six APDQ questionnaire was obtained from children's parents among five schools in Oshnaviyeh. The children with low APDQ score underwent speech in noise and dichotic digit test (DDT).

**Results:** The findings revealed that 37 children were suspected to CAPD based on APDQ. 35 of these participants in DDT and 24 of them in speech in noise test also indicated low scores, respectively. Moreover, results were unrelated to gender, however, age had a positive

correlation with the questionnaire scores.

**Conclusion:** Based on the findings, the APDQ can be used as a screening questionnaire for detecting CAPD.

**Keywords:** Central auditory processing disorder; auditory processing domain questionnaire; dichotic digit test; speech in noise test; children

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## Introduction

Central auditory processing disorder is referred to the conditions in which auditory information, in spite of fully healthy peripheral auditory system, are altered by injury in each level of neural pathways above the cochlear and can be defined as a deficiency in retrieving, transforming, analysing, organizing and storing the information from the audible acoustic signal [1].

Based on studies, central auditory processing disorder (CAPD) is a sensory processing impairment which is seen among about 5% of school children and causes the problems with

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discrimination, recognition and comprehension of auditory information. Since learning is often done through sense of hearing, disorder in this sense leads to learning, verbal, vocal and training problems among the children [2]. Symptoms of children with CAPD usually appear as they enter the school which includes numerous symptoms like problem with hearing the verbal message in noisy and resonant environment, problem with fast processing of speech, weakness in listening skill, excessive request for repeating the already said messages, wrong or delayed response to verbal commands [3]. Children with CAPD are often careless and get rapidly tired as they perform the long term or complicated intellectual activities [4]. Therefore, importance of diagnosis and early treatment of this disorder is underlined.

All existing questionnaires in the field of screening the central auditory processing disorder, except the auditory processing domains questionnaire (APDQ), only deal with the child's auditory behaviour and functioning and hence they likely result in wrong referrals [3,4]. From among the aforementioned questionnaires, APDQ is the only questionnaire in which language skills and attention are discussed in addition to the child's auditory behaviour [3].

APDQ is a standard questionnaire presented by Brain O'Hara in 2009 during the Annual Conference of American Speech-Language-Hearing Association (ASHA) with valid psychometric criteria. It includes 52 items which is completed by the child's parents or teacher [3].

Ahmadi et al. conducted this questionnaire to examine its validity and reliability on 260 normal children and 101 children with learning disorder of which the results indicate that APDQ has a high validity and reliability and is an appropriate tool for screening the auditory processing disorder [5].

To exactly assess the children, it is necessary to perform the screening process with a tool like questionnaire and those people suspected to this disorder are assessed with the help tests which can examine the neural pathways of auditory processing. Therefore, we need a test set after the screening stage so that we can examine

the whole neural pathway of central auditory processing. One test is not sufficiently sensitive to CAPD diagnosis [6,7]. Therefore, we intended to investigate the 8-12 age's children in Oshnavieh by using the APDQ and then assess those who were identified as the suspected persons to central auditory processing disorder based on the questionnaire results by speech in noise and dichotic digit testing.

## Methods

This study conducted in two phases. The first phase was to complete and examine the questionnaire and the second one was to perform the speech in noise (SIN) and dichotic digit test (DDT). The research population includes all 8-12 aged male and female students of Oshnavieh, western Iran, from among whom 385 were selected by using the minimum sample size formula. As required coordinated was made with the authorities of Western Azerbaijan Province Education Organization and schools' principals, 430 questionnaires were distributed randomly among the 8-12 aged students of Oshnavieh and the parents were requested to fill it after studying and signing the letter of consent. After two days, questionnaires were collected from the schools, then reviewed. Out of 430 questionnaires distributed among the schools, 396 ones were filled properly which included 195 male students (37 students with 8 years old, 37 with 9 years old, 46 with 10 years old, 37 with 11 years old, 38 with 12 years old) and 201 female students (38 with 8 years old, 37 with 9 years old, 47 with 10 years old, 41 with 11 years old, 38 with 12 years old). Results obtained for three auditory, language and attention indices were extracted from the questionnaires. 359 students were within the normal range in view of the achieved questionnaire scores and 37 students were in the suspected area to central auditory processing disorder.

Children suspected to CAPD were evaluated by SIN and DDT. It means that peripheral hearing was initially investigated; i.e. after otoscopy, pure tone audiometry (PTA), tympanometry and ensuring their healthy peripheral hearing, both tests were conducted.

**Table 1. Frequency distribution of normal and suspected individuals to central auditory processing disorder based on the hearing index of the auditory processing domain questionnaire by age and sex**

Age	Sex	The number of normal participants	The number of suspected participants
8	Girl	36	2
	Boy	35	2
9	Girl	32	5
	Boy	34	3
10	Girl	42	6
	Boy	40	6
11	Girl	37	4
	Boy	33	4
12	Girl	33	4
	Boy	37	1

Dichotic digit test included 20 pair digits which were presented simultaneously to both ears. Two first digits were presented simultaneously to both ears and then two second digits were presented again simultaneously to the ears and then the subject had to repeat four heard digits. Items were presented in 50 dBSL regarding the speech reception threshold (SRT) [8]. Responses for each person were recorded and scored, then compared with the test norm in Persian language (for 7 years old, the mean score of norm: right ear=92.33 (SD=3.14), left ear=86 (SD=3.05), for 8 years old, the mean score of norm: right ear=93.12 (SD=2.98), left ear=85.93 (SD=14.14), for 9 years old, the mean score of norm: right ear=95.64 (SD=2.38), left ear=89.85 (SD=3.12), for 10 years old, the mean score of norm: right ear=98.83 (SD=1.57), left ear=96.41 (SD=2.17), for 11 years old, the mean score of norm: right ear=99.75 (SD=1), left ear=98.16 (SD=2.17)) as well as the scores of APDQ [5]. Speech in noise included 50 one syllable words

of which 25 words were presented to the right ear and 25 to the left ear. Generally, white noise was used as the competing stimulus and both stimuli were presented simultaneously in one ear in 0 dB signal-to-noise ratio. The items were presented at 40 dBSL re: speech reception threshold. Test was conducted monaurally in which both noise and signal were presented into one ear [2]. The subject's task was to respond the target signal and ignore the noise. Before starting the test, three practice words were presented in each ear for making the child familiar with the test. Results were compared with the test norm in Persian language (for males 0.39 with SD=0.65 and for males 0.25 with SD=0.85) and scores of APDQ [5,2].

To describe the data, mean and standard deviation, to compare means, independent t test, and to determine the relationship between age and auditory index, Pearson correlation test were used, respectively.

## Results

Three hundred and ninety six questionnaires collected from the schools were reviewed revealing that out of this number, 359 students (179 males and 180 females) were within the normal range based on the auditory index of APDQ and 39 ones (18 males and 21 females) were in abnormal range. In Table 1, distribution of students' age frequency who were in normal range based on the auditory index of APDQ is separately given for age and gender included 201 females and 195 males in these categories: 75 students with 8 years old, 74 students with 9 years old, 94 students with 10 years old, 78 students with 11 years old and 75 students with 12 years old.

Results indicated that as the age raises, score of questionnaire auditory index is also increased (correlation coefficient=0.402 and  $p<0.001$ ). T-test results showed that this mean is not significantly different in normal group among the males and females ( $p>0.05$ ), but this difference was significant in the group suspected to CAPD ( $p=0.02$ ).

The mean scores of language and attention indices were compared in both male and female

**Table 2. Mean (standard deviation) of hearing, attention and language indices of the auditory processing domain questionnaire in normal and suspected participants in both sexes**

Index	Sex	The number of samples		Average score(SD)	
		Normal	Suspected	Normal	Suspected
Hearing	Girl	180	21	87.06 (5.16)	66.68 (5.48)
	Boy	179	16	85.82 (5.019)	67.66 (5.21)
Attention	Girl	180	21	82.85 (7.81)	63.14 (13.70)
	Boy	179	16	83.16 (7.80)	58.05 (9.34)
Language	Girl	180	21	76.96 (11.53)	64.29 (8.48)
	Boy	179	16	76.84 (9.28)	6.38 (12.23)

groups and it was specified that mean of such indices are not significantly different in both male and female groups ( $p>0.05$ ) (Tables 2,3). Thirty seven students suspected to CAPD based on the auditory index of questionnaire, were evaluated by SIN and DDT tests. Among them, 24 persons (64.9%) and 35 (94.6%) received the scores in SIN test and DDT lower than the normal limit (Table 4). In fact, 24 students evaluated by these two tests, received the scores lower than the normal limit in both tests.

### Discussion

In this study, from 396 students evaluated by the questionnaire, 357 students were normal and 39 were abnormal in terms of auditory processing index (normal limit of auditory index 79%-100%) [5], from the language index point of view, 387 and 9 students were normal and abnormal, respectively (normal limit of language index 65%-93%) [5], and from the attention point of view, 391 and 5 students were normal and abnormal, respectively, in terms of attention processing index (normal limit of attention index 72%-97%) [5].

In a similar study on investigating the amount of prevalence of CAPD in Arak, central Iran, out of 300 persons reviewed, 15 persons (5%) were suspected to central auditory processing disorder

[4]. In the present study, from among 396 persons, 39 ones (9.84%) are suspected to this disorder based on the questionnaire's scores.

The mean scores of three auditory, attention and language indices in both male and female groups between normal and abnormal participants were compared indicating that the difference in normal group is significant in terms of auditory index and there are no significant differences in other indices between sexes.

In this study, results show that as the age raises, the score of auditory index and total score of APDQ are increased which is similar to previous studies employing to APDQ [5,3].

On the basis of studies conducted by scholars, different percentages of prevalence of central auditory processing disorder were achieved. For example, in a study, prevalence of such disorder was found 2-3% in schooling students [9]. Some other studies have indicated that real value of this disorder as 7% [10]. In another study, the best approximation of CAPD percentage in schooling population was reported as 20% [11].

In our study, SIN and DDT were conducted on 37 student (two students gave up the collaboration) who were abnormal in terms of auditory index and based on its results, 24 persons (64.9%) and 35 persons (94.6%) obtained lower scores lower than the normal limit SIN and

**Table 3. Mean (standard deviation) of hearing, attention and language indices of the auditory processing domain questionnaire in normal and suspected participants in age groups and both sexes**

Age	Sex	N		Average hearing index(SD)		Average attention index(SD)		Average language index(SD)	
		Normal	Suspected	Normal	Suspected	Normal	Suspected	Normal	Suspected
8	Girl	36	2	81.56 (1.77)	56.60 (10.60)	82.82 (7.02)	33.75 (8.83)	76.35 (8.69)	51.25 (1.76)
	Boy	35	2	81.59 (2.40)	65.20 (5.37)	82.22 (7.34)	69.25 (4.59)	76.76 (8.86)	55.15 (17.04)
9	Girl	32	5	84.19 (4.80)	68.74 (2.50)	82.80 (7.80)	68.90 (2.92)	80.26 (7.16)	63.78 (6.93)
	Boy	34	3	83.13 (3.19)	66.36 (5.09)	84.90 (8.10)	52.80 (10.96)	77.02 (9.23)	62.76 (20.67)
10	Girl	42	6	86.47 (3.02)	68.10 (4.97)	82.60 (8.13)	67.86 (12.15)	76.16 (14.91)	67.16 (10.80)
	Boy	40	6	86.38 (5.59)	68.80 (4.91)	82.31 (7.87)	57.16 (9.10)	78.00 (10.42)	70.65 (10.23)
11	Girl	37	4	91.25 (3.18)	69.55 (1.76)	82.94 (8.01)	65.62 (5.90)	76.72 (14.93)	62.92 (7.24)
	Boy	33	4	88.59 (5.25)	70.30 (5.19)	82.84 (7.51)	59.75 (8.52)	77.00 (8.99)	65.57 (7.40)
12	Girl	33	4	91.89 (3.64)	64.15 (3.45)	83.13 (8.44)	61.10 (15.59)	75.69 (7.84)	68.52 (3.39)
	boy	37	1	89.20 (4.10)	59.10 (0.00)	84.38 (8.97)	50.00 (0.00)	75.37 (8.97)	51.25 (0.00)

DDT, respectively. Such results indicate the high consistency of APDQ scores and DDT results. Results of present research were compared with the studies developing the Persian versions of SIN [15] and DDT [12] and we used their normal values.

The mean scores of both tests in both male and female groups were compared indicating the differences were not significant ( $p < 0.05$ ).

Utilizing APDQ among the children with learning disorder have shown high validity (63%) and reliability (auditory index: 92%, language index: 88%, attention index: 86%) of the questionnaire. APDQ is considered as an appropriate tool for screening the auditory processing disorder [5] which is consistent with the present study.

In addition to identifying the problems with listening, APDQ can be used as a screening tool for diagnosing the children suspected with learning disorder, attention/hyperactivity disorder and auditory processing disorder. Regarding the overlapping behaviour existing in children with

CAPD with other neurological disorders like attention-deficit/hyperactivity disorder (ADHD) and learning disorder, CAPD screening is not sufficient without taking the attention control and language-cognitive factors into account and it is likely leading to inappropriate referrals of children. Due to investigating several aspects of attention and language skill, this questionnaire provide a more accurate and appropriate referrals for children suspected with auditory processing disorder [13]. For this reason, we used the APDQ for preventing the inappropriate referrals.

DDT has many advantages for assessing the central auditory processing including the high sensitivity, high resistance to high frequency hearing loss, and high reliability in test-retest among the people with CAPD in various ages. Another advantage of this test is familiarization of different age groups with digits [14]. For this reason, in the present study, DDT was used for evaluating the children for CAPD.

CAPD diagnosis is done based on the test

**Table 4. Frequency and percentage of normal and abnormal participants based on the results of the speech perception in noise and dichotic digit tests**

Ear	SIN		DDT	
	Normal	Abnormal	Normal	Abnormal
Right ear (n %)	24 (64.9)	13 (35.1)	33 (89.2)	4 (10.8)
Left ear (n %)	23 (62.2)	14 (37.8)	35 (94.6)	2 (5.4)

SIN; speech in noise, DDT; dichotic digit test

battery. Factor analysis made by Schow and Chermak in 1999 indicated that measuring two abilities of SIN and DDT is sufficient to diagnose auditory processing disorder (APD) [15]. For this purpose, in addition to questionnaire, we used two SIN and DDT tests.

In another descriptive study, psychometric properties of DDT were investigated. The research was conducted on 144 children ranging in 7–12 ages. Results showed that DDT is acceptable in terms of psychometric properties and has a high validity. In addition, it was indicated that as the age rises, scores of right and left are increased and the mean scores in both male and female groups are not significantly different. This study indicated that DDT has a high validity for clinical works and researches related to the central auditory system [16].

In a study, SIN was used for investigating the speech perception among the APD and healthy children [17]. In this test, sentences with high predictability and also the sentences with low predictability are used. SIN is able to investigate the auditory function and language function involved in the speech perception. Results showed that the ability to recognise the key words in sentences in presence of noise among the healthy children and children with APD is different and the latter has weaker performance than the former. In this study, speech perception of children suspected to CAPD was assessed by SIN scores test. Our results were consistent with that previous study.

### Conclusion

It can be concluded that in this study, APDQ

has a high efficiency for evaluating the children suspected to CAPD. Gender has no impact on the results, but as the age rises, the score of auditory processing index increases. It was also showed that results obtained from questionnaire are consistent with the results of both test of speech perception in noise and dichotic digit test.

Since there is not the Kurdish version of speech in noise test in Iran, we used the Persian version which is in accordance with the second language of children under study.

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### Conflict of interest

The authors declare that they have no conflict of interest.

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