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Teachers' opinions regarding the symptoms of central auditory processing disorder in children with reading and writing difficulties

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Central Auditory Processing Disorder (CAPD) refers to difficulties in perceptual processing of auditory information. It is a difficulty experienced by a person whose pure tone hearing, intelligence, and language abilities are within the appropriate age norms. In children with CAPD, difficulty in spelling and reading loudly can also be observed. Symptom scales (or questionnaires) are required to determine the presence of CAPD-like symptoms. If risks are found in the scales, the children are referred for diagnosis. The study reported on here aimed to investigate whether CAPD symptoms were underlying to reading and writing difficulty. Eight state schools were randomly selected. The questionnaire evaluating the presence of the CAPD symptoms was answered by 32 teachers for 328 children in total. While the children without reading and writing difficulty did not have CAPD indications, the probability of having CAPD was significantly higher in the children with reading and writing difficulties ($p < 0.001$). When gender effect was examined, a higher CAPD symptom score was found in males. As a result of the 18-item questionnaire, it was detected that children with CAPD symptoms had a significant disadvantage in reading and writing compared to children who did not have these symptoms. Children with CAPD symptoms should be referred for diagnosis if the CAPD indications are identified.

Keywords: central auditory processing disorder; initial reading and writing skills; reading and writing difficulties; reading and writing difficulty questionnaire

Introduction

Most information sent and received in classrooms, irrespective of the child's specific grade, is auditory, making central auditory processing skills critically important (Thomas & Mack, 2010). The concept of an auditory-specific processing disorder in children (CAPD) was first suggested by Helmer Myklebust almost 70 years ago. Myklebust, a psychologist, set up a clinic at the Northwestern University in Illinois, United States of America, to investigate children with hearing loss, and to help their parents. During the treatment sessions, it was realised that some of the children had normal audiograms, but that they had apparent hearing difficulties. The symptoms could not be attributed to peripheral hearing loss. In a controlled acoustic environment in the testing booth at the clinic, children heard faint sounds normally. However, they were unable to focus on particular sounds in the real acoustic world in which many sources of noise and competing speech existed.

Two important advances occurred in this research area in the past decade. Firstly, the researchers understood that the extra-auditory cognitive processes such as attention, influence the nature of the disorder, and that our diagnostics, tests and instruments had improved greatly. Secondly, many innovative treatment options had emerged (Musiek & Chermak, 2014).

It is believed that CAPD results from more general dysfunctions, such as neural timing deficit and attention deficit. Some of the dysfunctions include sound localisation and lateralisation, auditory discrimination, auditory pattern recognition, temporal resolution of audition, temporal masking of audition, temporal integration of audition, temporal ordering of audition, and auditory performance decrements with competing and degraded acoustic signals (Northern & Downs, 2002).

CAPD symptoms may include one or more of the following behaviour: inappropriate or inconsistent responses, misunderstanding the message, weak musical and singing skills, being easily distracted, having difficulty in localising sound, understanding competing messages while listening, understanding in reverberant environments, responding quickly in oral communication circumstances, comprehending and following speech, following commands or complex auditory directions, learning nursery rhymes or songs, paying attention, spelling and reading, and learning a new language (see American Speech-Language-Hearing Association, 2019).

Children with CAPD may complain about listening and related issues. They may experience difficulties in comprehending speech in noisy environments, following directions, and discriminating between similar-sounding speech sounds. They may behave as if they experience hearing loss, repeatedly asking for clarification (American Speech-Language-Hearing Association, 2014).

Reading literacy is one of the most crucial abilities for children as they progress in their early school years. Being a foundation for learning, literacy can be employed for recreation and self-improvement while integrating young children with their communities and societies better (Van Staden & Bosker, 2014).

In the reading process, a person forms meaning by transforming printed symbols, which are letters or visual characters, into recognisable words. This process consists of two components. The first is reading decoding, which is the ability to transform orthographic patterns of alphabetic letters into phonological patterns of a corresponding spoken word. The second component is word recognition, which is the ability to identify words when reading, either through word decoding or sight word identification (American Speech-Language-Hearing Association, 2018).

Spelling is a significant competence at all levels of written communication and a crucial skill for school-going children (Herold, Alant & Bornman, 2008). Bharuthram (2012) indicates a strong relationship between reading proficiency and academic success at all ages.

Children with CAPD may experience difficulty with skills such as spelling, reading, and understanding verbal information in classes. Children perform better when tasks are not based mainly on listening, and they can characteristically fulfil a task without help once they realise what they should do (see American Speech-Language-Hearing Association, 2014).

A multidisciplinary team approach is critical in assessing the status of the children with CAPD. The team should consist of the class teacher, a family member, the ear, nose and throat specialist, and an educational audiologist. To uncover teacher opinion (which is obviously important in evaluating children showing CAPD symptoms), an inventory could be used to ensure that the children are referred to the correct unit for diagnosis. An integrated collaborative management strategy is needed to yield the best results. Therefore, the purpose of this study was to evaluate teachers' opinions about the symptoms of central auditory processing disorder in children who experience difficulty in reading and writing – even though they had completed the first grade in primary school.

Method

In the study reported on here we used a quantitative descriptive survey design to answer the research question. As no reliable and valid Turkish instrument existed, a custom-designed questionnaire was developed.

Questionnaire Development

The questionnaire was first designed by researchers who obtained specialist opinions from three associate professors and two professors in the fields of child development, audiology and literacy, and included 20 items through which CAPD symptoms in children with reading and writing difficulty could be evaluated. The questionnaire was piloted with five schoolteachers who met the inclusion criteria of the main study (see the next subsection). Following the pilot study, 18 items were included in the final version of the questionnaire. Although they were related to reading comprehension skills, two items were excluded from the questionnaire as they were not related to CAPD symptoms. The questionnaire items (see Table 2) were divided into five subcategories, namely i) phonological awareness (questions 1–4), ii) reading (questions 5–6), iii) writing (questions 7–10), iv) speaking (questions 11–12) and listening (questions 13–17). Item 18 was included to determine from participant teachers whether the students with reading and writing difficulty achieved below the class average.

Participants were requested to score their responses in a binary manner by indicating "Yes" if they agreed with the statement, and "No" if they disagreed.

Teacher Selection and Consent

Inclusion criteria for teachers were at least ten years' teaching experience and having taught at least two primary school graduation cohorts. Of the 32 participating teachers, eight were between 30 and 35 years old with ten years' teaching experience (25%), 14 were between 45 and 50 years old with twenty years' teaching experience (43.75%), and 10 were between 51 and 59 years old with thirty years' teaching experience (31.25%). All the teacher participants held Bachelor of Arts (BA) degrees and were employed full time. The teachers were informed about the aim of the study and about the CAPD symptoms that could be observed in children with reading and writing difficulty.

The primary schools were selected randomly from the public schools affiliated to the Ministry of National Education in seven regions of Ankara (Çankaya, Keçiören, Yenimahalle, Mamak, Altındağ, Etimesgut, Sincan) during May-June 2017. This period was deliberately selected because the annual training period in the Turkish National Education system is completed in June; thus, the children are expected to have mastered the specific reading and writing skills by that time. Information about the study was given to the schools through a letter of informed consent from the Directorate of National Education of the Governorship of Ankara. Consent forms were also signed by the parents of all children who participated in the study.

Selection of the Children to be Included in the Study

In recruiting children for the study, teachers at the various schools provided information about the children from their school files. According to Turkish law, these files contain all information about potential disorders. Information about the children's achievement in a hearing screening test done during the first year of primary school, is also captured in the files. Four inclusion criteria were used, namely i) no hearing impairment (since central auditory processing functions could be assessed in

children with normal peripheral hearing) (Iliadou, Ptok, Grech, Pedersen, Brechmann, Deggouj, Kiese-Himmel, Śliwińska-Kowalska, Nickisch, Demanez, Veuillet, Thai-Van, Sirimanna, Callimachou, Santarelli, Kuske, Barajas, Hedjever, Konukseven, Veraguth, Stokkereit Mattson, Martins & Bamiou, 2017; Keith, Rudy, Donahue & Katbamna, 1989; Ludwig, Fuchs, Kruse, Uhlig, Kotz & Rübsamen, 2014); ii) no psychological-emotional disorders (since children with emotional problems might experience distractibility, and the results of the central auditory processing functions might not be reliable) (Iliadou et al., 2017); (iii) no physical/developmental disorders (since the central auditory processing test results might not be reliable in children with developmental delays) (Iliadou et al., 2017; Ludwig et al., 2014); and iv) no social problems (since communication difficulties cause listening and attention disorders, central auditory processing test results might not be reliable) (Iliadou et al., 2017; Keith et al., 1989).

The hearing screening is done by screening technicians in a silent location at schools, i.e. the library. Children with typical development in the 78–90 month range were included in this study.

A total of 328 children, 154 (47%) girls and 174 (53%) boys were included in the study. As shown in Table 1, the participant teachers defined 272 (82.9%) of the 328 children (137 (50.4%) girls and 135 (49.6%) boys) as a good performance group since they had learnt to read and write within the expected time. The remaining 56 children (17.1%) (17 (30.4%) girls and 39 (69.6%) boys) had presented reading and writing difficulty.

Table 1 Reading and writing difficulty and gender distributions of the participating children (n = 328)

Reading and writing difficulty	Frequency (n)	Percentage (%)	p-value
Reading and writing difficulty present	56	17.1	
Girls	17	30.4	
Boys	39	69.6	0.006
Reading and writing difficulty absent	272	82.9	
Girls	137	50.4	
Boys	135	49.6	

The data is displayed by number and percentage values. The Chi-square test was used to compare gender distributions of the children with or without reading and writing difficulty. There was a significant difference between the gender distributions of children with and without reading and writing difficulty ($p < 0.01$). For the children with reading and writing difficulty, a statistically significant difference was found between boys and girls. According to the results, the number of the boys was higher than the number of the girls. Based on the relevant literature, this could be explained in two ways. One is that gender differences influence phonemic awareness, which is significant in learning to read (Burt, Holm & Dodd, 1999). This accounts for the higher percentage of boys who have difficulty in reading and writing. The second explanation relates to auditory processing, which is linked to reading disability (Limbrick, Wheldall & Madelaine, 2011; Sharma, Purdy, Newall, Wheldall, Beaman & Dillon, 2006). The number of boys of school age with auditory processing disorders was double that of girls (Chermak & Musiek, 1997; Mülder, Rogiers & Hoen, 2007; Nagao, Riegner, Padilla, Greenwood, Loson, Zavala & Morlet, 2016).

Results

The Statistical Package for the Social Sciences (SPSS) 11.5 program was used to analyse the data and the statistical significance limit was considered as $p < 0.05$. The Chi-square test was used to compare the answers to the questionnaires given by children with reading and writing difficulty to those of children without reading and writing difficulty. The data was defined by number and percentage values. As the questionnaire used a binary score (Yes/No), each item was evaluated separately by means of a Chi-square test.

The participating children were divided into two groups – those with reading and writing difficulty and those without reading and writing difficulty. The answers to the questionnaire given by the two groups are shown in Table 2.

Table 2 Item-by-item comparison between children with and without reading and writing difficulty

Nr and description	Reading and writing difficulty present		Reading and writing difficulty absent		Chi-square test	
	N	%	*n*	%	X^2	*p*-value
1	S/he has difficulty to distinguish the sounds that form the word. (e.g. the phonemes of "okul" (school) /**o**/, /**k**/, /**u**/, /**l**/)					
No	15	26.8	269	98.9	207.906	< 0.001
Yes	41	73.2	3	1.1		
2	S/he has difficulty to distinguish sounds in similar words (such as honey-money, is it h or m?)					
No	17	30.4	269	98.9	195.390	< 0.001
Yes	39	69.6	3	1.1		
3	S/he has difficulty to break words into syllables.					
No	16	28.6	269	98.9	201.625	< 0.001
Yes	40	71.4	3	1.1		
4	S/he has difficulty to convert letters into syllables and words.					
No	16	28.6	269	98.9	201.625	< 0.001
Yes	40	71.4	3	1.1		
5	S/he has difficulty to read the words in a sentence.					
No	11	19.6	264	97.1	205.439	< 0.001
Yes	45	80.4	8	2.9		
6	S/he has difficulty to remember the words in a sentence.					
No	9	16.1	258	94.9	190.387	< 0.001
Yes	47	83.9	14	5.1		
7	S/he has difficulty to write the words correctly.					
No	11	19.6	263	96.7	200.453	< 0.001
Yes	45	80.4	9	3.3		
8	S/he has difficulty to write the sentence as a whole.					
No	10	17.9	263	96.7	206.792	< 0.001
Yes	46	82.1	9	3.3		
9	S/he has difficulty to write long and meaningful sentences.					
No	10	17.9	260	95.6	192.765	< 0.001
Yes	46	82.1	12	4.4		
10	During writing, s/he has difficulty to phrase subject, object and verb.					
No	5	8.9	261	96	229.440	< 0.001
Yes	51	91.1	11	4		
11	S/he has difficulty to give quick answers when necessary.					
No	9	16.1	262	96.3	208.305	< 0.001
Yes	47	83.9	10	3.7		
12	S/he has difficulty to discuss a topic without straying from the topic.					
No	10	17.9	260	95.6	192.765	< 0.001
Yes	46	82.1	12	4.4		
13	S/he has difficulty to follow long conversations. (e.g. listening to a teacher in a classroom)					
No	12	21.4	257	94.5	168.015	< 0.001
Yes	44	78.6	15	5.5		
14	S/he has difficulty to understand long sentences (including conjunction, suffix, and affix).					
No	10	17.9	260	95.6	192.765	< 0.001
Yes	46	82.1	12	4.4		
15	S/he has difficulty to follow verbal expressions in noisy environments.					
No	11	19.6	260	95.6	186.574	< 0.001
Yes	45	80.4	12	4.4		
16	S/he has difficulty to repeat the numbers, words or phrases. (e.g. to repeat the sentence "My friend wore his green coat yesterday")					
No	15	26.8	263	96.7	175.646	< 0.001
Yes	41	73.2	9	3.3		
17	S/he has difficulty to understand the uttered sentences or questions at once. (e.g. by saying "What?" s/he needs repetition several times)					
No	18	32.1	262	96.3	153.123	< 0.001
Yes	38	67.9	10	3.7		
18	Reading and writing skill is below the class average.					
No	5	8.9	265	97.4	249.865	< 0.001
Yes	51	91.1	7	2.6		

The questions in the questionnaire can be grouped as follows. Questions 1, 2, 3 and 4 were about phonological awareness. Significantly more children with reading and writing difficulty strug-

gled with phonological awareness compared to those without reading and writing difficulty ($p < 0.001$).

Questions 5 and 6 were about reading and indicated that significantly more children with reading and writing difficulty struggled with reading compared to those without reading and writing difficulty ($p < 0.001$).

Questions 7, 8, 9 and 10 were about writing. Significantly more children with reading and writing difficulty struggled with writing compared to those without reading and writing difficulty ($p < 0.001$).

Questions 11 and 12 were about speaking. Significantly more children with reading and writing difficulty struggled with speaking compared to those without reading and writing difficulty ($p < 0.001$).

Questions 13, 14, 15, 16 and 17 were about listening. Significantly more children with reading and writing difficulty struggled with listening compared to those without reading and writing difficulty ($p < 0.001$).

As a result, responses to Question 18 revealed that children with reading and writing difficulty achieved below the class average ($p < 0.001$).

Discussion

A significant relationship was found between central auditory processing disorder indications and reading and writing difficulty. Kraus and Anderson (2013) argue that auditory processing deficits could be underlying reasons for reading disorders in children. Children with CAPD may experience a good number of other difficulties besides their primary auditory processing problems. The *Technical Report* for school-aged children (American Speech-Language-Hearing Association, 2005) reveals that CAPD can cause or be linked to difficulty in learning, speech, social and all related functions.

Moreover, Cacace and McFarland (1998) suggest that CAPD differs from cognitive, language-based, and/or attentional problems, where modality-specific perceptual dysfunctions are not expected.

Studies have shown that the main challenge faced by children with literacy difficulties in the first grade in primary school is a lack of speech sound correspondence in language and learning (Brenneman, Cash, Chermak, Guenette, Masters, Musiek, Brown, Ceruti, Fitzegerald, Geissler, Gonzalez & Weihing, 2017). The main disorder was found to be central auditory processing disorder (Barrozo, Pagan-Neves, Pinheiro da Silva & Wertzner, 2017; Skarzynski, Wlodarczyk, Kochanek, Pilka, Jedrzejczak, Olszewski, Bruski, Niedzielski & Skarzynski, 2015).

Kraus and Anderson (2015) further state that reading difficulty is related to phonological awareness and temporal processing difficulties. With the help of the central auditory processing functions, the time processing of the phonemes takes place and the phonemes are recognised in the word and in the audio reading. For this reason, there is a direct relationship between reading and writing skills, which is a central auditory function and duration processing (De Bonis, 2015). Time processing deficit, as proposed by the dominant theories, can prevent the gain of literacy skills (Neef, Müller, Liebig, Schaadt, Grigutsch, Gunter, Wilcke, Kirsten, Skeide, Kraft, Kraus, Emmrich, Brauer, Boltze & Friederici 2017).

This relationship is evident in primary school because this is when learning primarily takes place through listening. While the teacher is lecturing, the speech signals are circulated into the class. On a time scale, speech signals transmit information very quickly (between minutes and microseconds). Typically, developing children's listening skills enable them to instantly resolve each sound-phoneme duration that constitutes the words in the sentences of the speech they listen to. However, children with CAPD find it difficult to identify the phonemes in the speech. Classrooms are important auditory learning environments for children, but many classrooms do not provide conditions that are conducive for hearing (echo, noise, et cetera). It is thus necessary for teachers to check whether their classrooms provide children with suitable conditions for hearing. The acoustics of the class increases the severity of the existing disorder, even if it does not create reading and writing difficulty alone.

The difficulty in understanding speech in a noisy environment is the most prevalent indication of CAPD. In addition, these children experience difficulty in recognizing speech degraded by the removal of temporal fine structure cues. This suggests that a speech perception deficit might be a consequence of the presence of an external or internal noise (Kraus & Anderson, 2016).

CAPD in children is therefore likely to be related to reading impairment. These children also have difficulty in listening in noisy environments, because noise is known to disrupt the neural coding of consonants more than vowels, which is critical in learning consonants as part of a phonemic inventory. Increasing classroom signal-to-noise ratios using assistive listening devices helps children to achieve better reading results (Kraus & White-Schwoch, 2015).

Sackstein, Spark and Jenkins (2015:2) point out that reading skills are vital for academic and personal growth and underline that reading is crucial as "few abilities have such an impact on children's overall achievement in the education process." Paton-Ash and Wilmot (2015) state that one of the most crucial predictors of academic success is the amount of time that children spend reading and added that this indicator is more accurate than

the social or economic status of the children, and therefore has valuable implications for all developing countries.

Language is the main instrument by which children make interpersonal contact, interact with others and develop friendships. When children's communication skills are weak, they may be unable to use them effectively. At the same time, many important social skills depend on language skills and familiar language abilities.

Green, Condy and Chigona (2012:320) note that "thinking and reasoning" is integrated into all language skills, which are listening, speaking, reading and writing. Therefore, it is likely that children who have difficulty in reading and writing will face failure in their academic lives.

Klapwijk (2012) suggests that improvements in reading and writing skills, which constitutes a foundation for academic success, would improve children's personal growth and the nation's economic prosperity.

Reading is considered as one of the most important linguistic skills that needs to be enhanced in young children, and the ability to read is a prerequisite for full participation in one's society and economy (Klapwijk, 2015). To develop reading, Iyitoglu and Aydin (2015) report some classifications about reading strategies such as cognitive, meta-cognitive and social/affective. Readers need all of these strategies to read successfully because they are regarded as a subset of learning strategies used in the active reading process.

It is important that the problems associated with the comprehensive framework used in diagnosing CAPD, treatments or therapies, are considered cautiously. As suggested by some researchers, the comprehensive framework does not provide sufficient insight into the nature of the processing problem(s), nor does it suggest an appropriate course for intervention. Recent studies suggest that perceptual training may improve language skills, especially reading ability in some school-aged children (Cacace & McFarland, 1998).

Critical Evaluation

This was the first study undertaken to evaluate CAPD symptoms in Turkish children who show reading and writing difficulty despite their typical development, based on teachers' opinions. The study was limited to children in the middle socioeconomic group in public schools in Ankara. As children from low socioeconomic and high socioeconomic environments may experience different problems and the nature of the disorder may not be auditory processing disorder, we suggest that future studies could compare the CAPD symptoms between children from lower and higher socioeconomic levels. Similar studies could also compare these children's language abilities with regard to reading and writing difficulty.

Conclusion

Being literate contributes undeniably to an individual's quality of life such as the ability to build stronger relationships, develop self-esteem and to function as an educated member of the society. The person who learns to read and write should be aware of the phonetic structure and combinations of the sounds in language. For some children, decoding the meaning of words by transforming letters to sounds, sounds to syllables and then into words, can be difficult, which in turn makes reading almost impossible. The child who has difficulty in reading and recognising phonemes may be unable to decode and encode using grammar and vocabulary (Yildirim, Ritz, Akyol & Rasinski, 2015).

It is thought that symptoms of CAPD may underlie reading and writing difficulties, and that these difficulties can be recognised by teachers (e.g. through the use of questionnaires). Early detection of these problems can lead to early and proper referral, which is of great importance for the correct treatment by the correct department. For example, a child who is suspected to have CAPD may be treated timeously by an experienced educational audiologist using the proper therapy.

CAPD symptoms may be used to confirm the diagnosis (Yalçinkaya, Türkyilmaz, Keith & Harris, 2015) and to reveal the areas affected by the child's reading and writing disorder. The main purpose should be to identify the nature and extent of the disorder as soon as possible and to clarify the individual educational plans to support the child (Yalçinkaya, Bayar Muluk & Budak, 2009), for example, classroom-based phonological awareness programmes (Kelly, Leitão, Smith-Lock & Heritage, 2019), music training programmes (Intartaglia, White-Schwoch, Kraus & Schön, 2017), enhancing children's rhythmic abilities (Kraus & Anderson, 2015), using frequency modulation (FM) systems in the classroom (Hornickel, Zecker, Bradlow & Kraus, 2012; Kraus & Anderson, 2016) and auditory training (Hornickel & Kraus, 2013).

Children's school readiness can also be affected by when they acquire speech, i.e. if they are regarded as late talkers (Singleton, 2018). If a child does not speak at the expected age, he/she is regarded as not yet being ready for school. These children with speech delays have difficulties in reading and learning. However, the situation is different for children with CAPD. They often have difficulties with reading aloud. Reading difficulties arise from the difficulty of temporal processing of phonemes. However, the power of central auditory processing does not affect language learning, but it affects the recognition of phonemes and the rapid catching of temporal cues through listening. Hence, the readiness of a child with CAPD to go to school and to read and write may be overlooked since the child was able to speak while in preschool. For this reason, all teachers at primary schools should be

made aware of the characteristics of CAPD. They should be trained on how to recognize CAPD (e.g. by using questionnaires) and that they should refer the child to an educational audiologist and implement an individual educational support plan. This is very important because delays in reading and writing skills are detrimental for children's future learning, education, and ultimately career and employment opportunities. Further research is required to develop reliable and valid questionnaires in Turkish to be used as part of a CAPD screening inventory.

Authors' Contributions

ISK conducted the original theoretical and empirical research and wrote a draft article. ADOO contributed to the conceptualisation of the study, the analysis and writing of the manuscript. FY contributed to the central auditory processing, conceptualisation of the study, the analysis and writing of the manuscript. All authors reviewed the final manuscript.

Notes

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