JRSR 2 (2015) 27-30

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

Auditory Working Memory Span of Children with (Central) Auditory Processing Disorders and Normal Children Aged 8 to 10 Years

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ARTICLE INFO

Article History:
Received: 21/1/2015
Revised: 15/8/2015
Accepted: 5/9/2015

Keywords:
Working memory span
Central auditory processing disorder
Top-down function

ABSTRACT

Background: The aim of the present study was to assess the auditory working memory span of children with (central) auditory processing disorders (C) APDaged 8 to 10 years and to compare the results with normal ones.
Methods: Twenty five children with (Central) Auditory Processing Disorders (8-10 years) and 75 normal children (8-10 years) from both genders participated in this comparative study. Participants were chosen by convenient sampling method to assess their auditory working memory (WM) span. Forward digit span, backward digit span and non-word repetition tests were used to evaluate the WM span. Nonparametric statistics (Mann–Whitney U) were used for comparing group differences.
Results: Forward digit and backward digit and non-word repetition tests showed significant differences in mean scores between those with (C) APD and normal children (P<0.001).
Conclusion: The results suggest that (C) APD children have poorer performance in the WM span than the age matched controls.

Introduction

Children with (central) auditory processing disorders (C) APD, have difficulty in speech perception in challenging auditory environments in spite of normal hearing. The deficit in auditory information processing (sensory and cognitive processing) in these children may lead to poor academic performance and suspension from school [1]. Auditory and speech processing is based on bottom–up (data–driven) processing which in turn depends on acoustic signal input and integration of central auditory pathways. Moreover auditory information processing involves top-down (concept–driven) mechanism, which depends on higher central resources such as working memory capacity and attention [2].

Working memory is the ability of maintaining information in mind for doing complex activities such as comprehension, learning and reasoning [3]. Working memory comprises of multiple components that interact with each other. These components include: phonological loop, visuo-spatial sketch pad and central executive [3]. Phonological loop consist of two parts: phonological store, which is temporary storage system and will hold memory traces before their fading and it is responsible for storage and temporary processing of phonological representation. Articulatory rehearsal, Memory traces can be refreshed by being retrieved and re-articulated in this part. The second part of working memory is visuo-spatial sketchpad which maintains the spatial and visual properties of information. Finally the central executive is the most important part of working memory and responsible for controlling and retrieval information from

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long-term memory and control of the other parts [4, 5].

The prevalence of auditory processing disorder is 2% to 3% of children,with a 2:1 ratio between boys and girls [6]. Studies show that in (C) APD both bottom-up and top-down processing were involved [7, 9]. Studies have shown (C) APD children have problems in sequence of information stored in working memory. Kiese-Himmel suggested that there was a significant difference between (C) APD and normal children in non-word repetition and recall of sentences tests. This finding suggests the existence of temporal processing and phonological working memory span deficit in these children [10, 11]. They also reported that 91% of (C) APD children could be diagnosed by using non-word repetition, speech in noise discrimination and phoneme differentiation tests [12]. Moore et al reported that the nature of auditory processing disorder could be related to cognition deficit (attention and working memory). Study of Nickish et al. showed that 96.5 % of (C) APD children could be diagnosed by using Numerical Sequence Memory and Non-word Repetition [11]. Moossavi et al. have suggested that impaired working memory preclude to precise auditory perception especially for complex processing and difficult tasks. According to these studies, Cognitive assessment such as working memory is important as bottom-up processing assessment in children with (C) APD [13]. Therefore the main goal of this study was to precisely assess the auditory working memory span of children with (C) APD and to compare the results with normal children.

Methods

This was a comparative study. 25 children with diagnosed (C) APD (8-10 years, 9.3±0.35) and 75 normal children (8-10 years, 25 persons /each age range, 9.5±0.5) from both genders participated (Table 1). Healthy children were recruited from students of schools of Tehran (Iran). Children with (C) APD were recruited from audiology clinics of the University of Social Welfare and Rehabilitation Sciences (USWR). Prior to testing, informed written consent for all tests was obtained from the parents of the participants. It was explained to each child that the experiment could be discontinued at any time at his/her will. Participants had normal otoscopy and better than 20 dB hearing level/ HL pure-tone air-conduction thresholds bilaterally in 500 to 8000 Hz range and had no articulation disorders. All (C) APD children had normal IQs (higher than 85 according to children Wechsler intelligence test results in school health profiles) [14].

Children with (C) APD failed in at least two auditory processing tests such as Dichotic Digit test (DD), Pitch Pattern Sequence Test (PPST),and Random Gap Detection Test (RGDT) [15]. This test battery has high sensitivity in (C) APD diagnosis [16]. The PPST and RGDT reflects the temporal components of auditory pattern recognition and the DDT measures the ability of binaural processing [17]. For a relative homogeneity in (C) APD group, only those children who failed in at least two auditory processing tests were included in this study.

The following instruments were used in this study: 1-Heine mini 3000 Otoscope, 2- Clinical MAICO MA 53 Audiometer. All the tests were executed in a quiet room and in the Most Comfortable Level of hearing (MCL). In the present study, we used non-word repetition and forward digit and backward digit recall tests for evaluating working memory span in children. Auditory working memory tests were spoken by the experimenter with live voice whiles the mouth hidden by a sheet of paper in order to prevent lip-reading [18]. In this test, the child is required to repeat accurately each non-word immediately after it has been presented. The test consists of 40 items and the number of correct repetition attempts is scored for each child. The child was allowed 3 seconds to repeat the non-word. Each attempt was scored 1 if the repetition was judged to be phonologically accurate and 0 if the experimenter judged that the child had produced an item that different from the target non-word by one or more phonemes. The test-retest reliability of the non-word repetition test is 0.8 for children [19]. The backward digit and forward digit recall tests of Wechsler intelligence Test Battery for Children were administered to each child .In this test, children hear sequences of spoken digits, and are asked to repeat them in backwards order. Test trials begin with a length of two digits and two trials and is continued in following levels by increasing one number in each level, until the child becomes unable to recall two correct trials at a level. If both of the trials on one level are repeated correctly the child is given 2 points and 1 point is given if only one of the two trials on one level is correct. The test-retest reliability of this test is 0.62 for children. This test has the same structure and scoring as the backward digit recall test, except that the children are asked to recall the digits in the same sequence presented to them. The test-retest reliability of this test is 0.81 for children [20] .All analyses conducted using SPSS (version 16). Due to the relatively small group numbers in the study, data did not meet the normality assumptions. Therefore, nonparametric (Mann–Whitney U) test was used to compare group differences. The significance level adopted was 0.05 (5%), with confidence intervals of 95%.

Table 1: Number of participants in the (C) APD group and normal children

Groups	Number	Age	Sex
Normal	25	8y	13 boys,12 girls (25)
	25	9y	14 boys,11 girls (25)
	25	10y	13 boys,12 girls (25)
(C) APD	10	8y	5 boys,5 girls (10)
	9	9y	6 boys, 3 girls (9)
	6	10y	4 boys, 2 girls (6)

Results

The mean scores and standard deviations for the auditory working memory tests in normal children are shown in Table 2.

The mean scores and standard deviations for the auditory working memory tests in (C) APD children are shown in Table 3.

The results comparing the performance of the (C) APD to normal group on auditory working memory tests are shown in Table 4. Between group comparisons revealed that the (C) APD group had a significantly lower scores than normal children in all tasks at each age (P<0.001).

Discussion

In this study, the majority of (C) APD children had a poor performance in all working memory tasks. Central processing mechanisms allow an individual to selectively focus the attention to the desired auditory streaming. Deficits in central executive function lead (C) APD children to have difficulties in selective focus and attention control on one stream of information while ignoring the others. This impaired central executive function precludes to auditory processing, especially for complex processing and difficult tasks (competing acoustic and degraded acoustic signals). These results are in agreement with Iliadou et al. [21] who showed that the (C) APD children had lower score on the memory and attention subscales of the Children's Auditory Processing Performance Scale questionnaire (CHAPPS) than non-(C) APD group .The present study showed that, there is a significant difference in mean score of non-word repetition test between (C) APD and normal children. These results are in agreement with Ferguson et al. [22] and Miller et al [23] and Moore et all. (C) APD children with phonological working memory deficit have difficulty in phonologic storagewith sequentially accurate phonologic representation of speech. So these children have poor performance in processing speech, especially input for which sequential order is important to comprehension.

Another important finding of this study is that WM problems may have a negative effect on central auditory processing. Moossavi et al. reported that children with poor WM span, more rely on bottom-up system to make sense of the acoustic information[13]. Moor et al. reported that (C) APD may not be attributable to a primary, bottom-up, sensor processing problem but may have their origins in higher-level, top-down processing. They revealed that the symptoms of (C) APD were not related to auditory sensory processing deficit. They have concluded that (C) APD is primarily an attention problem [1, 7]. Finally, it is suggested that because of the importance of auditory processing disorder, other related aspects of working memory must also be evaluated.

Conclusion

The present study showed that assessment of working memory span is important and necessary to detect auditory processing disorder. Our results indicate that impaired top-down function poses a significant effect on bottom-up processing. It can be emphasized, that evaluation of top-down processing should be considered in addition to bottom-up tests in (C) APD and diagnosis of (C) APD needs complete approach including assessment of cognitive factors such as working memory and central executive function.

Acknowledgements

Special thanks and regards for colleagues of audiology department and the rehabilitation clinics of University of Social Welfare and Rehabilitation Sciences, Navid-e- Asr rehabilitation center and all patients of this center and all students and officials of district 5 administration schools, Tehran.

Conflict of Interest: None declared.

Table 2: Means and standard deviations of auditory working memory test results in normal children

Normal children	N	Forward digit recall/FD	Backward digit recall/BD	Non-word repetition
8 years	25	6.24±0.86	4.72±0.89	36.4±0.7
9 years	25	7.2±0.95	5.76±0.72	39±0.7
10 years	25	7.84±0.62	6.44±0.65	39.36±0.7

Table 3: Means and standard deviations of auditory working memory test results in (C) APD children

(C) APD children	N	Forward digit recall/FD	Backward digit recall/BD	Non-word repetition
8 years	10	2.6±0.84	2.1±1.37	33± 2.26
9 years	9	3.88±1.05	3.44±0.88	34.8±2.27
10 years	6	4.83±0.75	3.84±0.75	35.83± 0.75

Table 4: Comparing the performance of the (C) APD group to the control group on the three working memory tasks

(C)APD and normal children	Forward digit recall/FD	Backward digit iecall/BD	Non-word repetition
8 years	<0.001	<0.001	<0.001
9 years	<0.001	<0.001	<0.001
10 years	<0.001	<0.001	<0.001

References

1. Moore DR, Ferguson MA, Edmondson-Jones AM, Ratib S, Riley A. Nature of auditory processing disorder in children. Pediatrics.126(2):e382-90.
2. Wilson WJ, Heine C, Harvey LA. Central auditory processing and central auditory processing disorder: Fundamental questions and considerations. The Australian and New Zealand Journal of Audiology. 2004;26(2):80-93.
3. Baddeley A. Working memory. Science. 1992;255(5044):556-9.
4. Baddeley A. Working memory: Looking back and looking forward. Nature Reviews Neuroscience. 2003;4(10):829-39.
5. Baddeley A. Working memory and language: an overview. J Commun Disord. 2003;36(3):189-208.
6. Chermak GD. Auditory processing disorder: An overview for the clinician. The Hearing Journal. 2001;54(7):10-25.
7. Moore DR. Listening difficulties in children: Bottom-up and top-down contributions. Journal of communication disorders. 2012;45(6):411-8.
8. Moore DR. The diagnosis and management of auditory processing disorder. Language, speech, and hearing services in schools. 2011;42(3):303-8.
9. Bamiou DE, Musiek FE, Luxon LM. Aetiology and clinical presentations of auditory processing disorders--a review. Arch Dis Child. 2001;85(5):361-5.
10. Dawes P, Bishop D. Auditory processing disorder in relation to developmental disorders of language, communication and attention: a review and critique. International Journal of Language & Communication Disorders. 2009;44(4):440-65.
11. Nickisch A, Kiese-Himmel C. [(Central) Auditory Processing Disorders in 8 - 10-year-old children: which tests distinguish between normal and impaired children?]. Laryngorhinootologie. 2009;88(7):469-76.
12. Nickisch A, Gohde K, Kiese-Himmel C. [CAPD in 2nd-Graders of Primary Schools: Which tests Discriminate Normal from Impaired Children?]. Laryngorhinootologie. 2013 Sep;92(9):594-9.
13. Moossavi A, Mehrkian S, Lotfi Y, Faghihzadeh S. The relation between working memory capacity and auditory lateralization in children with auditory processing disorders. International journal of pediatric otorhinolaryngology. 2014;78(11):1981-6.
14. Shahim S. Correlations for Wechsler Intelligence Scale for Children--Revised and the Wechsler Preschool and Primary Scale of Intelligence for Iranian children. Psychological reports. 1992;70(1):27-30.
15. Muluk NB, Keith RW. Random gap detection test and random gap detection test-expanded: Results in children with previous language delay in early childhood. Auris Nasus Larynx.38(1):6-13.
16. Domitz DM, Schow RL. A new CAPD battery--multiple auditory processing assessment: factor analysis and comparisons with SCAN. Am J Audiol. 2000;9(2):101-11.
17. Musiek FE. Assessment of central auditory dysfunction: the dichotic digit test revisited. Ear Hear. 1983;4(2):79-83.
18. Gathercole SE. Is nonword repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. Memory & Cognition. 1995;23(1):83-94.
19. Moossavi A, Khavarghazalani B, Lotfi Y, Mehrkian S, Mahmoodi-Bakhtiyari B, Bakhshi E. Validity and reliability of a non-word repetition test for evaluation phonological working memory span in Persian speaking children. Audiology. 2014:0-.
20. Dehkordi.S. Naming Speed and Performance in Three Components of Working Memory in Dyslexic and Normal Children. Iranian Journal of Exceptional Children. 2011;11(1):11-21.
21. Iliadou V, Bamiou DE. Psychometric Evaluation of Children With Auditory Processing Disorder (APD): Comparison With Normal-Hearing and Clinical Non-APD Groups. Journal of Speech, Language, and Hearing Research. 2012;55(3):791-9.
22. Ferguson MA, Hall RL, Riley A, Moore DR. Communication, listening, cognitive and speech perception skills in children with auditory processing disorder (APD) or specific language impairment (SLI). Journal of Speech, Language, and Hearing Research. 2011;54(1):211-27.
23. Miller CA, Wagstaff DA. Behavioral profiles associated with auditory processing disorder and specific language impairment. J Commun Disord.44(6):745-63.