Aud Vest Res (2016);25(1):1-6.

**RESEARCH ARTICLE**

# The effect of mild to moderate hearing impairment on Persian dichotic digit test in young children

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Received: 26 Aug 2015, Revised: 25 Oct 2015, Accepted: 2 Nov 2015, Published: 28 Dec 2015

## Abstract

**Background and Aim:** Hearing impaired students experience binaural hearing like normal peers and school age is challenging time for using dichotic listening. Lack of research was found on relationship of Persian hearing impaired children with central auditory processing (CAP). One of the aims of this study was a comparison between Persian dichotic digit test (DDT) score in children with mild and moderate hearing loss (HL) and normal ones.

**Methods:** Forty one hearing impaired children (16 mild HL and 25 moderate HL) and 41 subjects with normal hearing all between 7-12 years of age, in both genders (sex has no effect on this test), were selected and tested Persian DDT. Results from Right Ear/Left Ear scores, Right Ear Advantage (REA) and age effect were collected and compared with normal subjects.

**Results:** Results of this study showed the average of 89.07% correct scores in right ear and 82.24% in left ear. The difference between both ears was 6.83%. Comparison of the right ear correct scores and left ear correct scores showed a significant REA ($p<0.05$). But no significant differences were seen in comparing mild and moderate hearing loss groups ($p>0.05$).

**Conclusion:** This study pointed out which Persian DDT is not affected by mild-to-moderate sensory neural hearing loss. However, younger children need more interval time between two items to respond to the tests.

**Keywords:** Hearing impairment; Persian dichotic digit test; young children

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## Introduction

Implying by American Speech-Language-Hearing Association (ASHA) in 2005, auditory processing is considered as an effective and efficient function for speech perception. This function is conducted by central nervous system, using auditory information [1]. Normal function of sensory neural auditory system and central auditory pathways can be addressed, as the primary needs in order to develop normal speech and language. Central auditory processing (CAP) Impairment is told to be a deficit in sound processing, not related to peripheral hearing loss [2]. CAP deficits refer to difficulties in processing of auditory information,

related to central nervous system. In this case, patient would have trouble in conducting one or more of auditory system oriented skills which include functions like sound lateralization and localization, auditory resolution, auditory pattern discrimination, auditory temporal processing, auditory performance in competing acoustic signals, and auditory performance with degraded acoustic signals [1-4]. Patients with central auditory processing disorder (CAPD) often have some problems, either in hearing or speech perception, in different auditory or acoustic environments. It has been proven that 2-3% of normal hearing children will show auditory processing problems [2]. The concept of binaural hearing is that both ears work together in order to process auditory information [3]. This consists either in combination or comparison of information received by both ears. As the child grows, central auditory system (CNS) develops simultaneously and his binaural hearing skills improve. Children in school age would encounter more binaural hearing and dichotic skills challenges, having hearing loss can be considered as a negative effect on learning ability or development of such skills [2]. Sensorineural hearing loss (SNHL) is the most common sensory deficit in developed communities [5]. It is estimated that 8000 children with mild-moderate monaural or bilateral hearing loss are born yearly in USA. Studies have shown that patients with SNHL also show different levels of central processing difficulty [6-10]. Binaural processing is critical for binaural interactions and not working properly, can cause perception deficits in binaural auditory system. Dichotic speech recognition is one of the important skills that refer to high level of binaural processing [2]. Studies show that binaural processing difficulties occur in symmetrical SNHL [11]. Hearing loss in childhood has a significant effect on development of speech, language and hearing [12,13]. Even unilateral or mild and moderate hearing loss might have adverse effect on speech and language development [14]. Early diagnosis of the problem effects social and emotional behavior of a hearing impaired child [15-17]. It is implied in different studies that patients with peripheral hearing loss would show deficits in central auditory test battery [18,19]. In such cases, using auditory behavioral tests as screening tool is highly recommended to assess central deficits. Dichotic digit test (DDT) has been introduced as a reliable, easy to administer and suitable for mild-moderate hearing loss test for studying and determining CAP abnormalities [2-4]. In dichotic hearing task, 1-3 pairs of different speech stimuli are presented simultaneously to both ears. Listeners are typically asked to repeat one or both stimuli presented, depending upon stimulus and testing paradigm. In the free recall response condition, listeners would be asked to repeat the stimuli in the order they hear it. In the directed recall response condition, the listener is requested to repeat the stimulus firstly from the directed ear and then the other [2-4]. Listeners are usually asked to repeat one or both stimuli, depending on stimulus and testing method. There are two response conditions: Free recall (repeating heard stimuli in any order) and directed recall (repeating stimuli at first in directed and thereafter in the other ear) [2-4]. Studies have shown that adults with normal hearing show better response to the speech materials presented to the right ear than left ear [2-4,15]. Three parameters are critical for interpretation of DDT: first, the right ear correct score, second, the left ear correct score and third, the ear advantage which is the difference between the scores of the two ears. If right ear score is greater than left, right ear advantage (REA) can be concluded and if left ear scores are more, left ear advantage (LEA) is the result. Severe decrement of REA or both ear scores can be a sign of problem in dichotic speech discrimination skill [2,3,20]. Such a processing deficit causes high levels of abnormality in language or educational processing for a child, especially in classroom [16-20].

Reliability of Persian DDT (Persian version) test of this study, performed on Iranian normal hearing adults and children ($p<0.05$), has tried to evaluate mild and moderate hearing impaired children [21].

The main objective of this study was to investigate the effect of mild and moderate hearing loss on Persian DDT and comparison of RE/LE scores, REA in children aged 7-12 years and also age effect on Persian DDT scores in both groups (mild and moderate hearing loss).

## Methods

This cross-sectional study was conducted between October 2013 and March 2014. After approval of the research protocol by the ethics committee of Tehran University of Medical Sciences (TUMS), 41 children with hearing loss (16 mild hearing loss, 25 moderate hearing loss) were selected. Since sex had no effect on DDT we selected from both sexes but not in equal, native Persian children, aged 7 to 12, participated in this study. Children were recruited for a clinical evaluation of auditory and hearing aid in the School of Rehabilitation of TUMS. Then, they were clinically evaluated with dichotic listening. Inclusion criteria for all children were to have bilateral congenital mild to moderate hearing loss, flat audiogram, tympanogram Type An and intact tympanic membranes with no visible pathology shown in otoscopic examination. All cases were right-handed according to Edinburgh Handedness Inventory and they had enough cognitive abilities to understand and do tasks (mentioning to right and left ears and repeating 4 heard digits), no sign of attention problems according to abstracted Conner's criteria and no sign of CAPD; according to the questionnaire CAPD screening ASHA, 1996 [22]. All cases were assessed in Audiology Clinic of School of Rehabilitation of TUMS. Dichotic digits (Persian monosyllabic digits, including 1 to 10, except 4 because of being a two-syllabic digit) were presented at most comfortable level (MCL) and via TDH-50 Supra aural earphones to both ears. Children were asked to pay attention to digits in both ears and repeat them (free recall). Number of correct responses in each ear was calculated in percentage. Two pairs of dichotic digits (List A) including 25 items and each item included 4 digits, were presented as a pair simultaneously. Time interval between each pair of digits was considered to be 600 ms and intervals between 2 items for a single child were 6 seconds. Every correct reply was considered as 2 points and ear advantage was calculated via traditional approach (right ear scores minus left ear ones).

## Results

In this study, 41 (20 male, 21 female) 16 mild HL, 25 moderate hearing impaired children and 41 (20 males, 21 females) normal hearing children were assessed, using DDT.

Average of hearing loss (HL) for mild HL was 36.48 dB (SD=1.94) in right ear, and in left ear 37.47 dB (SD=2.9), this average HL for the other group (moderate HL) was 50.8 dB (SD=3.24) for right ear and 50. 9 (SD=4.1) for left ear.

Standard deviations and mean percent correct scores and word recognition score for each ear, standard deviations, minimum, maximum, and mean for ear differences categorized in six different ages and two hearing loss categories are summarized in Table 1 and 2. This study showed similar results to previous studies that systemically studied REA and correct scores for each ear in normal hearing children. Results of this study showed a mean 89.07% (median=88, SD=4.10, range=80-98%) correct scores in right ear and 82.24% (median=82, SD=6.96, range=70-98%) correct scores in left ear; in normal group mean 89.17% (SD=4.77, range= 80-100%) correct scores in right ear and 82.09% (SD=7.04, range=70-98%) in left ear was observed. The difference between both ears in sample group was 6.83% (median=6, SD=4.17) in average. The scores obtained in the right ear were higher than those obtained in the left ear for all groups. As age increased, the mean of left-ear scores showed an ascending pattern (Fig. 1). Comparing the collapse right and left ear correct scores, a significant REA was observed ($p<0.05$), except in the 12-year-old group. Significant differences were not observed between mild and moderate hearing loss categories (Table 2).

**Table 1. Mean (standard deviation) scores and ear advantage in right and left ears in all groups (n=41)**

| | | Mean (SD) | | | |
|---|---|---|---|---|---|
| **n** | **Age** | **DDT right** | **DDT left** | **ED** | **Min-Max ED** |
| 8 | 7 | 86.25(2.71) | 74.75 (3.1) | 11.5 (2.56) | 8-16 |
| 7 | 8 | 88.28(5.93) | 78.00(6.00) | 10.28 (2.42) | 8-14 |
| 9 | 9 | 88.88(2.66) | 82.66(2.82) | 6.22 (1.56) | 4-8 |
| 6 | 10 | 88.00(1.26) | 81.00(2.09) | 7.00 (1.67) | 6-10 |
| 5 | 11 | 93.60(4.33) | 91.20(5.21) | 2.40 (1.67) | 0-4 |
| 6 | 12 | 91.33(3.50) | 90.33(3.88) | 1.00 (1.09) | 0-2 |

DDT; dichotic digit test; ED; ear difference (R-L)

Two-related-sample test (Wilcoxon) was used to compare the correct score between the right and the left ear in all age groups, significant difference was observed in 7-10 year olds ($p<0.05$) and no significant difference was observed in 11 and 12 year olds ($p>0.05$). Mann-Whitney test was used to compare the score of two hearing loss categories, no significant difference was observed between mild and moderate hearing loss group. Two-tailed independent sample t-test was used to compare mean score between sample and normal group; also here no significant difference was observed ($p>0.05$).

## Discussion

This study aimed to use the Persian DDT developed by Shahmir et al. (21) and has been used for normal subjects, we used it in hearing impaired person. Results of current study showed correct scores of 89.07% in the right ear and 82.24% in the left ear that showed similar results to previous studies that systemically studied REA and each ear correct scores for normal hearing. The results in Persian DDT between two ears are in agreement with Bellis [3] and Iliadou [23], which showed better results in right ear in comparison with left ear. Muraki et al. implied that dissymmetry results between two ears in DDT test of children is related to immaturity of CNS, and implied that increase of DDT scores of children can be related to development of CNS [24]. This increase in scores was also seen in this study. In the present study, advantage between both ears was 6.83 in average, this is less than 8% found in other studies [2-4,20]. The different results in this study may be due to the inclusion of normal hearing young subjects. The double DDT produced REAs, a significant difference between ears in all age groups ($p</0.05$). Maximum REA was 16% in 7-year-old children

**Table 2. Mean scores in right and left ear and ear advantage in both hearing loss groups (n=41)**

| | | Mean (SD) | | | | | | | Min-Max | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hearing loss** | **n** | **HL in RE** | **HL in LE** | **WRS in RE** | **WRS in LE** | **DDT in RE** | **DDT in LE** | **ED** | **DDT in RE** | **DDT in LE** | **ED** |
| **Mild** | **6 boys 10 girls** | 36.48 (1.94) | 37.48 (2.9) | 95.19 (3.24) | 94.37 (3.42) | 89.75 (4.05) | 83.12 (6.32) | 6.62 (4.30) | 84-98 | 74-98 | 0-14 |
| **Moderate** | **11 boys 14 girls** | 50.8 (3.24) | 50.9 (4.1) | 93.46 (3.16) | 92.87 (3.16) | 88.64 (4.15) | 81.68 (7.4) | 6.96 (4.16) | 80-96 | 70-96 | 0-16 |

HL; hearing loss, RE; right ear, LE; left ear, WRS; word recognition score, DDT; dichotic digit test, ED; ear difference (R-L)

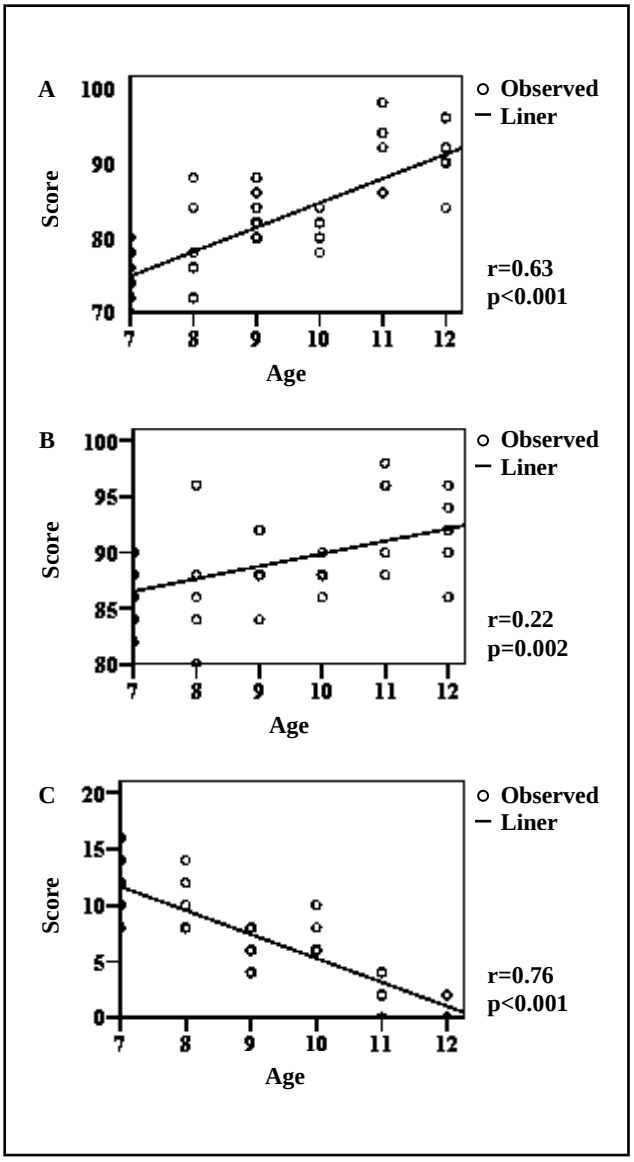


**Fig. 1. Correlation of increasing of the correct score in A) left ear, B) right ear, and C) ear difference with increasing age.**

that was consistent with previous studies [2-4,24-26]. An effect of age was seen like in previous studies [25,26]. In 10 year-old children, ear advantage was more than in 9 year-old. This is probably due to different number of children presented in each group. The maximum right and left ear correct scores do not reach ceiling level even in the older (12-year-old) age group. Younger children showed fewer correct answers in comparison with older children in both ears. It can probably be due to CNS development and myelinization beside maturation or development of the interhemispheric transfer system. In older children with mild and moderate hearing loss, scores were similar to older adults [2-4,20,25]. Nonetheless, in this study it was seen that hearing impaired children needed extra time between items to provide a reply. Another finding that is consistent with previous studies is that there was no significant difference between ear scores and ear advantage in mild and moderate hearing loss groups ($p<0.05$). Regardless of results, this study revealed that although mild and moderate hearing impaired children showed scores similar to those of age matched normal hearing persons, however from the behavioral point of view only 11 and 12 year-old children showed better results in dichotic digit test. 7 and 8 year-olds mild-moderate hearing impaired children needed more intervals between 2 items. In shorter intervals, 7 and 8 year-olds children had more difficulty. 10 second interval time led to better results in 7 and 8 year olds group.

## Conclusion

This study showed that SNHL, not only has an effect on Persian DDT, but also is resistant to mild and moderate hearing loss. Further studies is suggested on higher age groups and sensory hearing loss in comparison with neural hearing loss.

## Acknowledgements

This paper is emerged from part of N. Rahbar's Ph.D. dissertation in Audiology submitted in Tehran University of Medical Sciences, Tehran, Iran. Special thanks to the personnel of Audiology Clinic in TsUMS for their support and all families who participated and coordinated with us in conducting the present study are appreciated.

**REFERENCES**

1. American Speech-Language-Hearing Association. Technical report (Central) Auditory Processing Disorders: Working Group on Auditory Processing Disorder. 2005.
2. Chermak GD, Musiek FE. Central auditory processing disorders: new perspectives. 1st ed. San Diego: Singular Publishing Group, Inc; 1997.

3. Bellis TJ. Assessment & management of central auditory processing disorders in the educational setting: from science to practice. 2nd ed. Clifton Park, NY: Delmar; 2003.
4. Geffner D, Ross-Swain D. Auditory processing disorders: assessment, management, and treatment. 2nd ed. San Diego: Plural Publishing Group; 2013.
5. Szelag E, Skarzynski H, Senderski A, Lewandowska M. Hearing loss and auditory processing disorders: Clinical and experimental perspectives. In: Han S, Pöppel E, editors. Culture and neural frames of cognition and communication. 1st ed. Berlin: Springer-Verlag; 2011. p. 153-68.
6. Henry KS, Heinz MG. Effects of sensorineural hearing loss on temporal coding of narrowband and broadband signals in the auditory periphery. Hear Res. 2013;303:39-47.
7. Oates PA, Kurtzberg D, Stapells DR. Effects of sensorineural hearing loss on cortical event-related potential and behavioral measures of speech-sound processing. Ear Hear. 2002;23(5):399-415.
8. Miltenberger GE, Dawson GJ, Raica AN. Central auditory testing with peripheral hearing loss. ArchOtolaryngol. 1978;104(1):11-5.
9. Koravand A, Jutras B, Lassonde M. Auditory event related potentials in children with peripheral hearing loss. Clin Neurophysiol. 2013;124(7):1439-47.
10. Koravand A, Jutras B, Roumy N. Peripheral hearing loss and auditory temporal ordering ability in children. Int J Pediatr Otorhinolaryngol. 2010;74(1):50-5.
11. Leigh-Paffenroth ED, Roup CM, Noe CM. Behavioral and electrophysiologic binaural processing in persons with symmetric hearing loss. J Am Acad Audiol. 2011;22(3):181-93.
12. Sininger YS, Doyle K, Moore JK. The case for early identification of hearing loss in children. Auditory system development, experimental auditory deprivation, and development of speech perception and hearing. Pediatr Clin North Am. 1999;46(1):1-14.
13. Blamey PJ, Sarant JZ, Paatsch LE. Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. J Speech Lang Hear Res. 2001;44(2):264-85.
14. Moeller MP. Early intervention and language development in children who are deaf and hard of hearing. Pediatrics. 2000;106(3):E43.
15. Yoshinaga-Itano C. Levels of evidence: universal newborn hearing screening (UNHS) and early hearing detection and intervention systems (EHDI). J Commun Disord. 2004;37(5):451-65.
16. Quittner AL, Barker DH, Cruz I, Snell C, Grimley ME, Botteri M; the CDaCI Investigative Team. Parenting Stress among Parents of Deaf and Hearing Children: Associations with Language Delays and Behavior Problems. Parent Sci Pract. 2010;10(2):136-155.
17. Hintermair M. Parental resources, parental stress, and socioemotional development of deaf and hard of hearing children. J Deaf Stud Deaf Educ. 2006;11(4):493-513.
18. Miltenberger GE, Dawson GJ, Raica AN. Central auditory testing with peripheral hearing loss. Arch Otolaryngol. 1978;104(1):11-5.
19. Neijenhuis K, Tschur H, Snik A. The effect of mild hearing impairment on auditory processing tests. J Am Acad Audiol. 2004;15(1):6-16.
20. Moncrieff DW. Dichotic listening in children: age-related changes in direction and magnitude of ear advantage. Brain Cogn. 2011;76(2):316-22.
21. Shahmir B, Hajiabolhassan F, Mohammad-khani G, Tahaei AA, Jalaie S. Development and evaluation of the reliability of Persian version of double dichotic digit test in girls aged 7 to 11 years. Aud Vest Res. 2015;24(3):164-7.
22. American Speech-Language-Hearing Association. Central auditory processing: current status of research and implications for clinical practice (technical report). 1996. Retrieved October 30, 2007. http://www.asha.org/policy
23. Iliadou V, Bamiou DE, Kaprinis S, Kandylis D, Kaprinis G. Auditory processing disorders in children suspected of learning disabilities--a need for screening? Int J Pediatr Otorhinolaryngol. 2009;73(7):1029-34.
24. Mukari SZ, Keith RW, Tharpe AM, Johnson CD. Development and standardization of single and double dichotic digit tests in the Malay language. Int J Audiol. 2006;45(6):344-52.
25. Moncrieff DW, Wilson RH. Recognition of randomly presented one-, two-, and three-pair dichotic digits by children and young adults. J Am Acad Audiol. 2009;20(1):58-70.
26. Neijenhuis K, Snik A, Priester G, van Kordenoordt S, van den Broek P. Age effects and normative data on a Dutch test battery for auditory processing disorders. Int J Audiol. 2002;41(6):334-46.