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Dichotic training in children with auditory processing disorder

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ABSTRACT

Objectives: Several test batteries have been suggested for auditory processing disorder (APD) diagnosis. One of the important tests is dichotic listening tests. Significant ear asymmetry (usually right ear advantage) can be indicative of (APD). Two main trainings have been suggested for dichotic listening disorders: Differential Interaural Intensity Difference (DIID) and Dichotic Offset Training (DOT). The aim of the present study was comparing the efficacy of these two trainings in resolving dichotic listening disorders.

Methods: 12 children in the age range of 8 to 9 years old with APD were included (mean age 8.41 years old ± 0.51). They all had abnormal right ear advantage based on established age-appropriate norms for Farsi dichotic digit test. Then subjects were randomly divided into two groups (each contained 6 subjects): group 1 received DIID training (8.33 years old ± 0.51) and group 2 received DOT training (8.50 years old ± 0.54).

Results: Both trainings were effective in improvement of dichotic listening. There was a significant difference between two trainings with respect to the length of treatment (P-value ≤ 0.001). DOT needed more training sessions (12.83 ± 0.98 sessions) than DIID (21.16 ± 0.75 sessions) to achieve the same amount of performance improvement.

Conclusion: Based on the present study it can be assumed that DOT might be a good replacement for DIID training in cases that DIID is not applicable and DIID candidacy conditions are not met. To generalize the results, studies with larger sample sizes are recommended.

1. Introduction

Central auditory processing disorder (APD) is defined as a deficit in auditory performances such as sound localization and lateralization, auditory temporal processing, auditory discrimination, auditory performance in presence of noise, or comprehension of degraded signals [1]. Therefore, this term can refer to a wide variety of auditory functional deficits [2]. One of the complaints of these patients is listening difficulty in noisy environments which can lead to academic failure in children and can affect the quality of life in elderly [1,3,4].

Several test batteries have been suggested for APD diagnosis (e.g. Buffalo model, Bellis-Ferre Model and MAPA (multiple auditory processing assessments)) [5–7]. One of the important test that is included in almost all of the APD test batteries, is dichotic listening tests. The dichotic hearing is a condition in which different auditory stimuli are presented simultaneously to each ear [8]. In psychological studies dichotic listening has been used for evaluation of divided (binaural integration) and selective attention (binaural separation). In the former, listener must attend to both ears (free recall) and in the latter listener must attend to only one ear (focused or directed recall). Dichotic tests can also help determining language dominant hemisphere. Corpus callosum is important for inter-hemispheric transfer in dichotic listening [9,10]. A variety of stimuli can be used for dichotic testing including syllables, digits, words or sentences [11]. Test interpretation is based on individual ear score and ear advantage. Ear advantage is the difference between the score of two ears in a given dichotic listening task [12–14]. In children usually, right ear score is higher than the left ear and it shows that left brain hemisphere is language dominant. This phenomenon is called REA (Right Ear Advantage). REA has an age-related norm and if it is outside the established norm, it is interpreted as abnormal interaural asymmetry [14–16]. Stimuli presented to the left ear have to pass through corpus callosum and reach to left hemisphere which is language dominant brain hemisphere in most people. With age ear asymmetry (REA) decreases and in 11–12-year-old children, REA is similar to adults [16,17]. Dichotic listening maturation is highly related to corpus callosum maturation (myelination) which occurs by age of 10. Corpus callosum maturation facilitate inter-hemispheric transfer and leads to decrement in the ear asymmetry [18].

Significant ear asymmetry (usually REA) can be indicative of APD. Deborah Moncrieff suggested that when there is a significant interaural

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asymmetry in dichotic listening tasks, there is actually an amblyaudia [19]. Difficulty in dichotic speech recognition skills has a significant correlation with poor speech recognition in adults and poor auditory processing in the classroom in children [20].

Two main trainings has been suggested for dichotic listening disorders: Differential Interaural Intensity Difference (DIID) and Dichotic Offset Training (DOT) [21,22]. DIID uses interaural intensity difference (IID) and DOT uses interaural time difference (ITD). The aim of the present study was comparing the efficacy of these two trainings in resolving dichotic listening disorders.

2. Method

2.1. Participants

50 children with listening, spelling and reading problems were referred to the audiology clinic for auditory processing evaluations in November and December of 2017. Among these children, 12 children in the age range of 8–9 years old were diagnosed as having APD (mean age 8.41 years old ± 0.51). They had normal PTA (auditory threshold ≤ 20 dB HL in 500 to 4000 Hz) in both ears; symmetric hearing thresholds (PTA difference ≤5 dBHL between two ears); normal middle ear function (normal tympanogram); Wechsler IQ-children score ≥85, monolingualism (Persian language); no history of ADHD, seizures, behavioral or developmental disorders; not being on any central nervous system medications; having poor academic performance; abnormal results (≥2 SDs from established norms) in dichotic digit test (DDT), pitch pattern sequence test (PPST) and monaural selective auditory attention test (mSAAT). MAPA study showed that DDT/PPS/mSAAT test battery can provide 90% sensitivity and 100% specificity in APD diagnosis [5]. All these tests are available in Farsi language with appropriate age-related norms [1,16].

All the subjects were diagnosed as having APD for the first time and they were not under any training program at the time. Then subjects were randomly divided into two groups (each contained 6 subjects): group 1 received DIID training (8.33 years old ± 0.51) and group 2 received DOT training (8.50 years old ± 0.54). After the present study, they received comprehensive APD training. This comprehensive training included auditory attention and memory exercises, phonemic training program and noise desensitization training. The study protocol was approved by the Ethical Committee of Tehran University of Medical Sciences (TUMS) and written informed consent was obtained from all parents prior to the start of the study.

2.2. DIID procedure

After documenting that dichotic listening problem, a crossover performance point was established by reducing the intensity of the stimuli presented to the better ear. For utilization of the DIID, there are two conditions: performance in the poorer ear must be at normal or near normal limits at the crossover level and intensity of the stimulus presented to the better ear must not drop below the hearing threshold.

Once crossover point and candidacy for the procedure were established, initial training began with an interaural intensity difference (IID) that was 5 dB greater than the crossover point. The level at the poorer ear was kept at 50 dB HL. Tasks that were used included: dichotic CV, dichotic sentences and dichotic story in music background. During a session, patients were asked to attend to both ears (free recall), or attend to only one ear at a time (directed recall).

There were 4 sessions per week, each session lasted for 30 min. The aim was reducing the IID. If performance in the poorer ear was ≥80%, then training continued at that specific IID for the entire week. If performance was ≤80%, the IID was increased in 1 dB increments until the performance of the poorer ear reaches 80% or until the IID level returns to the starting level. The goal was improving performance to the normal limit [23]. Based on the established norms, when there was only 10% ear asymmetry, the performance was considered normal. When there was a 10% asymmetry or less, training was stopped and two weeks after training was completed, DDT was retested to make sure the outcome was permanent. DDT was tested at the end of each session, too.

2.3. DOT procedure

For DOT letters and CVs were used. Both materials were used during each session. The presentation was in the format of the staggered spondee word test (SSW test). Two letters and CVs were directed to the right ear and two letters and CVs to the left ear. There was an offset for the presentation of letters and for the first phoneme of the CVs [21]. Items began in the right ear (left ear lag). Lagging the presentation to the poorer ear helps it to process signal better. The patient had to repeat all four items in the correct order [24].

This training is similar in DIID II [25] and DOT [21,26]. DOT and DIID II have a common basic concept. The training started with competing items separated by 500 ms; gradually the offset was reduced by 100 steps for subsequent conditions. When the patient was able to perform the task with 80% accuracy or more at a specific offset, the offset was decreased [21]. At the end of each session, DDT was evaluated. When there was a 10% asymmetry or less, training was stopped and two weeks after training was completed, DDT was retested to make sure the outcome was permanent.

3. Results

12 children in the age range of 8–9 years old with APD were included (mean age 8.41 years old ± 0.51). Then subjects were randomly divided into two groups: group 1 received DIID training (8.33 years old ± 0.51) and group 2 received DOT training (8.50 years old ± 0.54). The results of the DDT before training were compared between two groups by using U-Mann Whitney, as data did not show normal distribution in K-S test of normality. There was not any significant difference between two groups (Table 1). As it is shown, there was a significant REA in all the cases. The results were compared with the age-appropriate norm in Farsi language [16].

Graph 1 and 2 show the trend of dichotic listening improvement (based on DDT) for DIID and DOT trainings. Both training were effective in improvement of dichotic listening. Table 2 summarizes the mean number of the training sessions for DIID and DOT trainings. There was a significant difference between the two trainings with respect to the length of training based on using U-Mann Whitney test (P-value ≤ 0.001). Table 3 shows patient characteristics and results in both groups.

4. Discussion

This study was performed on 12 children with APD who suffered from dichotic listening problems. They all had abnormal REA. They randomly received DIID or DOT trainings. Both trainings were effective and led to normal dichotic listening ability but DOT took more time to make the same amount of improvement in the dichotic listening task. Mean number of the training sessions for DIID was 12.83 ± 0.98 and for DOT was 21.16 ± 0.75. The training duration difference might be

Table 1
Results of the DDT in DIID and DOT groups before training.

		Mean	SD	SE	P-value
Right DDT	Group 1	91.66	4.08	1.66	0.72
	Group 2	90.83	3.76	1.53	
Left DDT	Group 1	36.66	6.05	2.47	0.51
	Group 2	34.16	6.64	2.71	
REA	Group 1	55.00	4.47	1.82	0.59
	Group 2	56.66	6.05	2.47	