

Dichotic integration: is it similar in the elderly and children?

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Background

Aging process is associated with central auditory changes, which may explain some understanding difficulties in elderly. It may be evaluated with the dichotic digits (DD) test, a widely used experimental paradigm for studying interhemispheric interactions.

Purpose

This study was performed to evaluate dichotic integration ability in the elderly and children populations by comparing it with adults who acted as reference.

Research design

The study design was a cross-sectional one. It was conducted in Ain Shams University, Faculty of Medicine, Demerdash Hospital, Audiology Unit, for a period of 4 years. The study comprised 75 participants divided into three groups: the adult group, the elderly group, and the pediatric group.

Data collection and analysis

Basic Audiological Evaluation and the DD test in the free recall condition were carried out in all participants.

Results

Results of this study suggest that central auditory processing concerning dichotic integration is different in children and elderly individuals when compared with adults. Moreover, there was no significant difference between elderly patients and children. The age had a direct correlation with DD test scores in children, but an inverse correlation in the elderly.

Conclusion

Dichotic integration as measured using the DD test is similar in the elderly and children, but in opposite directions with regard to its change with age progress.

Keywords:

children, dichotic integration, effect of age, elderly, progression, regression

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Introduction

Certainly, many listening difficulties experienced by the elderly are attributable to their presbycusis high-frequency hearing losses. Loss of peripheral hearing sensitivity, clearly, is an important factor in explaining the variation observed among the elderly on different speech recognition measures [1–3].

Over the past several decades, a considerable amount of research and theoretical speculation has accumulated on age-related changes in speech perception [4].

Three explanations of age-related declines in spoken language comprehension that have received the most attention are deficits related to the following:

- (1) Peripheral (i.e. cochlear) changes in auditory function.
- (2) General declines in cognitive performance.
- (3) Changes in more central auditory processes.

Certainly, one way to reduce redundancy in the assessment of central auditory processing is to present different speech stimuli to the two ears simultaneously, which is referred to as dichotic testing. It was proposed 50 years ago, when Doreen Kimura published two articles describing how dichotic digit (DD) testing could be used to help describe central auditory processing. Her explanation of the crossed auditory pathways, ipsilateral suppression, and the 'right ear effect' has withstood the test of time, and laid the groundwork for the design and interpretation of many audiologic tests that followed. Subsequently, in this study, my primary focus was to compare among children,

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adults, and elderly the dichotic integration process using the DD test.

Materials and methods

Patients

This study was conducted on a total of 75 participants who were divided into three groups: one control group and two study groups.

Control group

The control group comprised 18 adults, 12 male and six female, between 20 and 48 years of age selected from those attending the ENT outpatient clinic, Ain Shams University, Demerdash Hospital, according to the following criteria:

- (1) No history of peripheral hearing loss.
- (2) Normal hearing sensitivity (not exceeding 15 dB in the frequencies from 250 to 8000 Hz).
- (3) Normal middle ear functions.

Study groups

Group 1

Group 1 was divided on the basis of age into two subgroups. Subgroup 1a included 16 right-handed normal elderly individuals, 10 male and six female, between 65 and 75 years of age, selected from those attending the geriatric outpatient clinic in Ain Shams University, Demerdash Hospital, according to the following criteria:

- (1) No complaint as regards cognition.
- (2) No complaint as regards hearing.
- (3) Normal peripheral hearing sensitivity at least from 250 Hz up to 2 kHz.
- (4) Normal middle ear functions.

Subgroup 1b included 17 right-handed normal elderly individuals, nine male and eight female, between 75 and 85 years of age selected from those attending the geriatric outpatient clinic, Ain Shams University, Demerdash Hospital, according to the following criteria:

- (1) No complaint as regards cognition.
- (2) No complaint as regards hearing.
- (3) Normal peripheral hearing sensitivity at least from 250 Hz up to 2 kHz.
- (4) Normal middle ear functions.

Group 2

Subgroup 2a included 12 right-handed normal children, six male and six female, between 5 and 8 years selected from those attending the ENT

outpatient clinic, Ain Shams University, Demerdash Hospital, according to the following criteria:

- (1) No history of peripheral hearing loss.
- (2) Normal hearing sensitivity (not exceeding 15 dB in the frequencies from 250 to 8000 Hz).
- (3) Normal middle ear functions.
- (4) No complaint as regards scholastic achievement.

Subgroup 2b included 12 right-handed normal children, six male and six female, between 9 and 12 years of age selected from those attending the ENT outpatient clinic, Ain Shams University, Demerdash Hospital, according to the following criteria:

- (1) No history of peripheral hearing loss.
- (2) Normal hearing sensitivity (not exceeding 15 dB in the frequencies from 250 to 8000 Hz).
- (3) Normal middle ear functions.
- (4) No complaint as regards scholastic achievement.

Equipment

- (1) Two-channel audiometer, Grason-Stadler Inc. (GSI; Grason-Stadler Inc., Corporate Headquarters, USA, 10395 West 70th St. Eden Prairie, MN 55344) model 61 connected to a CD player
- (2) Sound-treated room IAC model 1602.
- (3) Immittance meter GSI model 33.

Methods

- (1) Full history taking with special emphasis on scholastic achievement in children and cognitive function in the elderly.
- (2) Otological examination.
- (3) Pure-tone audiometry, including air and bone conduction (age-based hearing threshold determination), and speech audiometry, including speech reception threshold and speech discrimination.
- (4) Immittance meter, including tympanometry and acoustic reflex threshold.
- (5) DD test: two versions of the test, carried out simultaneously in both ears at 50 dB SL [5]. In version I, the patient would hear one digit in one ear and simultaneously hear a different digit in the other ear. The task was to repeat back the two digits. In version II, the patient would hear two digits in one ear and simultaneously hear two different digits in the other ear. The task was to repeat back all four digits. This test was chosen to assess dichotic integration ability because it is a simple test that is suitable for different age

categories; moreover, it is not affected by mild hearing loss.

- (6) Informed consent was obtained from the patients (in the control group and group 1) and parents (in group 2).

Data analysis

Analysis was performed using SPSS, version 19. Means, SDs, and range were calculated for all test results of the participants. Analysis of variance was run to compare the results of the study groups and post-hoc test was run to compare all groups when analysis of variance test showed significant difference. Pearson correlation (*r*) was run to study correlation between age and DD test scores in each group.

Results

From Table 5 it is clearly evident that the youngest subgroup of children have similar scores to the oldest participants of the elderly group and the oldest subgroup of children have similar scores to that of the youngest subgroup of elderly group, with a statistically significant difference between the youngest and oldest subgroups of both groups.

Discussion

Dichotic work and its related tests for studying the functional asymmetry between the left and right hemispheres became more popular because it helped neuropsychologists to study significant aspects of brain function without invading the brain and without reliance on medical settings. They became an important addition to the traditional neurological methods of investigation.

Many studies investigated dichotic processing in the elderly. However, to the author’s best knowledge, no

study compared the elderly and children with regard to dichotic integration processing. In this study, all children and adults had normal hearing, whereas the elderly showed varying degrees of mild high-frequency sensorineural hearing loss consistent with presbycusis (Fig. 1). For this cause, the DD test was chosen, to avoid the effect of presbycusis in the elderly group.

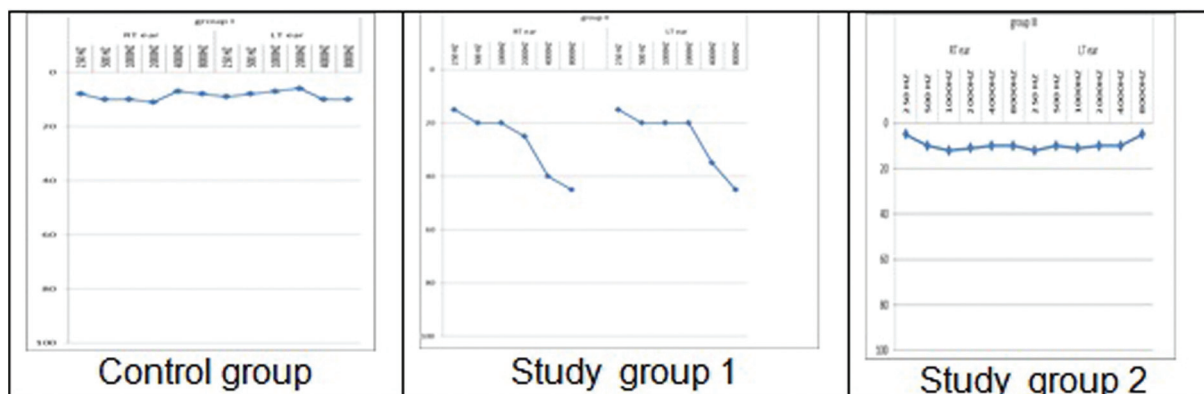
On the basis of crossed pathways, the suppression of the ipsilateral by the contralateral pathway and the representation of linguistic processing in the left hemisphere in most individuals remain an essential ingredient for understanding this basic asymmetry in sensory and perceptual processing. As regards right ear scores, all study groups had no statistically significant difference either in version I or version II. However, as regards the left ear scores, the adult group had the highest scores in both versions, in addition to smallest difference between the right and the left ear Right Ear Advantage (REA) (Table 1).

Lower scores were found in the left ear of both study groups, in addition to larger REA, with a statistically significant difference between the two study groups and the control group. Moreover, no statistically significant difference was found between the two

Table 1 Means and SD of the three groups

	Version I RT	Version I LT	Version II RT	Version II LT
Control				
X	99.166	96.166	90.183	88.6
SD	1.917	1.98	6.387	8.52
Group 1				
X	98.15	89.30	90.192	79.65
SD	8.245	1.991	5.55	5.43
Group 2				
X	97.18	89.45	89.54	80.36
SD	1.942	3.276	2.154	3.00

Figure 1



Means of pure-tone threshold in the three groups.

study groups, reflecting a similar processing of the central auditory system (Tables 2 and 3).

Dichotic integration processing is a top-down control of a bottom-up auditory processing, and hence deficiency in children can be explained by immature central auditory system, especially the corpus callosum; however, in the elderly, deficiency was mostly explained by senile changes and demyelination of the corpus callosum. Such findings match cognitive models that describe an overall reduction in the speed of mental processing [6,7].

Table 4 reports that age-related changes in the corpus callosum were in positive direction during childhood and in negative direction during senility but in the plateau phase during adulthood. Table 5 reflects that the youngest subgroup of children have similar scores to the oldest one of the elderly group and the oldest subgroup of children have similar scores to that of the youngest subgroup of the elderly group, with a statistically significant difference between the youngest and oldest subgroups of both groups. These findings reflect that the age-related regression in the

dichotic integration of elderly is continuous and of the same speed as age-related progression in the children. Comparable findings were found in a study by Jerger and Jordan. They compared performances between a group of young and older adults on a cued-listening task [8]. Moreover, similar findings were reported by Zenker *et al.* [9] using DD test in participants with ages ranging from 6 to 72 years. Heiran *et al.* [10] also

Table 2 Analysis of variance test to compare dichotic digits scores among the three groups

	Version I RT	Version I LT	Version II RT	Version II LT
<i>F</i>	0.029	38.031	0.065	8.659
<i>P</i>	3.918	0.000	0.937	0.001

Significant difference was found among the three groups in left ear scores of both versions of dichotic digits (DD).

Table 3 Post-hoc tests (least significant difference) to compare among the three groups in dichotic digits test

Test	I group	J group	Significance
Version I LT (left ear)	Control	Group 1	0.002
		Group 2	0.000
	Group 2	Control	0.000
		Group 1	0.366
Difference between ears (REA)	Control	Group 1	0.005
		Group 2	0.000
	Group 2	Control	0.000
		Group 1	0.180
Version II LT	Control	Group 1	0.000
		Group 2	0.050
	Group 2	Control	0.050
		Group 1	0.083
Difference between ears (REA)	Control	Group 1	0.000
		Group 2	0.042
	Group 2	Control	0.042
		Group 1	0.089

Left ear scores showed significant difference between the control group and either group 1 or 2. However, nonsignificant difference was found between group 1 and group 2. *The mean difference is significant at the 0.05 level.

Table 4 Pearson correlation between age and scores of dichotic digits test

Age	Control group	Group 2	Group 3
Version I RT			
Pearson correlation	0.053	-0.906**	0.554**
Significance (two-tailed)	0.834	0.000	0.008
Version I LT			
Pearson correlation	-0.106	-0.395	0.524*
Significance (two-tailed)	0.675	0.062	0.012
Version II RT			
Pearson correlation	-0.061	-0.898**	0.758**
Significance (two-tailed)	0.810	0.000	0.000
Version II LT			
Pearson correlation	0.141	-0.853**	0.654**
Significance (two-tailed)	0.577	0.000	0.001

Significant positive correlation with age in children and significant negative correlation with age in the elderly. However, no significant correlation was found with age in the adult group. *The mean difference is significant at the 0.05 level. **The mean difference is significant at the 0.01 level.

Table 5 Post-hoc test (least significant difference) to compare among the subgroups of groups 2 and 3 in the left ear dichotic digits test results

Test	I group	J group	Significance	
Version I LT	1a	1b	0.032*	
		2a	0.043*	
		2b	0.312	
	2a	1b	0.257	
		2b	0.026*	
		1b	0.041*	
Difference between ears (REA)	1a	1b	0.012*	
		2a	0.023*	
		2b	0.312	
	2a	1b	0.259	
		2b	0.016*	
		1b	0.031*	
Version II LT	1a	1b	0.002*	
		2a	0.033*	
		2b	0.362	
	2a	1b	0.267	
		2b	0.028*	
		1b	0.043*	
Difference between ears (REA)	1a	1b	0.027*	
		2a	0.036*	
		2b	0.982	
	2a	1b	0.814	
		1b	2b	0.016*
		2b	0.024*	

*The mean difference is significant at the 0.05 level.

reported diminished performance of both ears in the elderly compared with adults in free attention and left ear performance in focused attention condition.

This study had measured performance in normal children without complains of any scholastic underachievement and in the elderly without any complaint related to cognitive problems. Their data can be used as normative data to compare with individuals of different ages to assess dichotic processing in these populations.

Conclusion

Dichotic integration processing was similar in the elderly and children, but in opposite direction with regard to its progress with age. The dichotic processing curve along age is well understood from this study.

Recommendation

When assessing dichotic processing in children as well as elderly we should take the normative age-related values as a reference (not the adult values) and consider the age-related changes especially in the elderly population.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

- 1 Helfer KS, Wilber LA. Hearing loss, aging, and speech perception in reverberation and noise. *J Speech Hear Res* 1990; 33:149–155.
- 2 Humes LE, Roberts L. Speech-recognition difficulties of the hearing-impaired elderly: the contributions of audibility. *J Speech Hear Res* 1990; 33:726–735.
- 3 Humes LE, Christopherson L. Speech identification difficulties of hearing-impaired elderly persons: the contributions of auditory processing deficits. *J Speech Hear Res* 1991; 34:686–693.
- 4 Working Group on Speech Understanding and Aging. Committee on Hearing, Bioacoustics, and Biomechanics, Commission on Behavioral and Social Sciences and Education, National Research Council. *J Acoustic Soc Am* 1988; 83:859–895.
- 5 Tawfik S, Abdel Maksoud A, Weheiba H. Standardization of two binaural integration tests (dichotic digits & dichotic rhyme tests) in normal children [unpublished Master thesis]. Abbaseya, Cairo, Egypt: Ain Shams University; 2007.
- 6 Kemper S. Language and aging. In: Craik F, Salthouse T, editors. *The handbook of aging and cognition*. Hillsdale, NJ: Lawrence Erlbaum; 1992: 213–270.
- 7 Salthouse T. Speed of behavior and its implications for cognition. In: Birren J, Schaie K, editors. *Handbook of the psychology of aging*. 2nd ed. New York: Van Nostrand Reinhold Co., Inc; 1985: 400–426.
- 8 Jerger J, Jordan C. Age-related asymmetry on a cued-listening task. *Ear Hear* 1992; 13:272–277.
- 9 Zenker F, Mora Espino R, Marro Cosialls S, De Lucas Carmona G, Fernández Belda R, Barajas JJ. The effect of age over the Dichotic Digit test. 8th EFAS Congress/10th Congress of the German Society of Audiology (2007)
- 10 Heiran F, Mahdavi M, Baghban A, Heiran M. Free and focused attention in young and aged listeners using randomized dichotic digits test. *Aud Vest Res* (2015) 2015; 24:186–192.