

ORIGINAL ARTICLE

Open Access



# Effects of aging on dichotic listening ability

Somaia Mohamed Tawfik and Noha Ali Shafik\*

## Abstract

**Background:** Elderly patients frequently suffer from problems in speech discrimination especially in noisy situation, and they also have several problems from using amplifications devices especially binaural amplification. This necessitates the need for central auditory evaluation in association of peripheral auditory evaluation. The aim of the present study was to explore the effects of aging on dichotic listening performance. This was a case-control study conducted at the Audiology Unit, ENT Department. Participant were 46 individuals within the age range of 60 to 89 years with no history of neurological disorder or cognitive impairment, and all the participants were of high social class. Forty-five adult individuals (control group) with the age range 32–57 years, with no history of neurological disorders. Both cases and control groups were subjected to otological examination, immittanceometry, puretone audiometry, speech audiometry, and central auditory processing assessment by the use of central questionnaire for elderly and dichotic digits (version II) test.

**Results:** The elderly group scored significantly depressed scores of dichotic digits' test, especially in the left ear than in the adult group.

**Conclusion:** Dichotic listening ability was significantly affected in elderly patients.

**Keywords:** Elderly, Dichotic listening, Right-ear advantage, Speech discrimination

## Background

Dichotic listening refers to listening to different acoustic events presented to each ear simultaneously. The ability to both integrate and segregate binaural information during normal listening is essential in accurate speech perception and localization, especially in difficult listening situations. There has been strong evidence of weaknesses in dichotic listening among children with a variety of learning, language, and reading problems [1], and evidence suggests an aging effect on the perception of dichotic stimuli [2].

Dichotic listening (DL) has been used to estimate the language lateralization and auditory attention both in children and in adults [3]. The right-ear advantage (REA) in dichotic listening (DL) reflects stimulus-driven bottom-up asymmetry in speech processing. Moreover, it can be modified by top-down attentional control [3].

Elderly often have more difficulty understanding speech than younger adults, particularly in noisy and challenging listening situations. While loss in peripheral hearing sensitivity explains many of the listening problems of elderly persons, age-related declines in general cognitive skill and central auditory processing also appear to contribute [4]. Although prevalence data are not available, its prevalence appears to increase with age. In cognitively intact elderly with presbycusis and poor speech discrimination, CAPD may be present in 5–10% of patients [5].

Age-related changes have been documented in the auditory periphery, the auditory portions of the central nervous system, and in many non-auditory portions of the cortex that are believed to mediate various cognitive functions. Each of these age-related changes, in isolation or in combination, may lead to corresponding age-related declines in speech communications abilities. Identification of the underlying causes of age-related decline in speech communications is critical for remediation purposes of such difficulties [5].

\*Correspondence: [nohashafik4@gmail.com](mailto:nohashafik4@gmail.com)  
Audiology, ENT Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Aging is associated with cognitive changing. Central auditory processing dysfunction may explain some understanding difficulties in elderly. It can be evaluated with the dichotic listening (DL) test, a widely used experimental paradigm for studying inter-hemispheric interactions and attentional processes [6].

One important aspect of deficit in dichotic listening ability is its negative effect on the successful use of amplification in elderly. Assessment of dichotic listening ability is important to identify functional deficits that could be associated to difficulties in communication especially in noisy and challenging listening environments, like far, and faint speech even by using high-quality hearing aids for correction of peripheral hearing loss [7].

Right-ear advantage (REA), seen in dichotic listening tests, was considered as stemming from an impairment of the inter-hemispheric auditory pathways, that is responsible for transmitting auditory information between two hemispheres through auditory fibers of corpus callosum [7]. From this point of view, binaural amplification may not be the best intervention strategy for elderly persons with marked right/left ear asymmetry diagnosed by dichotic digits test.

This study sought to evaluate the effects of aging on dichotic listening performance. More studies are needed to investigate the predictive value of DD test and REA as a marker of an underlying structural problem in the central auditory pathways. That can help in implantation of auditory training program which may improve dichotic listening ability, hearing in noisy, and challenging listening environment and also help to gain more satisfaction of amplification in elderly persons.

## Methods

### Design

This was a case-control study.

### Settings

This study was set at the Audiology Unit, ENT Department. Forty-six individuals within the age range of 60 to 89 years were recruited from hospital out-patient clinic. All the patients are right-handed except two patients who were left-handed. The entire subjects included in this study are of high social class.

### Inclusion criteria

- Elderly patients more than or equal 60 years.
- Problem in speech discrimination in noisy situation.
- Unsatisfactory response to binaural amplification.

### Exclusion criteria

- History of neurological disorders.
- History of cognitive disorder.

The patients underwent basic audiological evaluation in the form of puretone audiometry, speech audiometry, immittance measures, and stapes reflex thresholds.

The control group was compared with 45 adult individuals with the age range 32–57 years, with no history of neurological or cognitive impairment. Both study and control groups were subjected to udiometry examination, immittancemetry, puretone audiometry and speech audiometry. All the subjects examined by “Scale of Auditory Behaviors” questionnaire and one of the central auditory psychophysical tests that assess the dichotic listening ability Arabic dichotic digits’ test version II.

### Equipment

- Sound treated room I.A.C model 1602.
- Two channel Audiometer interacoustics, model AC40.
- Immittancemetry model otopront.
- Cassette tape recorder
- CD for dichotic digits’ test.

Dichotic digits’ test was chosen as it assesses dichotic listening ability at a cortical level and is not affected by peripheral hearing loss which is a common finding in elderly patients. In this test, two Arabic digits were presented simultaneously to both ears at equal sensation level at the most comfortable level. The patient task is to repeat all the digits he/she heard and the percent correct score was calculated separately at each ear.

N.B. Dichotic Digits test (version I) was excluded from the central test battery as it was too easy.

### Auditory testing

Puretone audiometry (PTA) (air and bone conduction thresholds) and speech udiometry) including determination of speech reception threshold (SRT) using Arabic spondee words and word discrimination scoring (WDS) using Arabic phonetically balanced words were done by the use of double channel audiometer model (interacoustics AC33, Denmark). Immittancemetry (including tympanometry and acoustic reflexe thresholds measurement) was done by the use of a tympanometry model (Amplaid 720, Immittancemetry, Milan, Italy).

### Central auditory test battery

Scale of Auditory Behaviors questionnaire was developed by Simpson [8]. The questionnaire was translated into Arabic language to be applied in the present study [9].

Behavior items	Frequent	Almost always	Sometimes	Sporadic	Never
1. Difficulty to hear and understand in noisy environment.	1	2	3	4	5
2. Not understanding when someone speaks quickly or speak muffle.	1	2	3	4	5
3. Difficulty following oral instructions.	1	2	3	4	5
4. Difficulty in the identification and discrimination of speaking sounds.	1	2	3	4	5
5. Inconsistent responses to auditory information.	1	2	3	4	5
6. Poor reading skills.	1	2	3	4	5
7. Request to repeat things.	1	2	3	4	5
8. Easily distracted.	1	2	3	4	5
9. Academic difficulties or learning.	1	2	3	4	5
10. Short period of attention.	1	2	3	4	5
11. Daydreaming, seems inattentive.	1	2	3	4	5
12. Unorganized	1	2	3	4	5

Score ... ..(sum of items circled)

### Arabic version

Scale of Auditory Behaviors questionnaire was developed by [8]. The questionnaire was translated into Arabic language to be applied in the present study [9].

The greater the score the better the prognosis.

### Dichotic digit test

This is a central auditory test that assesses binaural Integration skills. It was administered using recorded Arabic digits at 50-dB sensation level (SL). The dichotic digits test has two versions [10]. Version II was used in this study and consists of 20 items, four digits in each item. Four additional items were included for practice. Digits were presented by tape cassette. Testing by version II includes presenting a pair of digits to one ear and another pair to the second ear simultaneously. The subject was instructed to repeat all what he/she has heard in both ears irrespective of the order of presentation.

### Results

Of the 46 elderly examined, all were right handed except two patients were left handedness and all of them had active social life. Twenty-seven were women and 19 were men. Fifteen elderly were between 80 and 89 years, 16 were between 70 and 77 years, 15 were between 60 and 69 years. Mean age was 73.6 years. All the patient's complaint from difficulty in speech discrimination in noisy situations or faint and/or far or fast speech.

Table 2 shows no statistically significant difference between 2 groups.

Table 4 shows reduced scores of questionnaire among study group than control group with high statistically significant difference between study and control groups.

### Psychophysical test results

Table 5 shows reduced scores of DD test in both ears in the elderly group than the adult group with high statistically significant difference especially in left ear and REA.

Table 6 shows depressed scores of DD test more in the left ear in the elderly subgroups, with more regressions of the scores in the left ear with more increase in the age, with subsequent increase in the REA.

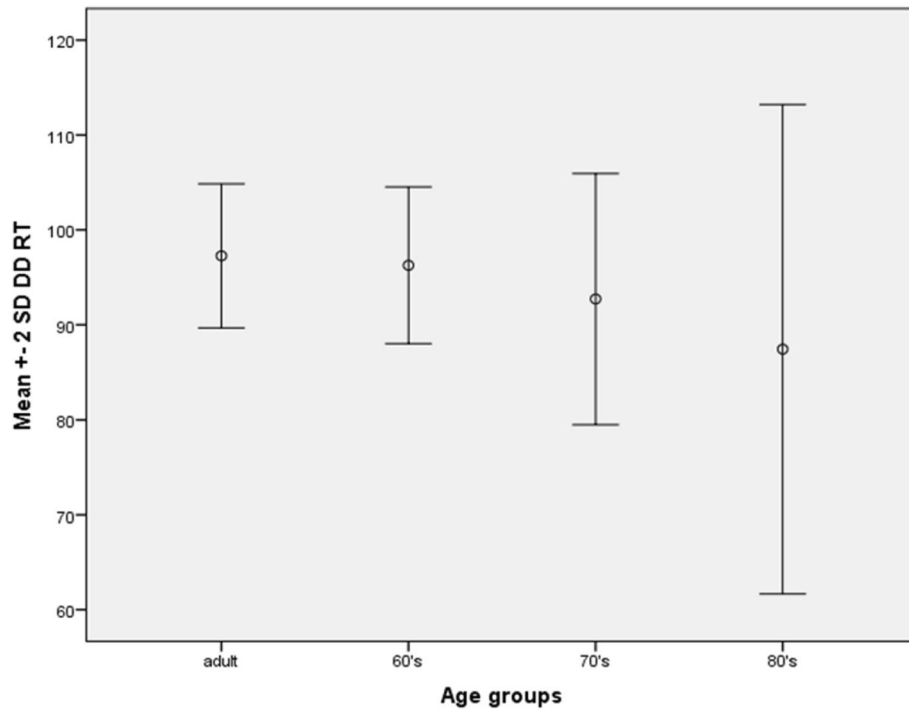
Table 8 shows strong significant correlation between age and results of DD test in both ears and REA.

Figures 1 and 2 show reduced mean scores of DD test (right and left ears) in the elderly subgroups with large SD especially with more advanced age

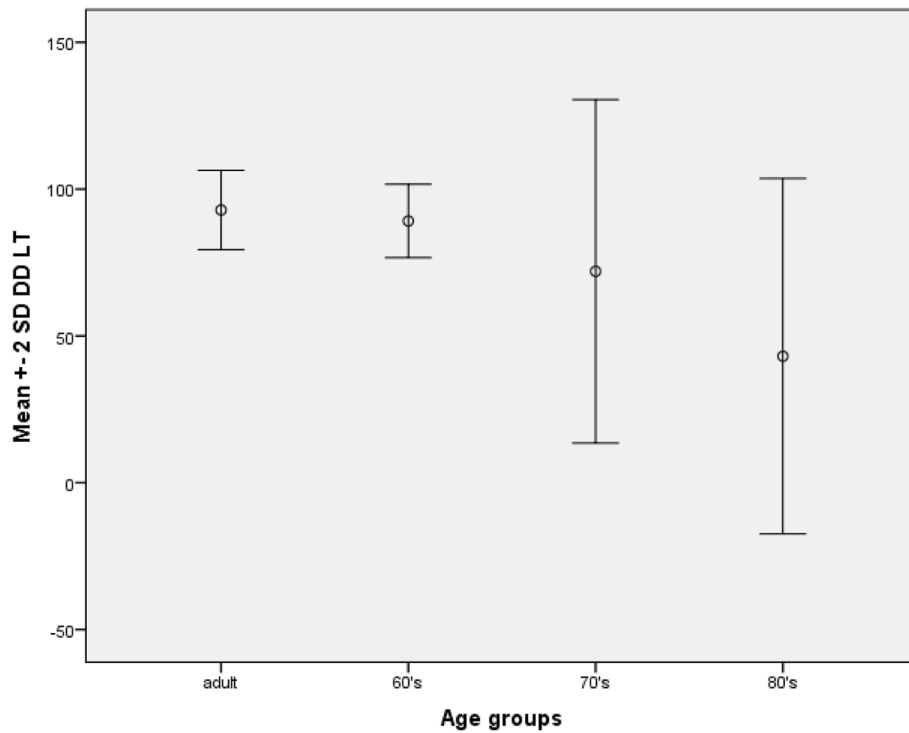
Figure 3 shows increase REA of DD test for the study subgroups with is evident with the elderly subgroups (70s and 80s), with large SD with more advanced age.

### Discussion

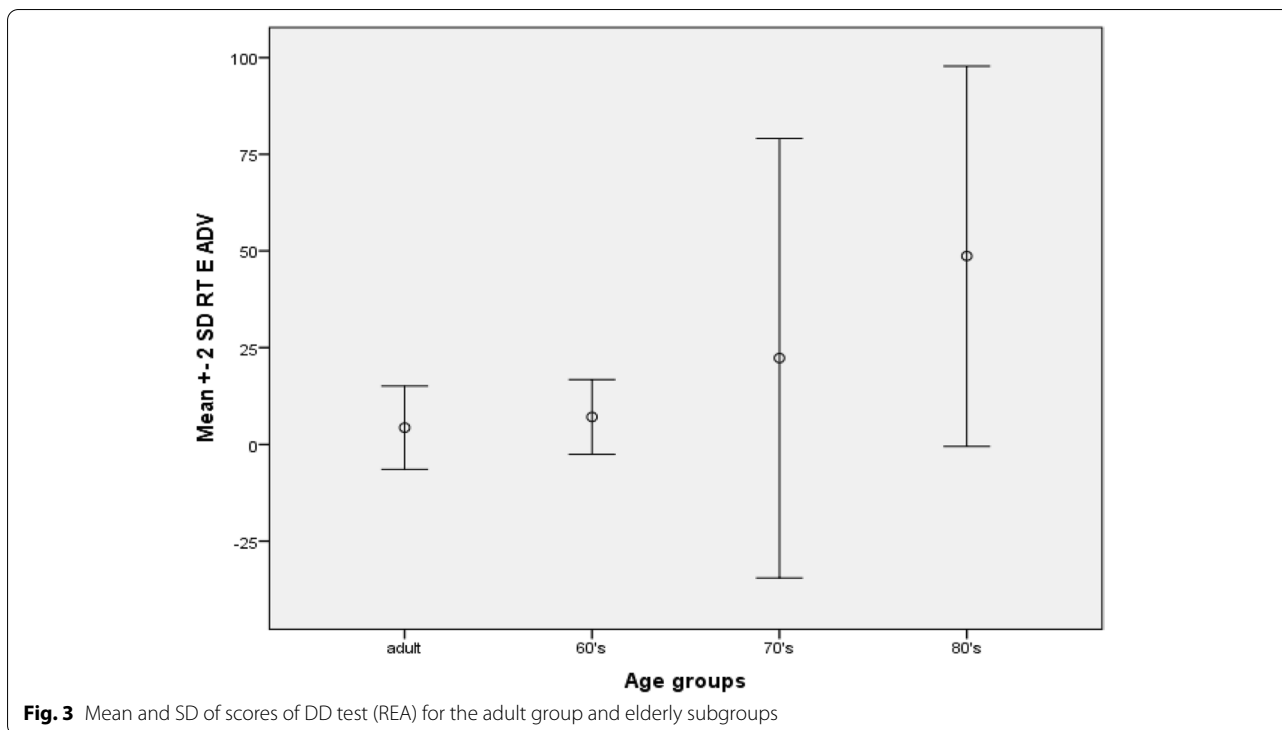
The study consisted of 46 elderly subjects with the mean age 73.6 (Table 1). Twenty-seven females and 19 males are included in the study group (Table 2). Most of the participant in the study are right handedness (Table 3). The results demonstrate the effect of age on performance on the DL task. Table 4 shows depressed mean scores of the questionnaire in comparison with the control. It demonstrates the problems frequently encountered by elderly in hearing in difficult listening situations and difficulty in speech discrimination especially far and faint speech. Psychophysical examination of the elderly subjects reported bad performance in dichotic listening tasks (dichotic digits' test) when compared to adult individuals (Tables 5 and 6 and Figs 1, 2, and 3). This finding agreed with [3]. Such finding could explain the impairment in some central auditory abilities. Right-ear advantage (REA) seen in dichotic



**Fig. 1** Mean and SD of scores of DD test in the right ear in the adult group and elderly subgroups



**Fig. 2** Mean and SD of scores of DD test in the left ear in the adult group and elderly subgroups



**Table 1** Age distribution in the study and control groups

Age	Study group	Control group
Mean	73.6	45
Range	60-89	30-56
Total number	46	45

listening tests was noticed in the elderly group, not in the adult subjects (Tables 5 and 6 and Figs. 1, 2, and 3). This could be result from an impairment of the inter-hemispheric transfer of auditory information through auditory pathways [11]. This finding agreed with Bouma and Gootjes (2011) [12], and they reported that elderly showed increasingly more difficult focusing attention on the left ear (LE) with advancing age. This finding was noticed in elderly due to different hypothesis, like

decrease myelination and decrease number of neuron cells.

Auditory processing assessment is an important aspect to identify central auditory deficits that could be associated to difficulties in speech understanding, and unsatisfactory response to hearing amplification interventions especially binaural amplification in elderly patients with peripheral hearing loss [13].

The inter-aural asymmetry (REA) characterizing performance on linguistically based dichotic listening tasks increases systematically with age with wide variability in the results with more advanced age (Tables 5 and 6 and Figs. 1, 2, and 3). This finding could be attributed to wide variability in the age-related decline in the efficiency of inter-hemispheric transfer of auditory information and to lesser extent by decline in cognitive abilities and age-related vascular insufficiencies [11, 13]. Takio et al. 2009 reported that the right-ear advantage (REA) in dichotic listening (DL) reflects

**Table 2** Gender distribution in the study and control groups

		Study		Control		$\chi^2$	P
		N	%	N	%		
Gender	Male	19	41.3%	23	50.0%	.701	.402
	Female	27	58.7%	23	50.0%		

**Table 3** Handedness distribution in the study group

Study		N	%
Handedness	Right	43	93.5%
	Left	3	6.5%

*N.B.* All the adult (control) group were right handedness

**Table 4** Mean and SD of score of questionnaire among study and control groups

Score of questionnaire	Mean	SD	Minimum	Maximum	P
Study group	43.1	10.7	22.0	56.0	.000
Control group	57.7	3.1	56.6	60	

importance of central auditory processing evaluation in association with the basic audiologic evaluation for better hearing intervention outcomes.

There was strong correlation between results of DD test and age of the subjects (Table 8). As the scores of DD test in the right ear, left ear decreased with increase age with more deterioration at the late 70s, with subsequent increase in the REA (Table 5). This explain that the interaural asymmetry characterizing performance on linguistically based dichotic listening tasks increases systematically with age. This due to decrease efficiency of inter-hemispheric transfer of auditory information across the corpus callosum. This could be attributed to decrease myelination of the neurons, firing capacity, and number of the neurons with increase age.

**Table 5** Mean, SD, and *t* test of the dichotic digits test (version II) (right ear, left ear, and REA) in both study and control groups

	Study		Control		Independent <i>t</i> test	P
	Mean	Standard deviation	Mean	Standard deviation		
DD RT	92.2	9.2	97.3	3.8	3.480	.001
DD LT	68.2	30.7	92.9	6.7	5.333	.000
REA	25.9	27.5	4.4	5.4	5.215	.000

stimulus-driven bottom-up asymmetry in speech processing. The REA can also be modified by top-down attentional control. Young adults were fully capable of doing so. However, in elderly group, this top-down attentional control was lost again.

In the present study, the elderly individuals examined, despite having good reasonable peripheral hearing as expected for age (Table 7), altered results in their dichotic listening were found. These results suggest the

This finding could explain why binaural hearing aids may not be the best intervention strategy for some elderly persons who complaint from bilateral hearing loss. So, in addition to traditional amplification, assistive listening devices are another useful resource to assist elderly persons in overcoming the problems caused by hearing loss, and the evaluation and remediation of the affected central auditory abilities should be considered.

**Table 6** Mean, SD, and range of the dichotic digits test (version II) (right ear, left ear, and REA) in the elderly subgroups (60s, 70s, 80s) and the adult group

		N	Mean	Std. deviation	Minimum	Maximum	F	P
DD RT	Adult	46	97.26	3.797	90	100	9.049	.000*
	60s	15	96.27	4.131	90	100		
	70s	16	92.72	6.608	80	100		
	80s	15	87.43	12.888	65	100		
DD LT	Adult	46	92.89	6.744	70	100	31.477	.000*
	60s	15	89.13	6.255	80	100		
	70s	16	72.00	29.251	0	100		
	80s	15	43.10	30.267	5	98		
REA	Adult	46	4.37	5.385	0	20	31.721	.000*
	60s	15	7.13	4.824	0	17		
	70s	16	22.28	28.391	-2	100		
	80s	15	48.67	24.565	4	90		

**Table 7** Mean, SD, and *t* test of (PTA) hearing threshold levels across tested frequencies (250 Hz–4000 Hz) and Ds% in right and left ears in both study and control groups

	Study		Control		<i>P</i>
	Mean	SD	Mean	SD	
250 R	27.7	10.6	21.3	2.5	.000
500R	26.3	13.8	16.6	2.6	.000
1000R	31.3	14.3	21.2	2.8	.000
2000R	36.0	13.4	26.1	3.2	.000
4000R	47.7	14.9	30.1	8.6	.000
8000R	54.1	16.0	36.0	9.1	.000
250L	27.7	12.9	17.9	4.5	.000
500L	28.7	14.6	20.1	.7	.000
1000L	31.2	13.5	21.2	2.6	.000
2000L	39.9	14.3	22.8	5.0	.000
4000L	50.0	15.4	31.9	7.7	.000
8000L	56.3	15.3	37.0	8.1	.000
Ds%R	86.3	13.8	95.7	5.2	.000
Ds% L	85.2	14.7	95.7	6.1	.000

Table 7 shows that the study (elderly) group mean PTA was mild to moderate high-frequency hearing loss

**Table 8** Pearson correlation between age and DD test

		Age	DD RT	DD LT	RT E ADV
Age	Pearson correlation	1			
	Sig. (2-tailed)				
	<i>N</i>	92			
DD RT	Pearson correlation	-.433**	1		
	Sig. (2-tailed)	.000			
	<i>N</i>	92	92		
DD LT	Pearson correlation	-.643**	.431**	1	
	Sig. (2-tailed)	.000	.000		
	<i>N</i>	92	92	92	
RT E ADV	Pearson correlation	.636**	-.301**	-.956**	1
	Sig. (2-tailed)	.000	.004	.000	
	<i>N</i>	92	92	92	92

## Conclusions

Aging has significant effect on the dichotic listening ability which is manifested by problem in speech communication ability and problem in satisfaction from amplification devices for correction of peripheral hearing disorders. The inter-aural asymmetry (REA) of dichotic digit test increases systematically with age with great inter-subject variability in advanced age. Setting up a protocol for assessment of central auditory processing abilities for elderly patient for both diagnostic and therapeutic purposes is needed.

## Abbreviations

CAPD: Central auditory processing disorders; REA: Right-ear advantage; DL: Dichotic listening; DDT: Dichotic digit test.

## Acknowledgements

Not present

## Authors' contributions

ST provided the idea of the research and worked in cases. NS contributed to the analysis and writing. All authors read and approved the final manuscript.

## Funding

Not funded

## Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

Ethical committee of Ain Shams University N 79343. Informed oral consent was taken from the participants.

### Consent for publication

Not applicable as no data of patients were published.

### Competing interests

The authors declare that they have no competing interests.

Received: 24 July 2021 Accepted: 12 February 2022

Published online: 18 March 2022

## References

- Billett C, Bellis T (2011) The relationship between brain temporal processing and performance on the tests of central auditory function in children with reading disorders. *J Speech Lang. Hear. Res.* 54:228–242
- Zenker F, Mora ER, Marro CS, De Lucas CG, Fernández BR, Barajas J (2007) The effect of age over the Dichotic Digit test. 8th EFAS Congress/10th Congress of the German Society of Audiology
- Takio F, Koivisto M, Jokiranta L, Rashid K, Kallio J et al (2009) the effect of age on attentional modulation in dichotic listening. *Dev Neuropsychol* 34:225–239
- Jeffrey M, James J (2005) Some effects of aging on central auditory processing. *J Rehabil Res Dev* 42(4):25–44
- Humes L., (2009): Issues in the assessment of auditory processing in older adults. Chapter 8. Anthony T. Cacace & Dennis J. McFarland: Controversies in central auditory processing disorders. Copyright by Plural Publishing, Inc.2009. web site: <http://www.pluralpublishing.com>.
- Hommet C, Mondon K, Berrut G, Gouyer Y et al (2010) Central auditory processing in aging: the dichotic listening paradigm. *J Nutr Health Aging* 14(9):751–756
- Sanchez ML, Barros FBNF, Caovilla MMGHH (2008) Auditory processing assessment in older people with no report of hearing disability. *Rev Bras Otorrinolaringol* 74(6):896–902
- Simpson J. A comparison of two behavioral screening scales for children with auditory processing disorders. Masters thesis (1981); Idaho State University, Pocatello. Quoted from handbook of central auditory processing disorders. Ch. (6):137–161
- Tawfik S, El Kholi W, Mekki S, Hassan N (2009) Gaps-in-noise test versus auditory fusion test in diagnosis of auditory temporal processing disorders. Master thesis in Ain Shams University
- Musiek F (1983) The evaluation of brainstem disorders using ABR and central auditory tests. *Monographs Contemporary Audiol* 4:1–24
- Bellis T (1996) Neuroanatomy and neurophysiology of the auditory system. In: Bellis T (ed) Assessment and management of central auditory processing disorders in the educational setting: from science to practice, vol 1. Singular publishing group, Ch, San Diego, pp 1–31
- Bouma A, Gootjes L (2011) Effects of attention on dichotic listening in elderly and patients with dementia of the Alzheimer type. *Brain Cognition* 76(2):286–293

13. Bellis T (2007) Differential diagnosis of ©APD in older listeners. In: Chermak GD, Musiek FE (eds) Handbook of central auditory processing disorder: volume 1: Diagnosis. Plural Publishing, SanDiego

### **Publisher's Note**

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Submit your manuscript to a SpringerOpen<sup>®</sup> journal and benefit from:**

- ▶ Convenient online submission
- ▶ Rigorous peer review
- ▶ Open access: articles freely available online
- ▶ High visibility within the field
- ▶ Retaining the copyright to your article

---

Submit your next manuscript at ▶ [springeropen.com](https://www.springeropen.com)

---