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RESEARCH ARTICLE

Auditory attention evaluation in the elderly using a Persian version of consonant-vowel dichotic test

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Abstract

Background and Aim: Aging is accompanied with changes in cognitive capacities. In spite of advances in neural imaging technologies, there is not a straightforward method to observe cognitive functions. For assessing brain functions, researchers mainly use psychometric tests. The aim of this study was using consonant-vowel (CV) dichotic test as a non-invasive behavioral test for auditory attention (focused and divided attention) and language laterality evaluation in young and old age groups.

Methods: In the present cross-sectional study, Persian version of consonant-vowel dichotic test was performed on 28 young subjects within 18-28 and 27 old subjects within 60-80 year-old age range of both genders. All subjects had normal peripheral hearing and were right-handed. Right and left ear scores were compared under three different attention conditions: divided or non-forced attention, attention to the right ear, attention to the left ear.

Results: In non-forced condition there was no significant difference for the right ear score between the two age groups ($p=0.97$) but the left ear score was statistically different ($p\leq0.001$). In addition, there was a significant difference between two ears' scores in attention to right/left ear for both age groups ($p\leq0.001$).

Conclusion: In the older group under divided attention condition, the left ear score was lower than the younger group and they had problem in paying attention especially to the left ear stimuli. In the older group, ear asymmetry for consonant-vowel dichotic test score was higher than the younger one.

Keywords: Focused attention; divided attention; dichotic consonant-vowel test; elderly; bottom-up processing; top-down processing

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Introduction

One of the world's problems is an increase in the elderly population and its sociopsychological consequences. World population is getting old quickly especially in developing countries. Based on Iran Census Data at 1996, 6.6% of Iranian population was over 60 years old and it was predicted that Iranian old population would rise to 10 million up to 2021. It seems Iran's population structure is changing from young to old, therefore, in coming years, detecting and dealing with their problems are vital [1,2]. Although the main nature of central processing changes with age is not thoroughly understood, it is obvious that aging

can change cognitive abilities and has effects on auditory attention, memory and processing speed. One of the most important problems in elderly is attention deficits like auditory distractions [3-5].

Attention is a system which is controlled by working memory of central executive system and due to the limited brain capacity for input information processing, attention system is used to decrease processing loads. There are different types of auditory attention. Focused and divided attention is evaluated in dichotic hearing tests [6-8].

Divided attention is the ability to attend to two auditory stimuli simultaneously (i.e. two information streams) so there is twice information processing at a time. Any processing deficit can affect divided attention. Focused attention is the ability to attend selectively to one information stream and to suppress processing of competing or intrusion stimuli from contralateral ear [6,7].

In daily life usually we encounter a lot of competing auditory inputs and processing of these inputs can be affected by sensory input characteristics itself (like perceptual saliency) and/or cognitive mechanisms (like attention control). For auditory perception in competing situations, attention control is critical and challenging. Elderly has more problems and less flexibility in facing two competing auditory sources (two different verbal inputs) and shows more perceptual laterality than youngsters [4]. For better understanding of changes in language laterality with age, Kinsbourne suggested that it is necessary to include different attention conditions in dichotic hearing tests. For controlling attention, switching and better evaluation of language laterality, divided and focused attention conditions are used in dichotic hearing tests [6,9].

Neuroimaging studies (like fMRI) can evaluate central nervous system functions but these techniques mostly evaluate anatomical structure and general brain function and are not able to specify the central auditory nervous system processing. For that matter, behavioral central auditory processing tests are less expensive and more sensitive tools [10]. Dichotic consonant-vowel (CV) test is a non-invasive behavioral technique for dichotic hearing, auditory attention (divided and focused attention) and language laterality assessments. CV pairs including 6 stop consonants (/k/, /g/, /t/, /p/, /b/, /d/) were used with vowel /a/. This test is sensitive to cerebral cortex and corpus callosum deficits [6,9]. Syllables have little language load and therefore semantic load would not interfere with the results. Due to CV pronunciation differences across languages, Persian version of CV test was constructed by Jafari et al. and was tested on 54 normal hearing youngsters [7]. This test has simple materials, is easy to perform, provides maximum competitive conditions due to close similarity between syllables in both ears, uses real simultaneous presentation (synchronous onset and offset), and has less reliance on short term memory. All of these characteristics make dichotic CV test, a suitable test for speech understanding in different age groups especially elderly [6,11]. Previous studies showed that dichotic hearing tests are adversely affected by neural degenerative diseases with attention deficits. There is not enough evidence to show dichotic hearing function in elderly with normal hearing [6]. The evaluation of cognitive changes like auditory attention with aging is critical. The aim of the present study was auditory attention (divided and focused) and language laterality assessment in elderly by dichotic CV test and comparing their results with youngsters.

Methods

This cross-sectional study was conducted from April to November in 2014. Control group included 28 young adults (15 females and 13 males) from 18 to 28 years old with mean age of 24.21 (SD=3.27), and experimental group included 27 normal hearing subjects (15 females and 12 males) from 60 to 80 years old with mean age of 66.33 (SD=5.52). Tests were performed in Kahrizak Elderly House and Akhavan Rehabilitation Center.

Random sampling was used for subjects who could meet inclusion criteria. All subjects

signed written consent. Demographic information including age and complete medical history were recorded. Right handed (by using Edinburgh test) and monolingual (Persian native speakers) subjects with education level of 3rd grade of guidance school or higher were enrolled. Exclusion criteria were any history of ear diseases, head trauma, brain surgery, taking any nervous system medications or suffering from seizers. For peripheral auditory system assessment, otoscopic examination (Heine mini 3000, Germany), pure tone audiometry and speech threshold tracing (by Midimate 622, Madsen, Denmark), and tympanometry (AZ26, Interacoustic, Denmark) were conducted. Before testing, all devices were calibrated by a sound level meter type II (Bruel & Kjar type 2209, Denmark) and artificial ear (type 4153, Denmark) and reference tone for calibration of speech circuit was 1000 Hz.

Normal hearing was considered hearing thresholds less than 30 dBHL in 250-4000 Hz octave frequencies. The spectral energy of the CV syllables was mainly in 500 to 4000 Hz, so this frequency range was considered adequate [12]. Only subjects with type An tympanogram (normal middle ear function) were included. Normal cognitive function was screened by minimal mental state examination (MMSE) in elderly [13]. Finally, dichotic hearing in divided and focused attention conditions, and language laterality were evaluated using Persian version of dichotic CV test [7]. For presenting stimuli, CD player was connected to clinical audiometer AC33 and syllables were presented via TDH39 headphone. Test was conducted at most comfortable level (MCL=55 dB HL). All subjects received full instructions about test procedure, stimulation and response technique. At first, 6 exercise trials were presented to ensure subjects had understood the test clearly.

In construction of Persian version of dichotic CV test, 6 stop consonants (/b/, /p/, /g/, /k/, /t/, /d/) has been used with vowel /a/. There were three different CV lists, each one including 36 CV syllables (like ba-pa, ka-ga). Presentation was done randomly and there were three different attention conditions: 1) non-forced attention 2) attention to the right ear 3) attention to the left ear. Each list was used for one of attention conditions to avoid repetition. For non-forced attention condition, subjects had to repeat whatever CV they heard. If subjects heard two simultaneous CV pairs, they had to repeat whatever CV they heard the best. In right/left ear attention conditions, subjects must pay attention selectively to right/left ear stimuli. Examiner calculated the scores of each ear separately and language laterality for every attention condition [12].

For calculating language laterality the following formula was used: ((right ear score-left ear score)/(right ear score+left ear score))*100. Positive result is indicative of right ear advantage (REA) and negative result suggests left ear advantage (LEA).

SPSS17 was used for data analysis. For describing data, mean and standard deviation were used. Kolmogrov-Smirnov test showed normal data distribution for both age groups so independent t-test was used for comparing mean scores between the young and old age groups. Type I error was considered 0.05 and p-value less than 0.05 was statistically significant.

Results

Independent t-test showed that right ear scores in non-forced attention or divided attention condition were not different ($p=0.97$) but left ear scores were significantly different ($p\leq0.001$) between the two age groups. Fig. 1.a shows mean dichotic CV score for each ear in non-forced attention condition in young and old age groups. When paying attention to right ear, the right ear score or REA showed an increment in both age groups but this change was greater in young age group than old age group and based on independent t-test both ears showed significant difference between the two age groups ($p\leq0.001$). Fig. 1.b shows comparison of mean dichotic CV test for both ears when paying attention to right ear in young and old age groups. In left ear attention condition, the left ear score showed an increment in both age groups but this change was greater than old age group and made a significant LEA in young age

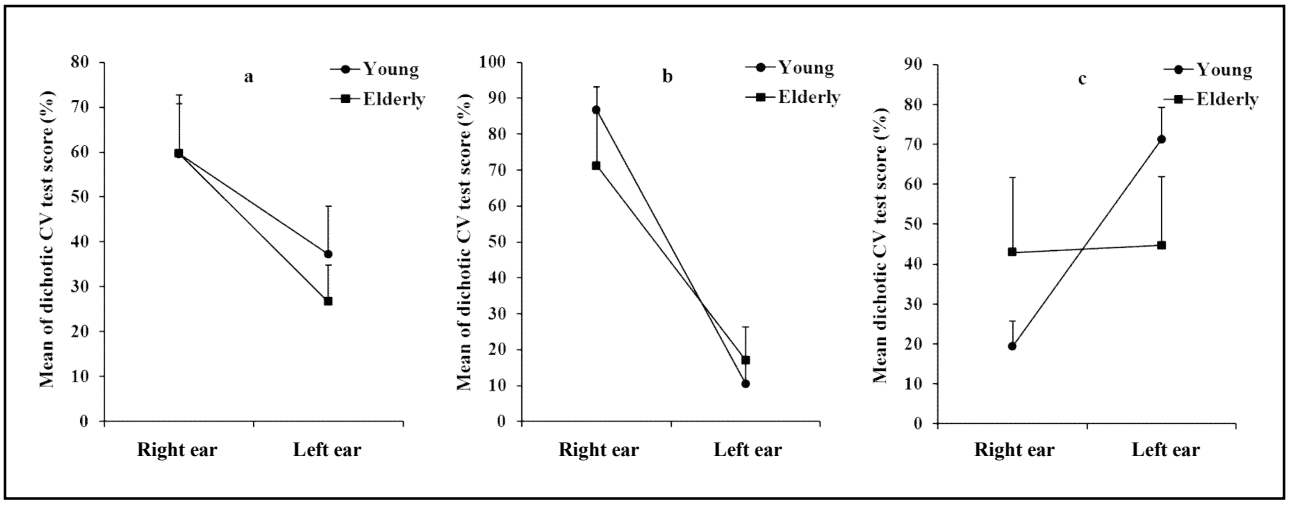

Fig. 1. Mean dichotic consonant-vowel score for each ear in three attention conditions in young and old age groups. a: in non-forced attention condition, b: in forced right condition, c: in forced left condition.

group. Based on independent t-test (in left ear attention condition) both ears showed significant difference between the two age groups ($p \leq 0.001$). Fig. 1.c shows comparison of mean dichotic CV test for both ears in left ear attention condition in young and old age groups. Independent t-test showed significant difference in ear advantage for all three attention conditions between the young and old age groups ($p \leq 0.001$). Fig. 2 shows ear advantage in dichotic CV test for three attention conditions for young and old age groups.

Discussion

This study showed significant findings regarding effects of aging on dichotic CV test and auditory attention. These findings show that auditory perception in old subjects has more laterality (more processing tendency to right ear) and is less effective in competitive environments than young subjects. This finding was in agreement with Gootjes et al. [9]. Divided attention is a difficult task and needs more brain activity and brain attention sources compete with each other for processing auditory inputs from both ears. This task is more challenging for old subjects and leads to less effective processing for left ear stimuli due to cognitive changes and less effective interhemispheric information conduction [9]. In right ear attention condition, REA increased in both age groups compared to non-forced attention condition. This advantage was greater in young group. In right ear attention condition, subjects occasionally repeated left ear stimuli; which is attributed to lack of suppression of competitive information or left ear intrusion. This finding was more common in elderly. In left ear attention condition, young subjects showed left ear score improvement and right ear score reduction so there was a significant LEA. In elderly, for left ear attention, there was REA or little LEA. Therefore, old subjects could not suppress competitive stimuli from right ear.

In fact, in the present study, both top-down and bottom-up cognitive processing were used for evaluating aging effects on cognitive tasks. Hugdahl [3] suggested that bottom-up processing can be evaluated in non-forced attention condition and top-down processing can be assessed in attention conditions. Attention is part of top-down processing and can modify bottom-up processing. Mostly bottom-up processing deficits are due to sensory (input) information processing limitations but top-down processing deficits happen as a result of cognitive inflexibility. Cognitive problems would reduce learning abilities, making

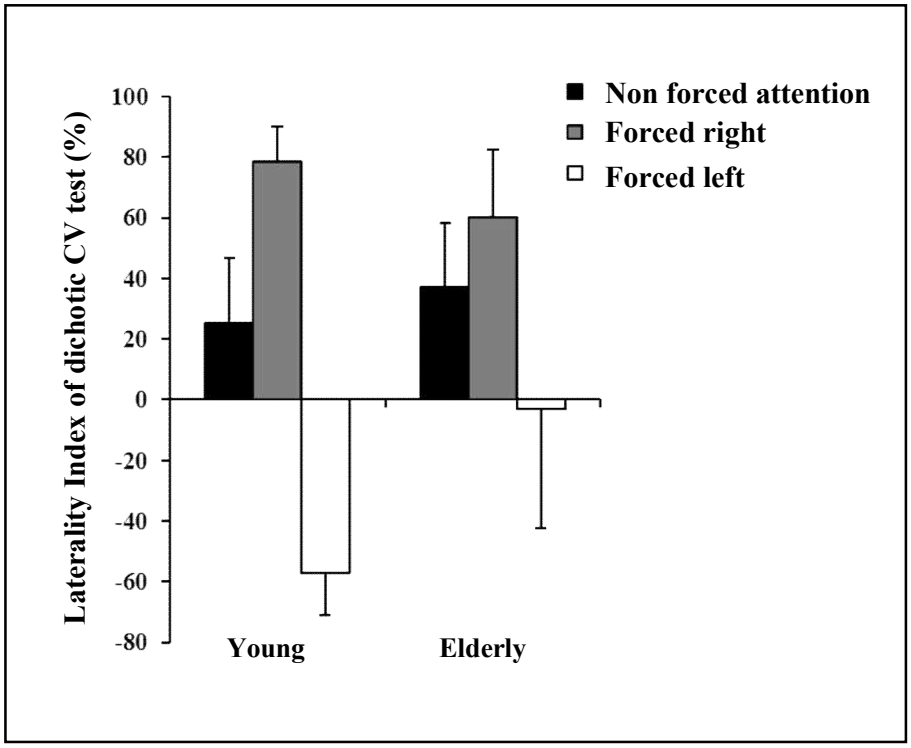

Fig. 2. Ear advantage in dichotic consonant-vowel test for three attention conditions for young and old age groups

use of experiences or processing solutions. Hugdahl [9], suggested that in non-forced attention condition, bottom-up processing is dominant and REA in non-forced attention condition is indicative of left brain hemisphere dominance in language processing. In attention condition, top-down processing can modify bottom-up processing and reduce REA. It is suggested that cognitive control is different between the right and left ear attention conditions. In right ear attention condition, top-down processing works in coordination with bottom-up processing but in left ear attention condition, they are in conflict. This explains why LEA is never as strong as REA in young right-handed subjects and why old subjects (over 50 years old) cannot easily pay attention to left ear. In fact, top-down control decreases with age. In Bergen dichotic test by Hugdahl [6], old subjects (50-70 years old) had lower scores in divided attention condition compared to youngsters (16-30 years old) in both ears. In right ear attention condition, both groups had REA. Right ear advantages in right ear attention condition could not show any significant difference between the two age groups. Young group in left ear attention condition had LEA. These findings are in agreement with the present study. There are some differences between the present study and Hugdahl et al. study regarding sample size, handedness and elderly age range. They used 1018 subjects in the age range 6 to 70, including 825 right-handed and 193 left-handed subjects in 4 age groups (8-15, 16-30, 31-49, 50-70 years old) [6]. Anderson et al. evaluated dichotic CV test in 193 middle-aged (31-49 years old) and old (50-74 years old) subjects. In non-forced and right ear attention condition, REA was significant in both age groups. In left ear attention condition, only middle-aged subjects showed LEA. These findings are in agreement with our study. They suggested that aging can reduce top-down attention control on bottom-up processing

laterality or stimulus-related processing. As Hugdahl et al. claimed left ear attention imposes heavy burden on processing capacity in elderly [3]. Dichotic hearing tasks are dependent on structural integrations among ascending processing pathways, interhemispheric connections and attention source allocations. Interhemispheric connections are dependent on myelination for faster neural conductions. Grey cerebral matter in temporal lobe grows nonlinearly till 17 years old and it starts to decrease after 28 years old [14]. Takio et al. used dichotic CV test in 186 subjects in 5-79 year old age range. As it is expected, young subjects (19-32 years old) had greater REA in right ear attention condition. Although, LEA in left ear attention condition was not significant, only youngsters could suppress REA. In fact, they could suppress intrusions from unattended ear and facilitate processing in attended ear. Old subjects (59-79 years old) had weaker scores in all three attention conditions. They could not overcome REA in left ear attention condition. These findings show dichotic hearing deficits and cognitive impairments which are in agreement with the present study [9].

There were some limitations that make testing process progress slowly. These limitations include time consuming office work and coordination process with Kahrizak Elderly House for having testing license. In addition, there was limited number of old subjects with education level above guidance school and also in Persian language /ba/ and /pa/ are not nonsense syllables.

Conclusion

This study shows that at least part of speech understanding difficulties in the elderly is due to age-related deficits in dichotic hearing, divided and focused attention. Attention deficits can be a primary sign of dementia and focused attention is highly susceptible to first stages of dementia, so it is recommended that any changes in information processing (like dichotic listening) should be considered as a possible primary sign of cognitive involvements.

Also, the findings of this study confirmed the presence of dichotic listening difficulties in older adults so it is necessary to add these central auditory processing tests to auditory test battery to detect binaural interference which is an early central processing problem and consequently apply some considerations for hearing aid fitting, such as monaural amplification. Additionally, auditory rehabilitation programs with special focus on dichotic listening will be recommended accordingly.

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