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RESEARCH

THE EVALUTION OF CENTRAL AUDITORY PROCESSING IN THE GERIATRIC POPULATION

ABSTRACT

Introduction: C: The purpose of this study is to evaluate whether the frequency auditory pattern recognition test (FAPRT) and the duration auditory pattern recognition test (DAPRT) have a place in the routine audiologic test battery for geriatric patients aged 60 years and older.

Materials and Method: 88 ears of 44 patients (27 females and 17 males) aged 60 years and over were evaluated. Digital CD recordings of the Gaps-in-Noise (GIN) test (full version F.E. Musiek, Ph.D.Version 02.04.2003) were used to evaluate these patients.

Results: A negative correlation was detected between increasing age and pure-tone hearing thresholds, discrimination scores, and FAPRT and DAPRT scores ($p < 0.01$). A positive correlation was found between aging, pure-tone threshold and speech dicrimination percentage, and FAPRT and DAPRT scores ($p < 0.01$). Moreover, discrimination percentages showed a positive correlation with FAPRT and DAPRT scores.

Conclusion: A significant correlation was noted between FAPRT and DAPRT scores and classical auditory test battery scores. These results show that FAPRT and DAPRT can be included in the auditory test battery for the geriatric population.

Key Words: Aged; Audiology; Audiometry; Auditory Perceptual Disorders.

ARAŞTIRMA

GERİATRİK POPÜLASYONDA SANTRAL İŞİTSEL İŞLEMLEMENİN DEĞERLENDİRİLMESİ

ÖZ

Giriş: Bu çalışmanın amacı frequency auditory pattern recognition test (FAPRT) ve duration auditory pattern recognition test'in (DAPRT) 60 yaş ve daha yaşlı geriatrik hastalarda rutin odyolojik test bataryasında yer alabilecek testler olup olmadığını değerlendirmektir.

Gereç ve Yöntem: 60 yaş ve üzerinde (27'si kadın 17'si erkek) olmak üzere 44 hastaya ait 88 kulak değerlendirildi. Bu hastaları değerlendirmede orijinal Gaps-in-Noise (GIN) testi (Full Version F.E.Musiek, Ph.D.Version 02,04,2003) dijital CD kayıtları kullanıldı.

Bulgular: Artan yaş ile; saf ses işitme eşikleri, diskriminasyon skorları, FAPRT ve GAPRT skorları arasında negatif korelasyon tespit edildi ($p<0,01$). Yaşlılık, saf ses işitme eşikleri konuşmayı ayırd etme yüzdeleri, ve FAPRT-GAPRT skorları ile pozitif korelasyon bulundu ($p<0,01$). Ayrıca diskriminasyon yüzdelerinin FAPRT ve GAPRT skorları ile pozitif korelasyon gösterdiği tespit edildi ($p<0,01$).

Sonuç: Klasik odyolojik test bataryası test sonuçları ve FAPRT, DAPRT skorları arasında belirgin korelasyonlar tespit edildi. Bu sonuçlar FAPRT ve DAPRT'in geriatrik popülasyonda odyolojik test bataryası içinde yer alabileceklerini göstermektedir.

Anahtar Sözcükler: Yaşlı; Odyoloji; Odyometri; İşitsel Algı Bozukluğu.

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INTRODUCTION

As mean lifespan increases along with the size of the geriatric population, so also do auditory problems. Auditory disorders as a result of aging are known as presbyacusis. Presbyacusis results from degeneration of the auditory pathways, both sensorial and neural. Subjects with presbyacusis hear sounds, but do not comprehend their meaning. In their audiograms, low-frequency hearing thresholds are normal or near normal. Deficit occurs in speech frequencies of 500 Hz, 1000 Hz, 2000 Hz and higher. Even in subjects with low hearing loss, difficulty in speech discrimination is experienced. Some studies suggest that this speech discrimination inefficiency results from problems with central auditory processing (1,2).

Histopathologically, auditory deficits derive from pathologies of the cochlear sensorial epithelium, the spiral ganglion, the acoustic branch of 8th cranial nerve, and the central auditory pathway. Willott, in his study on the central auditory pathway, claimed that a decrease in the volume and number of neurons in the central auditory pathway plays an important role in hearing loss (3).

It is important to evaluate central auditory performance in addition to the evaluation by routine auditory test battery, which is used to evaluate hearing inefficiencies in the geriatric age group, in order to assess hearing problems and determine treatment options.

Disorders in the central pathway, which processes auditory inputs, are called central auditory processing disorders. Central auditory processing disorders occur as a discrimination deficit (especially in noisy enviroments), difficulty in determining sound localization, speech disorders, and clinical presentations of primary pathology. In clinical practice, auditory problems that result from aging are not generally considered symptoms of central nervous system disorders.

Detecting central auditory processing disorders that occur as a result of central neurodegenerative changes is important for the rehabilitation of hearing loss. Tests that evaluate central auditory processing must be easy and practicable to apply to the geriatric population, sensitive enough to detect central neurodegenerative changes, and specific to the central neural auditory pathway.

This study investigates whether FAPRT and DAPRT are capable of assessing central auditory processing in the geriatric population.

MATERIALS AND METHOD

We evaluated 44 healthy volunteer subjects, 27 of whom are females and 17 of whom are males, aged 60 years and over. All patients signed informed consent before entering the study. Subjects were not discriminated against in terms of gender, age, or social status. We selected subjects without a history of ear disease, ear surgery, acoustic trauma, head trauma, or ototoxic drug use. This study was approved by the Ethics Committee for Scientific Research at Hacettepe University.

We chose subjects with normal otoscopy and who had ± 50 daPa middle ear pressure and type A tympanograms, whose contralateral reflexes for both ears were positive for 500, 1000, 2000, 4000 Hz, and whose ipsilateral reflexes were positive for 500, 1000, 2000 Hz. Subjects underwent otoscopy, audiometry, tympanometry, central processing tests (FAPRT and DAPRT), a radiological examination of the brain, and a cranial MRI to rule out major brain pathology.

Audiometric tests were performed in double-walled rooms using interacoustics AC-40 clinical audiometry devices produced by the Industrial Acoustics Company (IAC). Air way hearing threshold measurements and speech tests were performed with TDH-39 standard earphones. The Oticon-60273 vibrator was used for bone conduction hearing measurements. Air conduction hearing thresholds were between 125 Hz – 8 kHz. Bone conduction hearing thresholds were between 500 Hz – 4kHz. Hearing loss was determined according to the norms of the American Speech-Language Hearing Association, as set forth in the 2007 ASHA Guide. Comprehension of speech was tested using three-syllable words (FD-300), which were used in our clinic. Single-syllable phonetic balanced word lists were used to evaluate the subjects'discrimination of speech. Middle-ear function was evaluated using the 226 Hz probe tone of the Amplaid 775 tympanometry device, TDH-39 and MX41/AR earphones. Ear pressure, compliance, and acoustic reflexes of the ipsilateral and contralateral ears were determined. FAPRT and GAPRT were used to evaluate central auditory processing, and these tests were performed using the original GIN test (full version F.E. Musiek, Ph D. version 02.04.2003, digital CD recordings). The Interacoustics AC-40 clinical audiometry device was combined with a CD player. The tests were performed using TDH-39 standard earphones in a silent cabinet. Cranial MRIs were performed using the General Electric Sigma Horizon LX 1.5 Tesla device (Wisconsin, USA). Statistical evaluation was performed using the SPSS 11.5 software program. Left and right ear results were compared using the Mann-Whitney U test, and comparison between groups was accomplished by t-test. Results were considered statistically significant when $p < 0.05$.

Results

In our study, gender distribution was 27 females (61.4%) and 17 males (38.6%). Subjects were aged between 60-85 years, and the average age was 66.25 years. Hearing loss averages were 24.63 and 25.90 dB hearing level (HL) for the left and right ears respectively. Discrimination scores were 88.95% HL for the left ear and 89.72% HL for the right ear. Six subjects had normal cranial MRI findings (13.6%), the remaining 38 subjects had minimal nonspecific degenerative changes (cortical atrophy, gliotic changes). DAPRT scores were 44.88 (73.13%) and 43.95 (73.25%) for the right and left ears respectively. FAPRT scores were 48.54 (80.9%) and 48.50 (80.83%) for the right and left ears respectively (see Graphics 1 and 2).

With regard to gender distribution, the FAPRT and DAPRT scores were evaluated by Mann-Whitney U test, the results of which were not found to be statistically significant. Increasing age was found to be negatively correlated with hearing loss, discrimination percentages, and FAPRT and DAPRT scores ($p<0.01$). PTTs were found to be positively correlated with increasing age ($p<0.01$), discrimination scores ($p<0.01$), and with FAPRT and DAPRT scores ($p<0.01$). Discrimination percentages were found to be positively correlated with FAPRT and DAPRT scores ($p<0.01$). The difference between FAPRT and DAPRT scores was not considered significant, and the difference for either ear was not found to be significant for these tests.

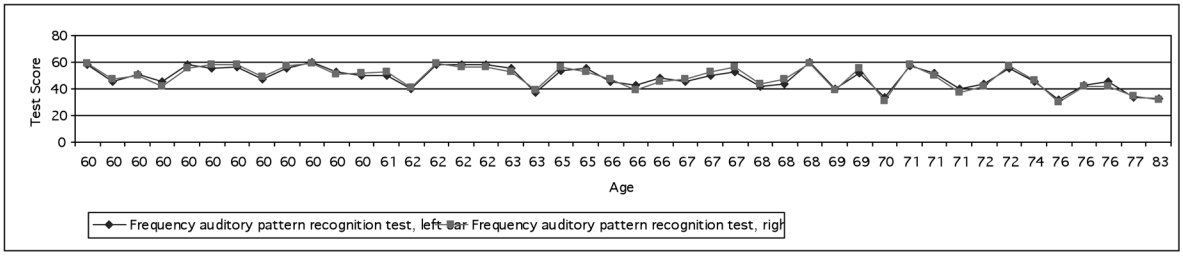
Discussion

Central auditory processing disorders describe disorders of upper neurologic functions, such as discrimination, localization, remodeling, and temporal processing of sound (4,5).

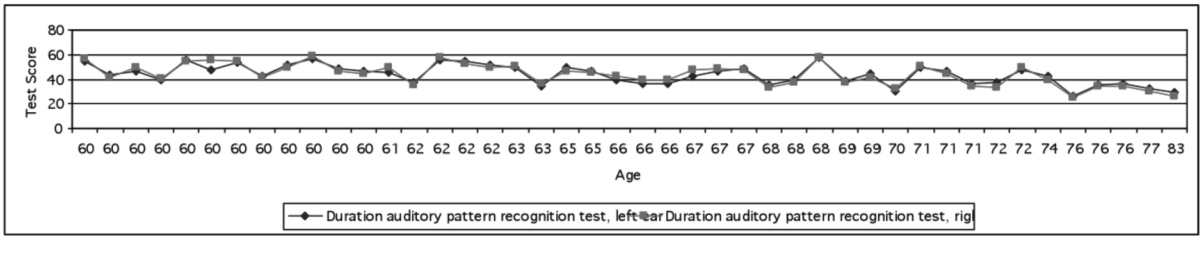
The cerebral cortex, which performs the most complex functions in humans, is the last step of evolution in a philogenetic sense. The complexity and precision of the cerebral cortex make it vulnerable to degeneration in the later years of life. Because the cerebral cortex is the newest structure, philogenetically speaking, one could postulate that it has not yet reached its fullest capacity for protection and adaptation.

The best evidence for this claim is that aging of the central nervous system and traumatic neural degeneration result in defective higher cognitive functions. Based on this inference, we can hypothesize that the central auditory functions will begin to decline early in the geriatric period. Tests that can evaluate deterioration of central auditory processing in the elderly can help to detect central auditory processing disorders early.

In this study, we discuss central auditory problems, which people increasingly face, given our prolonged lifespan and



Graph 1— Frequency auditory pattern recognition test (FAPRT) scores of all individuals.



Graph 2— Duration auditory pattern recognition test (DAPRT) scores of all individuals.

growing geriatric population. Among geriatric patients, hearing problems, aphasia, attention deficit, and memory disorders are common, but as central auditory processing tests are not used routinely, the probable diagnoses are not reliable. Confirming central auditory disorders will help to evaluate those patients who frequently experience speech problems, and can facilitate improved treatment methods.

The research of Bocca et al. in 1954 brought attention to central auditory processing disorders. In these investigations, PTTs of subjects with hearing complaints and cerebral lesions were found to be normal. This finding prompted the idea that hearing matters far beyond hearing pure-tone sounds, and is a complex process in which the central nervous system is involved (6). The subjects in our study did not have hearing complaints, and their audiometry tests were normal. They did not have any bulking mass that influenced the central nervous system. Being symptomatic could refer to diffuseness of the lesion or damage to the central nervous system.

Routine conventional audiologic testing is not sufficient to evaluate central auditory processing. We need more comprehensive central auditory tests to evaluate cortical and hemispheric lesions. Beasley has claimed that we need more complex stimuli to analyze neurologic problems in the higher central nervous system (7). Frequency and duration auditory pattern recognizing tests (FAPRT-DAPRT) depend on consecutive stimuli with different frequency and time intervals. These tasks evaluate the auditory processing function of the temporal cortex and are the most sensitive tests for auditory temporal cortex functions.

In 1961, Neff demonstrated that tonal stimuli pattern recognition disappeared in dogs with bilateral gyrus ablation (8). In 1974, Colavita demonstrated that temporal discrimination deteriorated in cats with insular gyrus ablation (9). Fifer showed in 1993 that insular strokes resulted in auditory processing disorders (10), while Griffiths demonstrated in 1997 that right hemispheric infarcts resulted in temporal processing deficits (11). All these studies indicate that lesions of the temporal region result in central auditory processing inefficiencies.

Temporal processing is an important part of central auditory processing, a function in which both hemispheres take part (12). The left hemisphere is known to function in temporal directives such as speech and language skills, while the right hemisphere serves in the discrimination of acoustic contours and models of sound. The corpus callosum facilitates the interactions between both hemispheres (13).

In 1980, Musiek and Geurkink developed a frequency pattern test and applied it to children with auditory perception inefficiencies (14). Musiek, who applied this test in his extensive research to patients with cochlear and brain stem lesions, demonstrated in 1987 that the frequency pattern test was sensitive to cerebral lesions, and moderately sensitive to cochlear and brain stem lesions (15). The DAPRT that Musiek developed in 1990 is significantly sensitive and specific to the central auditory pathways, and is influenced to a lesser extent by cochlear functions compared to FAPRT (16). Because cochlear pathologies are so common in the geriatric population, using this test in routine practice may be of value.

As both tests evaluate distinctive functional mechanisms in the brain, research has demonstrated that using both tests together will increase the sensitivity and specifity of the screening (17). Based on this inference, we preferred to use both of these tests in our study.

In the case of central nervous system pathologies, even if the lesion is within one hemisphere, the influence is bilateral, as evidenced by the test results (17,18). These tests indicate central auditory processing inefficiencies rather than the laterality of the lesion. As a result, they can be used as detection purposes only.

Hearing inefficiencies in the geriatric population that are concomitant with central neurodegeneration, which increases with age, are known as central presbyacusis. When subjects older than 60 years were evaluated using the Auditory Brainstem Response (ABR) test, the 1st, 3rd, and 5th waves were lacking, and interpeak distances between the (1-3), (1-5), (3-5) waves were prolonged with increasing age. In subjects with retrocochlear hearing loss detected by ABR evaluation, deterioration in central auditory performance was detected (19). These results indicate electrophysiologically that central auditory processing performance decreases with increasing age as a result of neurodegeneration. Consistent with the literature, our study demonstrates that the sensorineural decrease in PTTs with aging is statistically significant. Increasing age, a decrease in hearing thresholds, and a decrease in central auditory test scores are positively correlated with one another.

The correlation that has been demonstrated elsewhere between the ABR results of presbyacusis patients and their central auditory processing tests results has also been demonstrated between presbyacusis patients and their central auditory processing test scores in our study.

Musiek demonstrated that there was no significant difference between FAPRT and DAPRT scores in normal subjects of either gender, and for either ear (17). In our study, we also did not find any statistically significant difference for either ear, or for either gender, with regard to both test results.

When FAPRT and DAPRT tests are performed at different sound pressure levels (40, 50, 77 dB-SPL), test results of 78% for FAPRT and 73% for DAPRT are achieved in 90% of cases (15,16). On the basis of those findings, we administered the tests in our study at the most comfortable loudness (MCL) for each subject.

In our study of the geriatric population of 60 years and over, the average test scores were 80.8% for FAPRT, and 73.1% for DAPRT. The scores for tests performed at MCL values specific to each subject were found to be within Musiek's test score ranges, which had been performed using three different SPL values. Based on the knowledge that FAPRT and DAPRT scores are independent of pure-tone hearing scores, we can claim that it is better to apply these tests at MCL values specific to each subject, in order to determine norm values (17).

Temporal processing of phonemes is of vital importance for discrimination. The main factor in determining an individual's temporal integration ability is the active sound pressure on the cochlea. However, the main features of sound, such as frequency, duration, and intensity, are also important variables that influence temporal auditory processing. According to Liebermann's concept of "catagoric perception," introduced in 1967, the phonemes of words have standing relationships between their frequencies, time intervals, and intensities. So, changes in duration, frequency, and intensity are percieved by the subject, and the phoneme is comprehended. When some acoustic components are changed, words can be perceived differently in terms of their meaning (20, 21).

Research has shown that when the duration of auditory stimulation changes, then the perceived meaning changes. The shift in meaning that depends on a prolonged or shortened duration of sound occurs more frequently in the elderly than among young individuals (22, 23). DAPRTs and FAPRTs are based on this phenomenon. Decreased test scores that accompany increasing age result from ineffiecient functioning due to aging.

Discrimination inefficiencies as a result of aging occur when words, structured by phonemes with different frequencies and duration models, cannot be perceived. This presents itself as a discrimination disorder (24). In our study, a positive correlation between decreased discrimination scores and DAPRT and FAPRT scores is an evidence of this phenomenon.

Aside from their use as scientific references, these tests have a practical applicability to geriatric individuals, whose cognitive functions have decreased. In the administration of these tests, non-language stimuli are used; so, these tests can be applied internationally. This enables us to determine normative values, and to perform the tests on elderly individuals whose language skills are restricted. Another advantage in clinical practice is that the tests last only 10 minutes, which is an advantage in the case of geriatric individuals with some attention deficit.

The fact that the tests can be performed anywhere an audiometry device can be connected with a special mechanism and a silent cabin is available, is another advantage. The tests are digitally recorded onto CD, and standardized for practical use.

We conclude that, given all their advantages, it is advisable to use these two tests to detect central auditory processing disorders in the geriatric population. Further research is needed with extensive sample groups to determine the norm test scores for this population.

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