THE EFFECT OF AGE OVER THE DICHOTIC DIGIT TEST

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The Central Auditory Processing mechanism of binaural integration can be assessed through behavioural non-invasive procedures such as the Dichotic Digit Test. This procedure consists of simultaneous presentation of digits to the two ears in an unpredictable presentation in groups of one, two and three pairs of items. The Dichotic Digit Test is commonly used in the diagnosis of Central Auditory Processing Disorders in the educational setting and in the clinical audiological practice. In the present study the effect of age, ear and difficulty were studied in a group of 127 participants aged from 6 to 72 years old. Results showed a Right Ear Advantage of scores obtained by the right ear in all subjects. As age and difficulty increase worse scores were obtained. The effect of age over the items recognitions were described by a curvilinear regression function. Normative values are obtained according to the age of the subjects who took part in the present study.

Introduction

Dichotic listening has been a component of many auditory processing assessment protocols following the introduction of dichotic digits by Broadbent (1) and its subsequent refinement by Kimura (2) and Byrden (3). In this test, different auditory stimuli are presented to the two ears simultaneously. Right- handed subjects typically have a better response to materials presented to their right ear than to those presented to their left ear. This response pattern is called the Right Ear Advantage (REA) and is dependent upon the difficulty of the listening task.

Dichotic speech tests can include a variety of stimuli such as: nonsense syllables, digits, monosyllabic words, spondaic words or sentences. In the evaluation of young and older adults, dichotic digit materials are ideal because digits: are relatively immune to the effects of cochlear hearing loss (4); have demonstrated high inter-test reliability for both young and elderly adult listeners (5) and digit stimuli generally are familiar to most listeners of all ages.

The clinical interpretation of Dichotic Tests mainly depends on the REA scores. Dichotic Tests are primarily designed for neurological patients. Hearing-impaired and non-neurological subjects don't show a clear REA in tests designed for neurological patients. No significant REA is found in dichotic tasks involving only one or two pairs of digits. When the difficulty of the listening task increased, as with the three- pair stimuli, the REA increased and large between-group differences emerged (6). The difficulty of the dichotic digit test can be altered by increasing the numbers of digit pairs and listener uncertainty about the characteristics of the target stimuli (7). It is well known that an inverse relationship exists between recognition performance and the number of digit pairs. As the difficulty of the test stimuli increases, the magnitude of the ear advantage also increases.

Literature suggests that with advancing age, changes occur within the central auditory system. Aging is accompanied by a decline in cognitive as well as auditory function. Speech perception problems, especially in the elderly population, cannot be predicted solely from the degree of peripheral hearing loss. Speech perception problems reflect both peripheral and central components (8). The effect that aging has on recognition performance on dichotic materials is unclear. Some studies show that recognition performance on materials presented to the left ear declined as a function of age (9), whereas performance on materials presented to the right ear was constant as a function of age (10).

The purpose of the current experiment is to evaluate the effect of age and test difficulty over the Dichotic Digit Test (DDT). A version of one- two- and three pair of digits were employed in order to obtain a significant REA for all age-groups studied. Specifically, this study addresses two questions: First, we try to establish if there is a development effect for this REA across age; second, we want to know if difficulty and aging can reveal whether this REA is the consequence of a reduction in the left hemisphere activation or the enhancement of the right hemisphere.

METHODS

Materials

The 1 to 9 waveform digital files, with a female voice, were edited so that the onset of the stimulus coincided with the start of the data files. A silent interval was concatenated to the end of the file to equalize the file lengths to the longest digit. A 500-ms silent interval, which served as the inter-digit interval for the multi-pair digit sets, was added to the end of each 1-pair dichotic digit file. The 2-pair and 3-pair files were made by concatenating ads required, 2 or 3 of the compiled 1-pair dichotic digit files, with an inter-stimulus interval of 4, 5, and 6 following the 1-, 2-, and 3- pair stimuli, respectively. A list of 108 items was compiled that contained 36 stimulus sets from 1-, 2-, and 3- pair digits. Additionally, a 10-item practice list was compiled.

Subjects

A total of 125 right-handed subjects (63 male, 64 female) were evaluated, ranging in age from 6 to 72 years old. There were 25 subjects in each of the following five groups: 6 to 11 years, 12 to 17 years, 18 to 33 years, 35 to 59 years and 60 to 72 years. All subjects had normal hearing (20 dB HL at octave intervals from 250-8000 Hz). Word recognition scores were greater than or equal to 80 percent in each ear.

Procedures

The dichotic digits were reproduced by a CD player and fed trough an audiometer to TDH-47 earphones. All stimuli were presented at 70 dB HL. The subjects were instructed to recall, in any order, the digit pairs presented to both ears.

RESULTS

The mean data from the six age groups by ear are shown in Figure 1. The ANOVA indicated a significant difference between scores on materials presented to both ears ($F[1,29]=57{,}212$; $p<0.0001$) and test difficulty ($F[2,29]=93{,}573$; $p<0.0001$). The main effect of age-group was also significant ($F[4,29]=18{,}201$; $p<0.0001$). A significant interaction was found between the test difficulty and the presentation ear ($F[4,29]=5{,}791$; $p<0.0001$). As the difficulty of the test increased, the score in both ears decreased in a different way for the right and the left ear. The identification of correct items in the left ear was worse than in the right ear as the number of pairs of digits increased. A significant interaction was also found between ear and age-group ($F[2,29]=3{,}162$; $P<0.043$). The scores obtained in the left ear were higher than those obtained in the right ear for all groups studied. The REA was greater in the oldest and youngest groups than in the middle-aged groups.

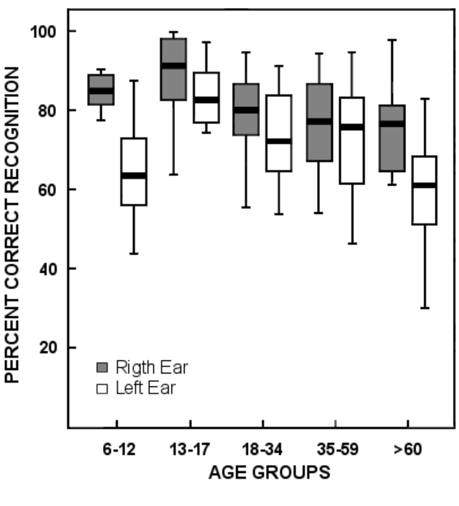

Figure 1: Descriptive measures of the scores in the Dichotic Digit Test. Scores are displayed in box plots. The boxes represent scores of 50% of the subjects, with the bold black line showing the median. The horizontal lines, above and below, show the maximum and minimum after removal of outliers and extremes.

In order to determine the interactions between ear and group, a regression analysis was carried out over the data. A significant curvilinear function ($y=0{,}32x2-0{,}509x+71{,}75$; $p<0.0001$) was fitted for the whole range of ages studied. In figure 4 we show the graphic representation of the scores obtained by ear as a function of test difficulty. A clear REA was observed in all groups. The greatest magnitude of this REA was found in the hardest items of the DDT.

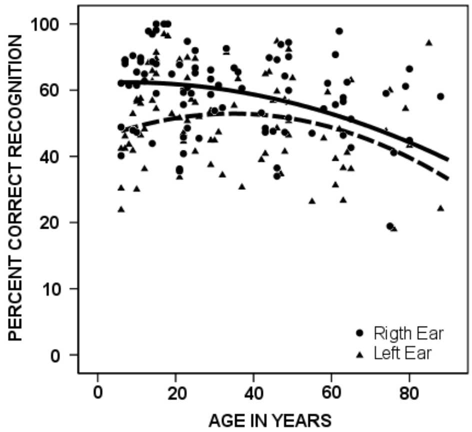

Figure 2: Curvilinear relationship between age and correct recognition percentage for the right ear (thick line) and left ear (discontinuous line) from infancy to old age.

DISCUSSION

This study reproduced similar results to those obtained in previous works were a systematic REA was found (4,5,6,7). Our results show a 73% of correct scores in the right ear and 64% in the left ear. Strousse & Wilson (7), with the same dichotic digit test, found a 94% correct scores in the right ear and a 86% correct scores in the left ear. In the present study, the difference between both ears was 8%. These results are consistent with other studies (6). The difference in the direct scores in both ears obtained in Strousse & Wilson's study were probably due to the inclusion of young subjects, from 6 years-old, in their study.

A greater difficulty of items implies an increase in score differences for both ears. This effect can be explained by a greater demand of the subject's attention and memory resources due to the difficulty of dichotic processing items. The greatest differences between both ears were found in the most difficult items and for the youngest and eldest group. A greater magnitude in the REA was obtained with the present version of DDT that clinically can be more clearly interpreted.

An aging effect was observed. Oldest and youngest subjects show greater hemispheric asymmetries and lower accuracy in the scores obtained in the present test. The analysis of the scores obtained in both ears for the whole range of ages studied is better fitted with a curvilinear function than with a linear function. The inclusion of young subjects in our study shows that the differences between ears are a phenomenon not only present in the elderly population.

CONCLUSIONS

From this study, the following conclusions can be established:

First, aging and task complexity decreased the capacity of digit recognition.

Second, age and task difficulty also increased interaural asymmetries.

The ability of the auditory system to cope with binaural information is better in the middle ages of life. In the extremes of the life span, subjects trend to report the information presented to only one ear, mainly the right.

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