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AUDITORY EVOKED RESPONSES TO VERBAL AND NONVERBAL STIMULI AND SELECTIVE ATTENTION

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Introduction

Event-related brain potentials, such as evoked responses, contingent negative variation, etc. vary under different task and subjects conditions.[2] These potentials have been widely used as indices of higher cerebral functioning.[6] Recently, the relationship between verbal behavior and hemispheric lateralization has come to be studied by means of event-related potentials as well as other physiological activites, psychological methods, anatomical and pathological data, etc.[7] In this paper, we will analyse the auditory evoked responses to verbal and nonverbal stimuli under various conditions of selective attention to investigate the mechanism of bilateral information processing in the human nervous system.

EXPERIMENT

Subjects

Ten right-handed male volunteers (mean age = 27) served as subjects. They had no history of neurological or psychiatric disorders.

Stimuli

The set of stimuli consisted of a speech sound of vowel /a/ (150 ms duration) and a 1KHz tone burst with the same duration as the speech sound. The interstimulus intervals were 3 seconds each. The stimuli were presented to the subjects via a frontal speaker or earphones at approximately 70 dB SL.

Procedure

Each subject participated in three sessions. In the first session, the subjects were instructed to listen to a stimulus sequence of tone bursts presented via right, left, or both earphones. In the second session, three stimulus sequences (tone bursts alone, speech sounds alone, and their blend) were presented via the speaker. Through the two sessions, the subjects were required to relax with eyes closed. In the final session, the stimulating condition was the same as the second. A visual attention task was imposed on the subjects, who had their eyes directed to the centre, to the right, and to the left in each trial, by a marker placed on the speaker.

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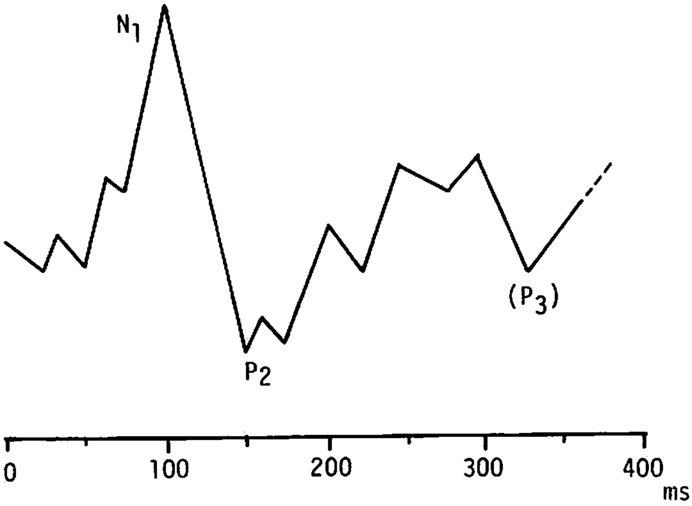

Fig. 1: A model of auditory evoked response (AEP).

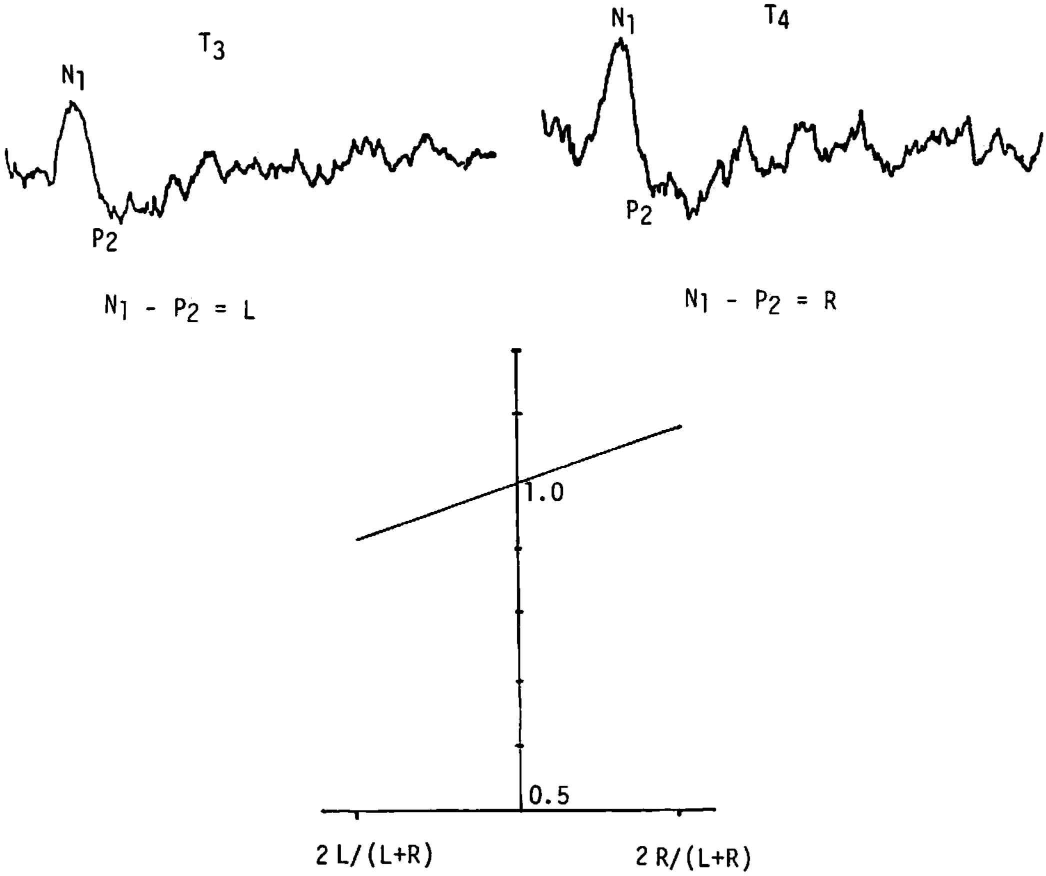

Fig. 2: An example of laterality of AEPs to nonverbal stimuli. T_3: left temporal region, T_4: right temporal region.

Recording

Electroencephalograms(EEG) were recorded from the vertex (C_z), the left temporal region (T_3), and the right temporal region (T_4) referenced to linked earlobes ($A_1 + A_2$). A ground electrode was affixed to the sprasternal bone. The electro-oculogram (EOG) was also recorded between the superior orbital ridges of the right and left eyes. The EEG and EOG were monitored and recorded with stimulus signal on an FM tape recorder. A total of 128 data with no artifacts were selected in each trial and averaged by a mini laboratory computer.[4]

Data analysis

The peak-to-peak amplitudes between two AEP components (N_1, P_2) were measured on T_3 and T_4. The N_1 component can be seen as a negative going wave at a latency of 80-140ms, and the P_2 component as a positive going wave at a latency of 140-200ms (see Fig. 1). The amplitudes of the left (L) and right (R) hemispheres were normalized with reference to (L+R). The laterality of the AEPs was measured in terms of the following index (see Fig. 2).

$$Z = \frac{L-R}{L+R} \times 100\ (\%)$$

RESULTS

Ear Differences

The effect of ear difference of stimulation on laterality of AEP is shown in Fig. 3. The AEPs to non-verbal stimulus (tone bursts) had a tendency for the right hemisphere to be dominant (Z: negative). The tendency was enhanced when the stimuli were presented to the left. However, the enhancement by the left ear stimulation was decreased under the random condition (right figure).

Verbal and Nonverbal Differences

The laterality of AEP to speech sound denoted the oppsite tendency (see Table 1), and the difference between verbal and nonverbal stimuli was larger than the ear difference. This laterality showed no change even when the verbal and the nonverbal stimuli were presented randomly (blend condition) (see Fig. 4).

Visual Attention

Figure 5 indicates that the visually directed attention could affect the laterality of AEP both for verbal and nonverbal stimuli.

DISCUSSION

Spirduso has suggested that three factors are important in explaining human hemispheric differences: 1. hemispheric input/output coupling, 2. hemispheric dominance and specialization, and 3. hemispheric

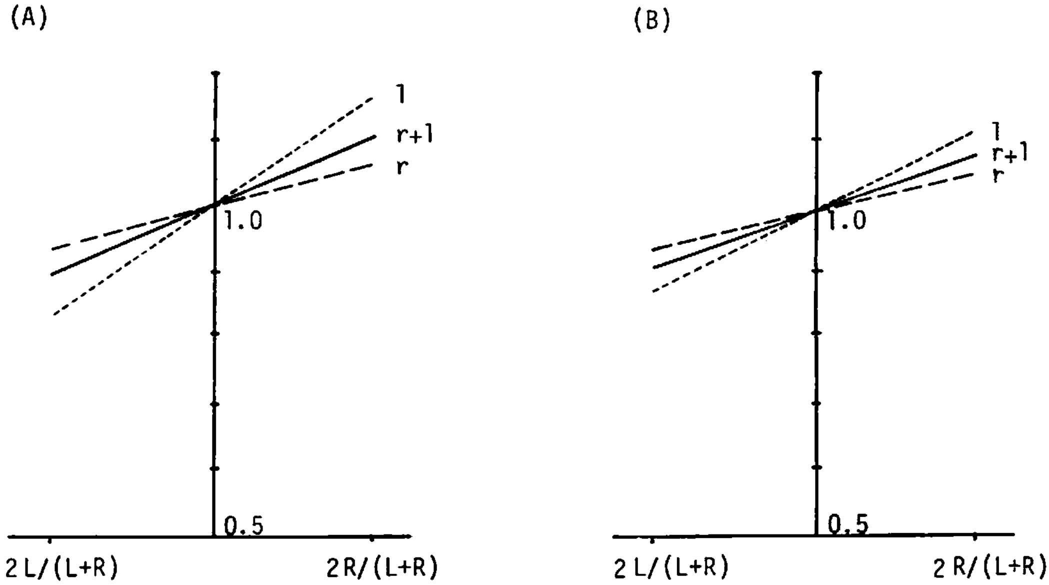

Fig. 3: Hemispheric lateralities of AEPs for tone-bursts presented continuously to the right (r), left(l), and both (r+l) ears (A), and presented randomly to the right or left or both ears (B).

Table I

Means and standard deviations of indices of laterality (Z)

	N	mean	SD	max	min
TONE BURST	10	-8.9 %	3.1	-14.3	-3.4
VOWEL	10	8.7	2.9	14.3	5.7

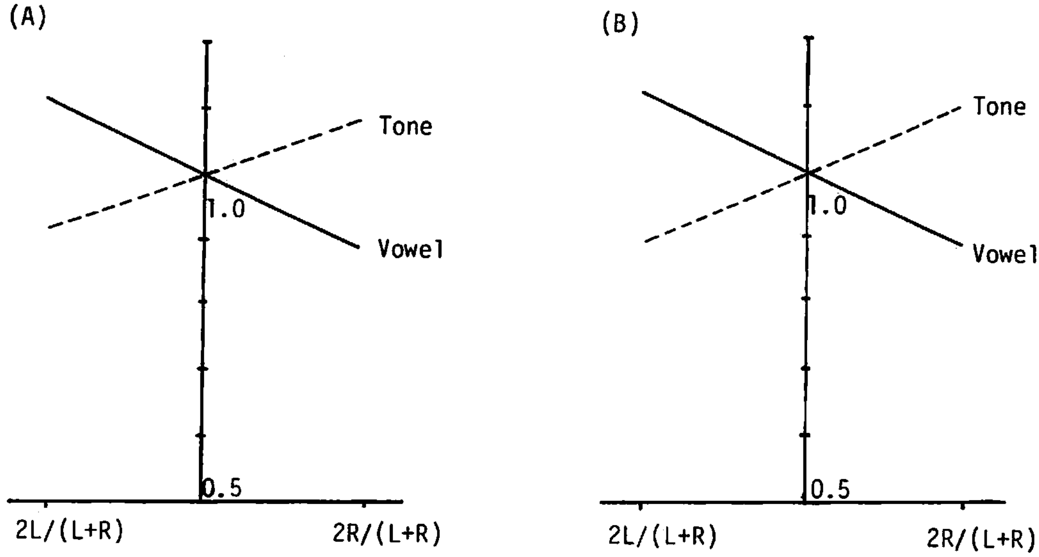

Fig. 4: Hemispheric lateralities of AEPs for tone-bursts and vowels. (A) tone-bursts alone or vowels alone presented on each trial. (B) their blend presented.

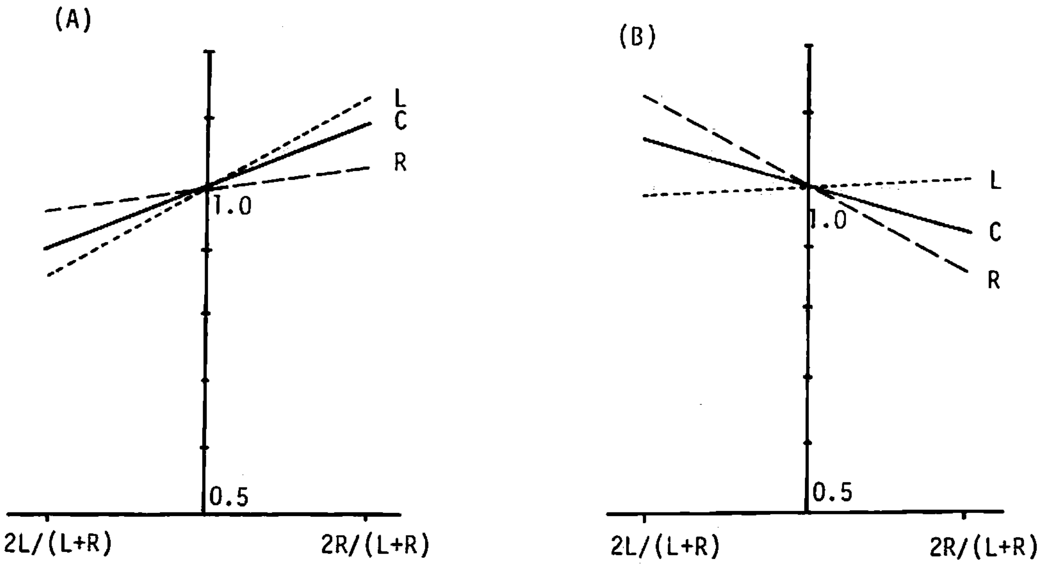

Fig. 5: Hemispheric lateralities of AEPs for tone bursts (A) and vowels (B) while eyes directed to the centre (C) to the right (R), and to the left (L).

orientation.[10] In the auditory system, about 60% of the afferent fibers project to the contralateral hemisphere. The ear difference shown in Fig. 3. could be due to the factor of hemispheric input coupling. However, the ear difference under the condition of the stimulation to one ear alone seems to have resulted from an additional factor, possibly that of hemispheric orientation.[1]

The difference betweeen verbal and nonverbal stimuli can be explained by the factor of hemispheric dominance and specialization, but some control mechanism should be assumed for activating the hemisphere dominant to the stimuli.[8]

The third component, hemispheric orientation, has been argued by Kinsbourne, et al.[5] The laterality shift in terms of visual directed attention as shown in Fig. 5 were due to this component because orientation is dependent on eye and head positions.

In our experiment, orientation refers to intentional directed attention, but reflexive orientation also exists which is accompanied by phasic eye and head movements.[11] Reflexive orientation cannot be neglected when doing a wave analysis of AEP,[3] nor when considering the control mechinism activating the dominant hemisphere.[12] Our results show that the two types of orientation, that is, intentional attention and automatic attention,[9] have an important influence on verbal and nonverbal information processing in the right and left hemispheres.

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