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HEMISPHERIC ASYMMETRY OF AUDITORY EVOKED RESPONSES AND ABNORMAL VERBAL BEHAVIOR

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INTRODUCTION

Recent studies indicate that intermodal interaction play an important role in the human communication system[1,2,15]. Event-related brain potentials such as late components of evoked responses, contingent negative variation (CNV), etc., have been widely used as indices of higher cerebral functions[4,6,7,10]. In this paper, we will analyze the hemispheric laterality of auditory evoked responses to verbal and nonverbal stimuli under visually selective orientation in order to investigate the mechanism of auditory-visual interaction in bilateral information processing, and in order to apply this method to analysis of abnormal verbal behavior, especially auditory hallucinations in schizophrenic patients.

EXPERIMENT

Subjects

Ten right-handed male volunteers (mean age = 29) served as normal subjects. They had no history of neurological or psychiatric disorders. Ten schizophrenic patients (six hallucinators and four non-hallucinators) also served as subjects.

Stimuli

The set of stimuli consisted of a speech sound vowel /a/ and a 1kHz tone burst, both with a duration of 150ms. Interstimulus intervals were 3 seconds each. The stimuli were presented to the subjects via a frontal loudspeaker at approximately 70dB SL.

Procedure

Each subject participated in two sessions. In the first session, the subjects were instructed to listen to a stimulus sequence of tone bursts or speech sounds. Throughout the session, the subjects were required to relax with eyes closed. In the second session, the stimulating condition was the same. A visual orientation task was imposed on the subjects, who had their eyes directed to the center, to the right and to the left in each trial, by a marker placed on the loudspeaker.

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Recording

Electroencephalograms (EEGs) were recorded monopolarly from the vertex (Cz), the left temporal region (T3) and the right temporal region (T4) linked with ear lobes (A1 + A2). A ground electrode was affixed to the upper part of the sternal bone between the right and left sterno-clavicular joints. The EEGs were recorded with stimulus signals on an FM tape recorder. A total of 128 data with no artifacts were selected in each trial and averaged by a laboratory mini-computer.

Data Analysis

The peak amplitudes of N1 peak were measured from the level at stimulus onset time in AEP on T3 and T4. The N1 component can be seen as a negative wave at a latency of 70 – 140ms. The amplitudes of the left (L) and right (R) hemispheres were normalized with reference to (L + R). The laterality of the AEPs was represented as the following index:

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

The N1 latencies of T3(l), T4(r) and Cz(c) were also measured.

RESULTS

Visual Orientation

Figure 2 shows the lateralities of AEPs of normal subjects to verbal and nonverbal stimuli under various conditions of visual orientation. The laterality of AEPs to nonverbal stimuli had a tendency toward right hemisphere dominancy (z:negative). The AEPs to verbal stimuli denoted the opposite tendency. Under the condition of eyes directed to the right, the laterality shifted to left hemispheric dominancy, and under the eyes to the left, it shifted to right hemispheric dominancy.

Temporal Laterality

Figure 3 shows the differences in N1 latencies among T3(l), T4(r) and Cz(c) in response to verbal and nonverbal stimuli. In each figure, the ordinate indicates peak latency difference between of l and c, and the abscissa denotes the difference between r and c. The data were from normal subjects (A) and schizophrenic patients (B) with (●) and without (○) auditory hallucinations. The difference was relatively small in the normal subject nonverbal data showing a tendency toward positive r-c. In the normal subjects, the verbal data variation in the l-c axis was increased, resulting in a similar positive r-c tendency.

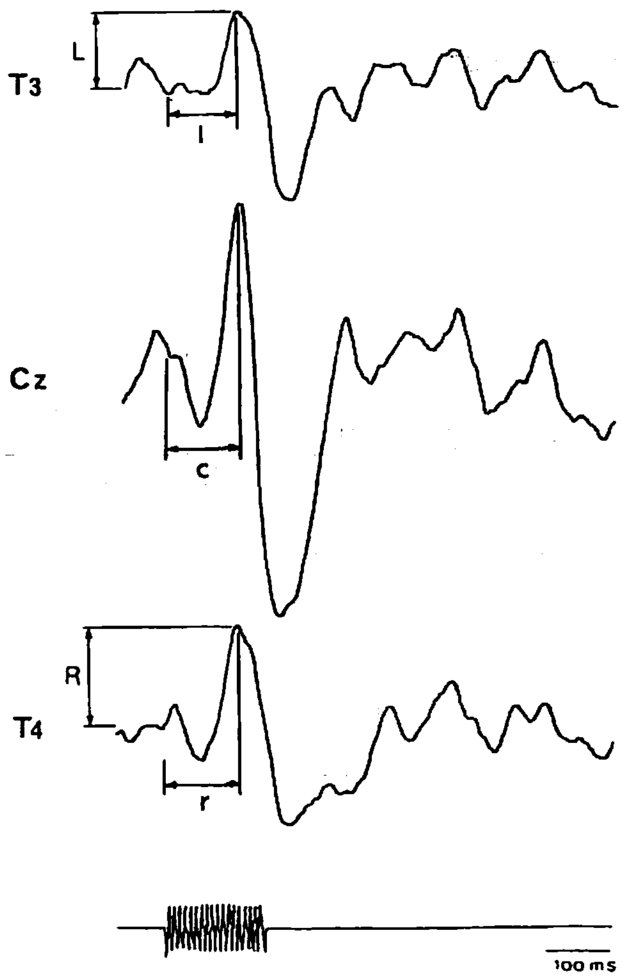

Fig. 1 Examples of auditory evoked responses.
T3: left temporal, C3: Vertex,
T4: right temporal. L, R: amplitudes
of N_1 peak. l, c, r: latencies of N_1 peak.

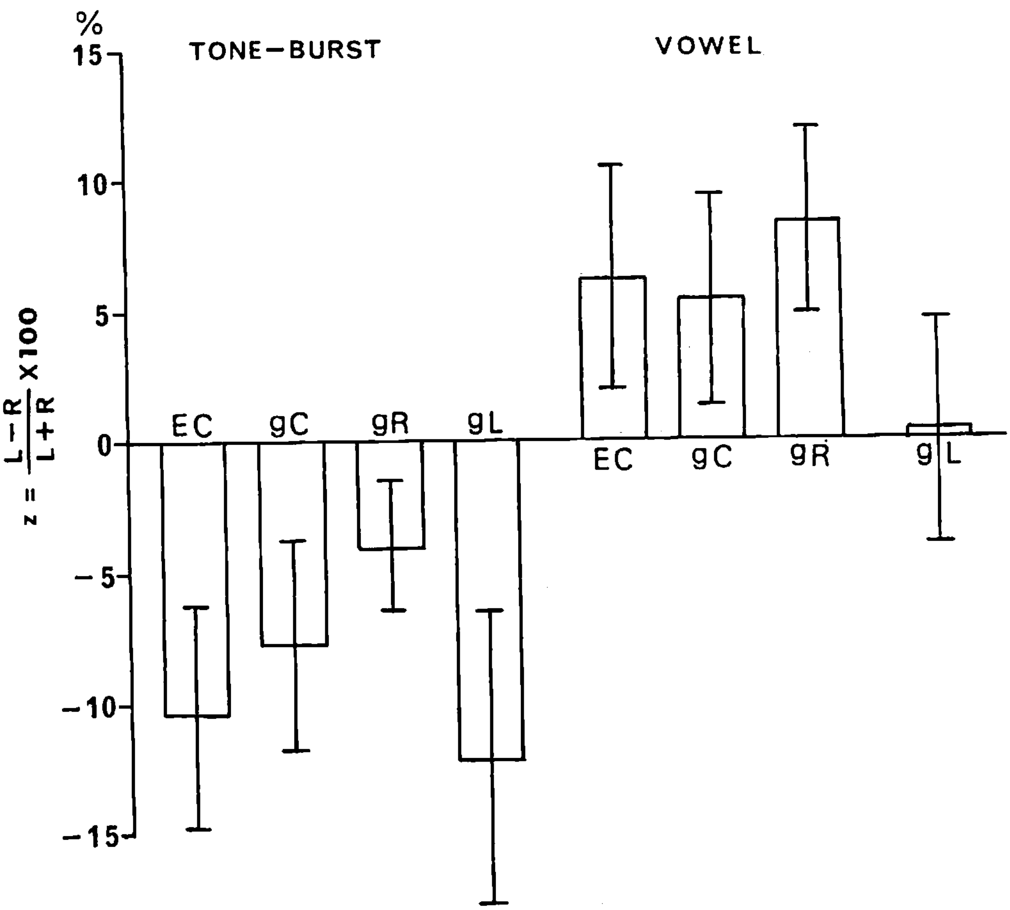

Fig. 2 Lateralities of N_1 amplitudes for tone burst and for vowel under visual orientation tasks. EC: eyes closed, gC: eyes directed to the center, gR: eyes directed to the right, gL: eyes directed to the left. Normal subjects (N = 10)

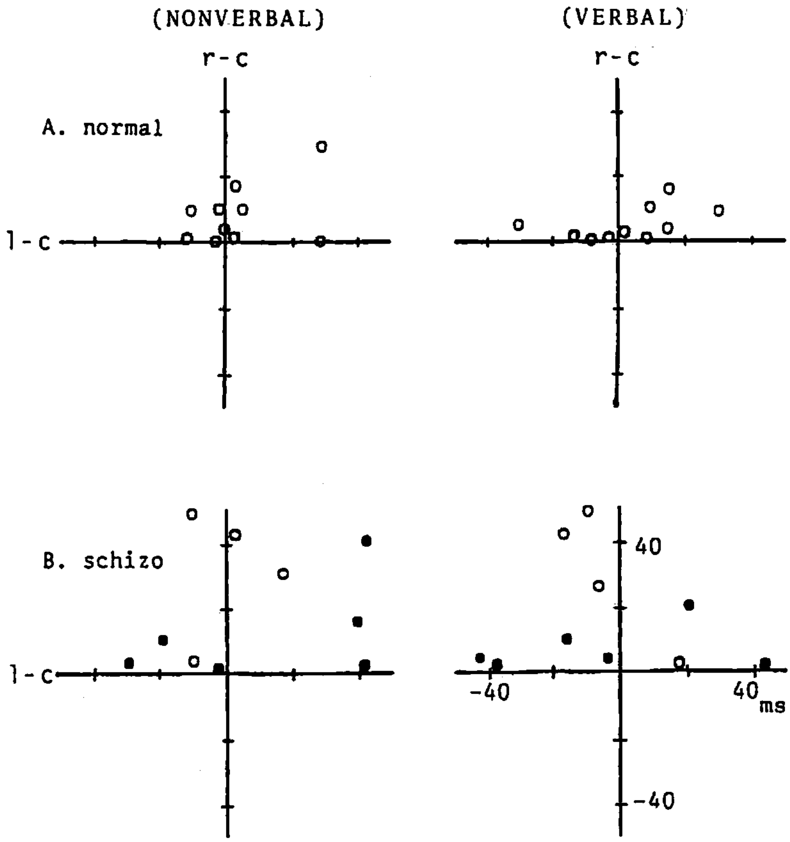

Fig. 3 Differences of N_1 latencies among T_3, T_4 and Cz AEPs in response to verbal (vowel /a/) and nonverbal (tone burst, 1kHz-150ms) stimuli. A. data from normal subjects. B. data from schizophrenic patients with (●) and without (o) auditory hallucinations.

DISCUSSION

The N1 latencies of schizophrenics varied widely. The lateralities of N1 amplitudes were not consistent with the visual orientation tasks. Walpaw and Penry have proposed a temporal AEP model which consists of two components, i.e., nonspecific response and specific 'T-complex'. They regarded the Cz AEP as the nonspecific response to be extracted from the T-complex to indicate temporal AEP (see Fig. 4). We applied this model to

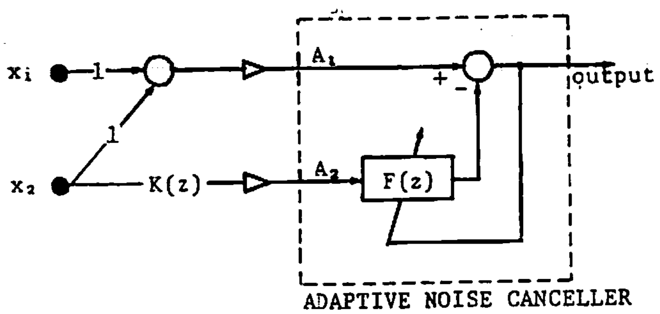

Fig. 4 Single-channel adaptive noise canceller without noise in the inputs. The sources x_1 and x_2 correspond to 'T-complex' and 'nonspecific response', respectively, in Walpaw & Penry's model on auditory evoked responses of temporal cortex (A_1) and vertex (A_2).

the AEPs from normal subjects and from schizophrenics in order to analyze the abnormal AEP characteristics of schizophrenics. Figures 5 and 6 show the auditory evoked responses to verbal stimuli from normal and from schizophrenic patients with auditory hallucination (A), as well as waveforms derived from the AEPs above by the indicated algebraic calculations (B). An evident component remained in (T3 - 1/2 Cz) only from the schizophrenic patients. The methods of EP decomposition such as T-complex technique may be useful for analyzing abnormal AEPs like those in Fig. 6.

Kinsbourne argues that interaction exists between hemispheric information processing and orientation.[8] Crosby's data indicate that eye orientation is controlled by the opposite hemisphere.[3] Gur describes schizophrenic eye orientation shifts to the right abnormally (overactivation of the left hemisphere).[5] Our data show that AEPs can be used to analyze auditory-visual interaction. It would be interesting to discuss the problem of verbal information processing in an egocentric spatial system, such as "cocktail party effect" and "grammar of discourse" on the basis of auditory - visual interactions.[1,2,9,11,13,14]

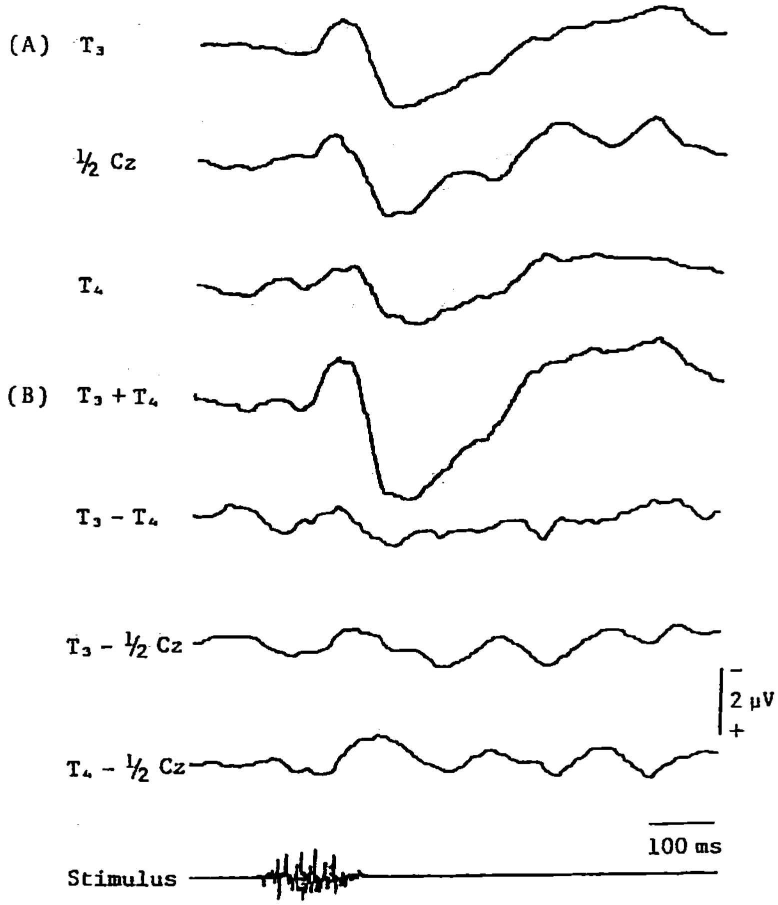

Fig. 5 Auditory evoked responses to verbal stimuli from normal subject (A) and waveforms derived from the AEPs above by the indicated algebraic calculations (B).

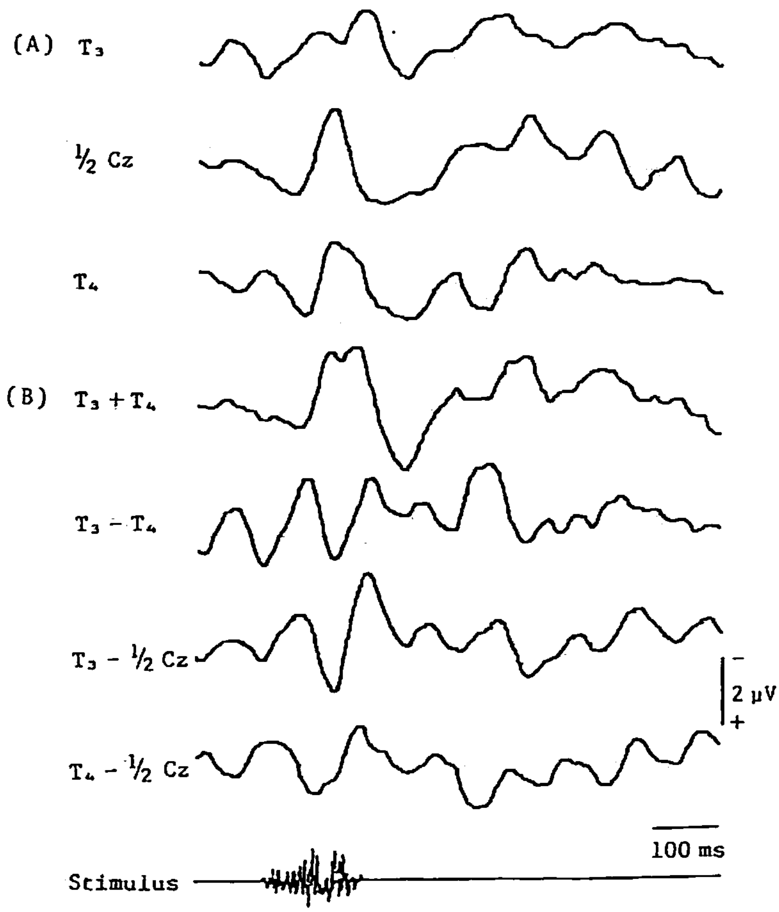

Fig. 6 Auditory evoked responses to verbal stimuli from schizophrenic patient with auditory hallucination (A) and waveforms derived from the AEPs above by the indicated algebraic calculation (B).

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