RELATIONSHIP BETWEEN FRONTAL MIDLINE THETA ACTIVITY IN EEG AND CONCENTRATION

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The relationship between the appearance of EEG theta rhythm in the frontal midline area (Fmθ) and the level of concentration was investigated by using warning signals in simple reaction tasks on 6 male subjects. The result that Fmθ appeared in the foreperiods between the warning and the signal to respond suggests a relation between Fmθ and concentration. Fmθ also appeared, however, at other times. This suggests that a component of Fmθ may not be related to concentration.

Since Ishihara and Yoshii (1972) found a distinct theta activity of EEG over frontal midline area during mental tasks, which is called Fmθ, Japanese investigators have clarified some characteristics of Fmθ. It has been suggested that Fmθ is related to a state of mental concentration (focused attention).

Niwa and Yamaguchi (1975) measured reaction time of the dominant foot to sound stimulus while the subjects were performing adding task with two terms, with Fmθ and without Fmθ. The result was that the reaction time in the term with Fmθ was longer than that in the term without Fmθ. So they concluded that the variation in the reaction time was reflected by the difference in the level of concentration to the adding task. Mizutani et al. (1988) measured performance time in a serial adding task in the term of Fmθ appearance and the term before appearance of Fmθ. The performance time in the term with Fmθ was shorter than that before Fmθ. Nakashima and Sato (1992) suggested the correspondence of the amount of Fmθ to the level of concentration by examining the appearance of Fmθ during various mental tasks.

The exact relation between Fmθ and specific psychological processes is, however, left unresolved. The purpose of the present study was to elucidate the relation between the level of concentration and the appearance of Fmθ in the

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experiment in which the concentration level was controlled by using warning signals in simple reaction tasks. It was supposed that the concentration level was enhanced in the foreperiod between the warning signal and the signal to respond.

METHODS

The subjects were 6 male students aged 21–24 years. They were selected as the Fm θ appearance group at the previous experiment, in which Uchida-Kraepelin test (a serial addition task) was performed for 5 min.

The monopolar EEG records were obtained from disk electrodes placed on Fz (International 10–20 Electrode System) using A1 as a reference. Criteria for Fm θ were: rhythmical sinusoidal configuration, markedly higher amplitude as compared with background activity, duration exceeding 1 s, and frequency of 6–7 Hz.

First, the subjects performed the reaction task without a warning signal. They were asked to respond to an auditory signal by pushing a key on a keyboard as fast as possible. The reaction time was measured and recorded with a personal computer. Ten trials were performed at 12–17 s intervals.

Next, the subjects performed the reaction tasks with warning signals. The warning signal, which was same auditory stimulus as the signal to respond, was given before the signal to respond. Four lengths were employed for the intervals between the warning and the signal to respond, i.e., 2, 3, 4, and 5 s. The foreperiods were almost constant in a series of trials (task). To avoid an anticipatory response the length of intervals was varied spontaneously within the range −0.2 s to +0.2 s for each foreperiod. Similar to the reaction task without a warning signal, ten trials were performed for each foreperiod at 12–17 s intervals. The order of the tasks with different foreperiods was counterbalanced among the subjects. Total time of the experiments for each subject was about 40 min.

Statistical comparisons were made with paired or unpaired t-tests.

RESULTS AND DISCUSSION

Reaction time and Fm θ appearance time (the percentage of time during which Fm θ appeared relative to the experiment time for the task) in each task are shown for each subject in Fig. 1. The reaction time of subject NOG was shorter than those of MAC and SUE (p < 0.01) and ISA and IWA (p < 0.05) at the task with no warning, and was shorter than ISA and MAC (p < 0.01) at the task with a 2-s foreperiod, of subject MAC (p < 0.01) and subject IWA and SUE (p < 0.05) at 3 s task, and of subject MAC (p < 0.01) and subject ISA and SUE (p < 0.05) at 4 s task. NOG, who had the shortest reaction time, also had a high Fm θ appearance time, but not the highest one. MAC, who had the highest Fm θ appearance time, had a longer reaction time than the other subjects.

The periods of Fm θ appearance in five tasks are shown for two subjects (IWA
and NOG) in Fig. 2. Fmθ in IWA, who generated the least amount of Fmθ among all the subjects, was restricted to the foreperiods. In other subjects, there were many instances in which Fmθ appeared immediately after the warning signal and disappeared just before or after the signal to respond. These results suggest that Fmθ appears when the level of concentration is high. For each task in each subject, however, no statistically significant difference in reaction time was observed between the instances with and without Fmθ appearance in the foreperiods. As in the previous study (NAKASHIMA and SATO, 1992), no correspondence between Fmθ appearance time and performance of the task was observed.

Fmθ also appeared besides the foreperiods in all subjects except IWA. NOG, shown in Fig. 2, typifies this type of response. It seems that Fmθ is sometimes not related to concentration. MIZUKI (1982) reported the periodicity of Fmθ appearance. Excluding Fmθ in the foreperiods, the periods of Fmθ appearance are shown for all tasks in all subjects in Fig. 3. Distinct periodicity was not observed in the present study.

It is suggested that Fmθ is related to at least two different psychological processes. One is concentration, and the other is apparently not related to concentration. The nature of the process is a problem for future research.
Fig. 2. Periods of Fmθ appearance in two subjects (IWA and NOG). In each task the upper thick bar shows the experiment time, and the black sections within show the foreperiods between the warning and the signal to respond. The thick black bar below indicates the periods of Fmθ appearance.

Fig. 3. Periods of Fmθ appearance excluding Fmθ in the foreperiods.

REFERENCES


