Usefulness of Computer-Assisted Portable EEG Recorder for Field Work in Applied Human Science

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Quantitative analysis of EEG frequencies provides useful information about the arousal level of the awake human (Matousek and Petersén, 1983; Okawa et al., 1984). It has been reported that the arousal level can be evaluated by measuring characteristics of power spectral densities in the range of alpha waves (Hyoki et al., 1993; Michimori et al., 1994; Ogilvie et al., 1991; Torsvall and Åkerstedt, 1987). In laboratory experiments, EEG measurements have been conducted using conventional clinical EEG recorders furnished in the room. However, there are some disadvantages to the conventional clinical EEG recorder despite its generally recognized usefulness, such as, limited availability in clinical setting, adverse effects on the emotional state of the subject, and economic cost (Ebersole and Leroy, 1983). In field study, for example, a study aimed at evaluating the arousal level of the community-dwelling elderly in their daily life at the time of a health check-up, it was difficult to provide a conventional clinical EEG recorder because of transportation difficulty and measurement complexity. Recently, a computer-assisted, economically priced, portable EEG recorder was developed for possible use in academic studies. This EEG recorder is commercially available, and is marketed under the name Brain Machine Interface (BMI, Nouryoku Kaihatsu Kenkyujo, Tokyo). BMI is a portable one-channel EEG recording apparatus that is connected to a personal computer. Two electrodes are attached to a plastic hair band, and one electrode is attached to an ear with a short lead wire. As there is little available data to ascertain the reliability of EEG frequencies measured using this apparatus, in the present study we aimed to determine the reliability of measurement of this apparatus by comparing the BMI EEG frequency structure with that from a conventional clinical EEG recorder.

Sixteen healthy male adult subjects voluntarily participated in this study after informed consent. The mean age was 32.8 ± 10.3 years. Subjects were synchronized to a sleep cycle from midnight to 7 o'clock for one week before the day of the experiment. On that day, subjects were seated in a comfortable chair, in a bright, electrically shielded, sound-attenuated room. The room air temperature was controlled at $25 \pm 1.0^\circ\text{C}$, and

the light intensity was 500 lux at the eye level. After being instructed about the experimental procedure, EEG measurement was first conducted using the conventional clinical EEG recorder, Neuropack (Nihon Kohden, Tokyo), and then conducted using the portable EEG recorder, BMI. The duration of measurement as well as the EEG recording time schedule were the same for each of the two measurement conditions. The time schedule used during EEG recording was as follows: (1) eyes closed for 60 seconds, (2) eyes open for 60 seconds, and (3) eyes closed for 60 seconds. During the recording, subjects were seated in a resting position. EEGs were recorded using electrodes placed on the left frontal scalp (Fp1) with the left ear as a reference in both conditions. The EEG potential amplitudes were converted into power spectra domains by Fast Fourier transformation analysis. In this study, the frequency domain between 1 and 15 Hz was analyzed because of a limitation in the analyzing software program of Neuropack. The percentage of delta (1–3 Hz), theta (4–7 Hz), alpha (8–13 Hz), and beta (14–15 Hz) waves were calculated for both measurement conditions. Pearson's product-moment correlation coefficients were calculated from the frequency data in order to reveal an associations between the frequency percentage (delta, theta, alpha and beta) obtained using Neuropack versus BMI. The mean power spectral density, in percent, of each frequency obtained during the measurement period was used for the correlation analysis.

Figure 1 shows the relationship between alpha wave frequency percentages, with eyes closed, as measured by the portable EEG recorder and by the conventional clinical EEG recorder. A significant correlation was confirmed ($r=0.52$, $p<0.05$) (Fig. 1). When the frequency band for alpha₂ (10.5–12.5 Hz) was considered, the correlation of measurement data between the two EEG recorders was stronger ($r=0.77$, $p<0.001$). There was no significant correlation in percentages of EEG frequencies between the portable EEG recorder and the conventional EEG recorder when the subjects' eyes were open.

The results show that the portable, computer-assisted EEG recorder provides reliable data for alpha

Fig. 1 Relationship of alpha wave frequency percentage comparing a computer-assisted portable EEG recorder (BMI) and a conventional clinical EEG recorder (Neuropack) ($r=0.52$, $p<0.05$).

waves EEG frequencies when subjects are resting in a quiet comfortable condition with eyes closed. With eyes open, blinking and other eye movements cause potential changes, and these artifacts increase the component of the low frequency band. With eyes closed, the frequency data were less influenced by these artifacts, which could explain the significant correlation of alpha waves frequency percentages between the two EEG recorders.

The portable, computer-assisted EEG recorder used in this study was primarily developed for commercial application, that is, to aid in the mental relaxation of ordinary people in everyday life. The operation of the machine is easy and measurement time is short. Furthermore, this machine is useful in applied human science field work because of its portability and cost-effectiveness. However, there are some points that should be carefully considered when using this machine for academic applications. First, measurement conditions with a portable EEG have to be carefully chosen. The room should be quiet and kept under neutral thermal conditions with little illumination. Secondly, reliable data for EEG frequencies were obtained only with subjects'

eyes closed. Thirdly, the duration of measurement was at least three minutes adopted in our study.

With these reservations, the portable, computer-assisted EEG recorder used in this study can become a useful tool for studying EEG in applied human science field work. Examples of studies using this tool are a public health study of the alertness level of the community-dwelling, mentally ill elderly for the purpose of amelioration of their activities of daily living, and an industrial health study of alertness changes in shift workers.

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