

Sleep EEG

Quantitative characteristics of alpha and theta EEG activities during sensory deprivation

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Abstract

Our previous study showed that theta and alpha electroencephalographic (EEG) activities occurred together during sensory deprivations (SD). The respective activities are expected to manifest different physiological states. In this study, we investigate statistical properties of both types of EEG activities during SD. Wavelet analyses of the original EEG activities during SD and the corresponding surrogation data can distinguish meaningful alpha and theta activities in the original data from accidentally detected ones. As a result, the mean duration of the theta wave is found to be longer than that of the alpha wave. This result could be useful to disclose physiological processes during SD.

Key words

alpha EEG activity, sensory deprivation, theta EEG activity, wavelet analysis.

INTRODUCTION

During sensory deprivation (SD), peculiar experiences such as visual images have been reported.¹ Our previous study showed that theta and alpha activities occurred together during the SD sessions in which the subjects experienced visual images (VI).² Since the respective activities are expected to manifest different physiological states, their dynamics are important to understand physiological processes during SD. In this study, we investigate statistical properties of both types of electroencephalographic (EEG) activities during SD.

MATERIALS AND METHODS

Subjects left for 1 h in the flotation tank to realize SD,² where a polygraph (EEG: Fp1, Fp2, C3, C4, O1 and O2; EOG: left and right; EMG: chin muscle; and ECG) was recorded. We examined EEG data of one male (aged 32 years) and one female (aged 29 years). They experienced VI in 12 SD sessions out of 14. Among the 12 VI sessions, coexistence of theta and

alpha EEG activities was recognized in five sessions of the female subject. Scalograms of the EEG data (C3) in these five sessions were obtained in terms of an absolute value of the complex wavelet coefficient (Gabor wavelet, $\sigma=7$). The alpha and theta activities were detected by applying an appropriate threshold to the integrated scalogram over the scaling ranges corresponding to the theta (5–8 Hz) and alpha (9–12 Hz) bands, which were subject to construction of duration histograms. In order to observe the statistical significance of the original histograms, a difference histogram was constructed by subtracting the duration histograms for 20 ensembles of surrogation data from the original. Surrogation data has the same power spectrum as the original data but has a randomised phase spectrum.³ Therefore, detections performed on the ensembles of the surrogation data show the detections come from possible statistical variations (i.e. accidental detections).

RESULTS AND DISCUSSION

Figure 1 briefly shows a representative segment of the scalogram together with the corresponding EEG and detected theta and alpha activities. Figure 2 shows representative histograms of durations of theta / alpha activities. The difference histogram shows an early negative and later positive pattern, which suggests

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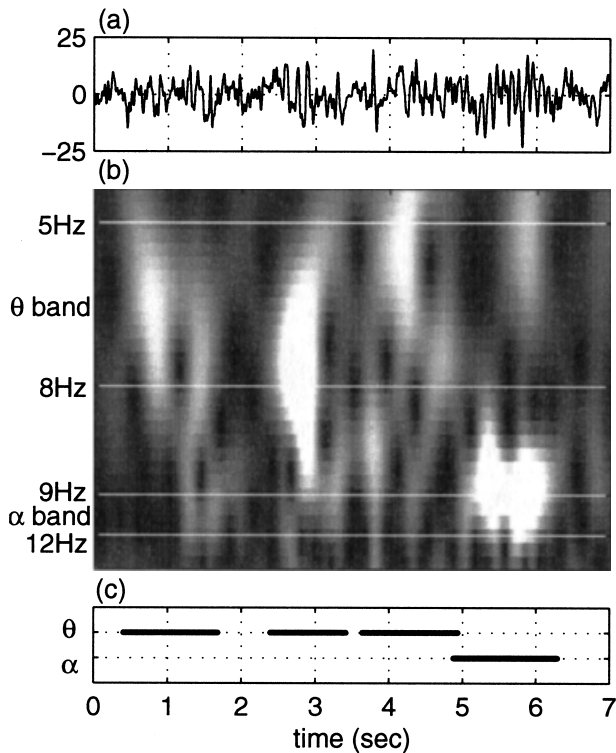


Figure 1 (a) EEG activity (C3) during sensory deprivation. (b) Scalogram, the lighter part indicates a larger amplitude. The wavelet scale is transformed into the frequency using the relation $f=1/2\pi a$, where f and a are the frequency and the scale parameter of the wavelet, respectively. (c) Detected theta and alpha activities.

that the accidental detections are distributed in the shorter range of duration, and in contrast the original samples exist in the longer range. Here, mean and standard deviation (s.d.) were calculated for the samples beyond 1 s. Estimated mean and s.d. for the five sessions are: theta mean (s)±s.d. (s) (n), alpha mean (s)±s.d. (s) (n)=1.83±0.75 (173), 1.51±0.59 (213); 1.99±0.91 (26), 1.48±0.51 (25); 1.98±0.77 (59), 1.37±0.35 (58); 1.87±0.92 (155), 1.48±0.70 (167); and 2.18±1.00 (115), 1.57±0.62 (174). This result shows that the duration of the theta activity tended to be longer and to be distributed more broadly than the alpha. The duration of the theta activity tends to be overestimated compared with the alpha (i.e. estimation bias) due to the difference in the support length of the respective wavelets for the theta and alpha bands. The bias is roughly estimated as 0.2 s in terms of the difference in correlation times of theta and alpha band scalograms. Therefore, considering the

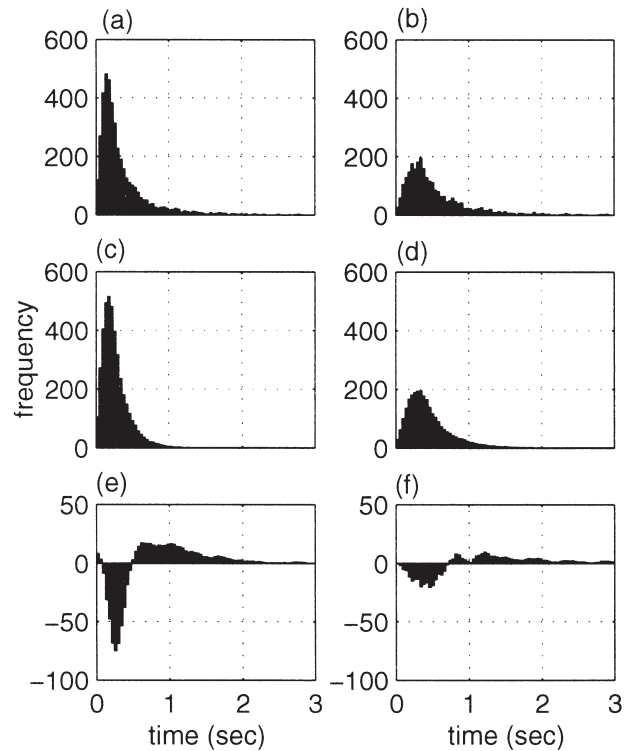


Figure 2 Duration histogram of (a) alpha and (b) theta activities (original). Duration histogram of (c) alpha and (d) theta activities (surrogate). (e) Difference histogram of (a-c) alpha activity. (f) Difference histogram of theta activity (b-d).

estimation bias, the difference between durations of theta and alpha activities is regarded as significant. The mixed occurrences of theta and alpha activities and the difference in their durations will be studied further to understand the physiological processes during SD.

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