A Static Magnetic Field of an MR Scanner Modulates Brain Activity

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Purpose: To investigate whether brainwaves are changed by the static magnetic field of an MR scanner, we monitored brainwaves during the task performance and the rest condition inside and outside the MR scanner in different two days before and after demagnetization of the 1.5-T MR magnet.

Materials and Methods: The Ag/AgCl electrodes (Nihonkoden, NE-706A) were placed at Fz, Cz and Oz in the scull of eight right-handed volunteers (aged 20-28 years). We measured EEG of each volunteer who performed a modified counting oddball task task (3 minutes) and stayed at rest (3 minutes) on the patient table, both inside and outside a 1.5-T MR scanner (SIGNA Horizon LX, General Electric). All electrodes were referenced to the left earlobes. This EEG measurement was done in different two days before and after demagnetization of the 1.5-T MR magnet. The volunteers were not told that the magnet had been demagnetized in the second measurement. The refrigerator was kept moving to make sound even after the demagnetization to keep the same perceptual circumstance for volunteers. Large pulsatile waveform due to ballistocardiogram (BCG) overlapped on EEG data inside the MRI scanner before the demagnetization. The averaged waveform during a pulse (BCG waveform) was obtained by averaging EEG data time-locked to the QRS peaks. To reduce the influence of BCG, the BCG waveform was subtracted from the original EEG data synchronously to each QRS peak. Then the subtracted EEG was Fourier-transformed to give the power spectra in which the influence of fluctuation of BCG (δ_B) still remained. δ_B increased power spectral intensity by 2-10 times, compared to that without the static magnetic field. To remove the influence of δ_B, we plotted the power spectral intensity of the subtracted EEG versus that of the averaged BCG (S_B) (Fig. 1a). As the origin of BCG is the pulsatile blood flow in aorta, the influence of the fluctuation of BCG appears on EEG in the same manner that is characterized by the fluctuation of the pulsatile blood flow in aorta. Therefore, the ratio δ_B / S_B at all electrode positions should be the same for each spectral component (α, β, δ, θ). In particular, when the intrinsic brainwaves of three electrode positions differ insignificantly, the y-intersect represents the spectral intensity of the intrinsic brainwave (Fig. 1a).

Results and Discussion: During both periods of task performance and the rest condition, each brainwave showed no significant difference for the experimental conditions without the static magnetic field: outside the magnet before the demagnetization, inside and outside the magnet after the demagnetization. Each intrinsic brainwave of α, β and δ estimated from y-intersect (Fig. 1a), which is the brainwave in the static magnetic field, did not change significantly, compared to the brainwave without the static magnetic field. In contrast, the θ-wave increased during the task performance only in the static magnetic field. This conspicuous evidence at Fz and Cz is shown in Figure 1b. The θ-wave that characteristically appears at the center of the frontal lobe of subjects taking intelligence tests is called as frontal midline θ rhythm (Fmθ)(1). An increase in slow brainwaves of δ and θ is accompanied by a decrease in cerebral blood flow(2) causing a decrease in shear rate of the blood flow. Lower shear rate enhances the blood viscosity in the static magnetic field(3). Therefore, a decrease in blood flow is accelerated in the static magnetic field. The physiological response like an increase in Fmθ with a decrease in blood flow may be accelerated in the static magnetic field.

Conclusion: We elucidated that the Fmθ increases during the odd ball task conspicuously in a 1.5-T static magnetic field. This evidence may lead to a conclusion that brain activity can be modulated by the static magnetic field of an MR scanner.

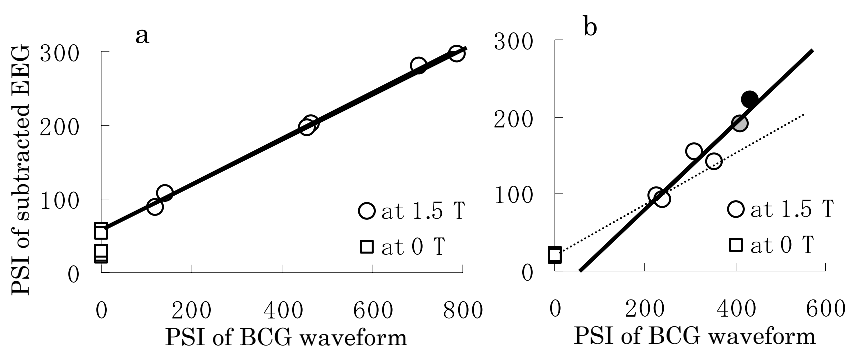

Fig. 1 Power spectral intensity (PSI) of subtracted EEG versus PSI of BCG waveform. (a) α-wave. (b) θ-wave: PSIs at Fz (closed circle) and Cz (gray circle) during the task performance at 1.5 T increase from the theoretical line (dotted line) derived from the data of other brainwaves.

References

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