Development of Neurofeedback Method for Motor Imagery-Based Brain-Computer Interface

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Introduction

■ BCI (brain-computer interface)

- An interface between humans and machines based on brain activity.

■ MI-BCI (motor imagery-based BCI)

- BCI that uses brain activity generated by the imagery of limb movements.

■ SMR (sensory motor rhythm)

- EEG mainly in μ-band(7-13Hz) β-band(14-30) are suppressed during motor execution and motor imagery.

■ ERS/ERD (event-related (de)synchronization)

- Changes in EEG bandwidth intensity during task performance relative to rest period.

■ Body part localization

- The specific body parts that make up the body correspond to specific areas of the cerebral cortex.

■ Neurofeedback

- A method to encourage users to improve themselves brain activity by presenting their brain activity in real time and asking them to self-regulate.

◆ In this study

- We proposed the NF system that can be operated intuitively by users by visually presenting feedback indicators to them, and evaluated its effectiveness.

Method

■ NF Experiments

- The red bar was presented as a feedback indicator updated in real time during the execution of the experimental task.
- **Length:** the bandwidth intensity (11~13Hz) of the EEG response obtained from electrode positions C3 or C4, which correspond to the body part of motor imagery.
- **Direction:** the ratio of the bandwidth intensity (11~13Hz) of the EEG response at electrode positions C3 and C4.

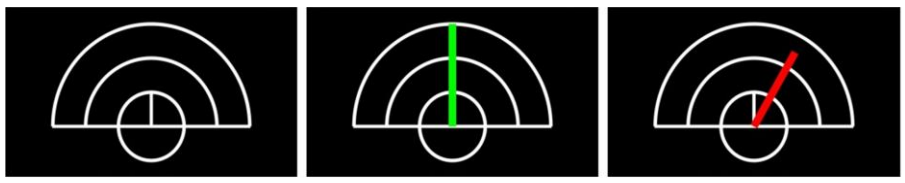


Fig.1 Screens presented during the NF experiment

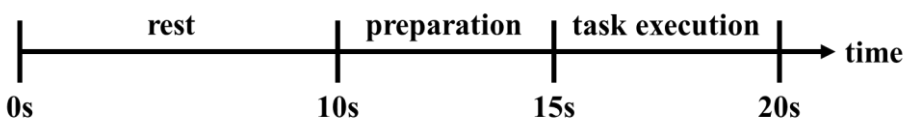


Fig.2 Experiment flow

- As a comparison, experiments with No-NF and Dummy-NF were conducted on the same day.

■ Measurements

- Ag-AgCl EEG electrodes at 64 locations
- Reference and ground: right and left earlobe
- Sampling frequency: 1000Hz

■ Data analysis

- Rejection of epoch data: magnitude exceeding $\pm 100\mu V$
- ERS/ERD was calculated based on the following equation.

$$ERS/ERD\ [\%] = \frac{A(t) - R}{R} \times 100$$

$A(t)$: bandwidth at t R: time average of Bandwidth at rest time

- The r^2 value was calculated based on the following equation.

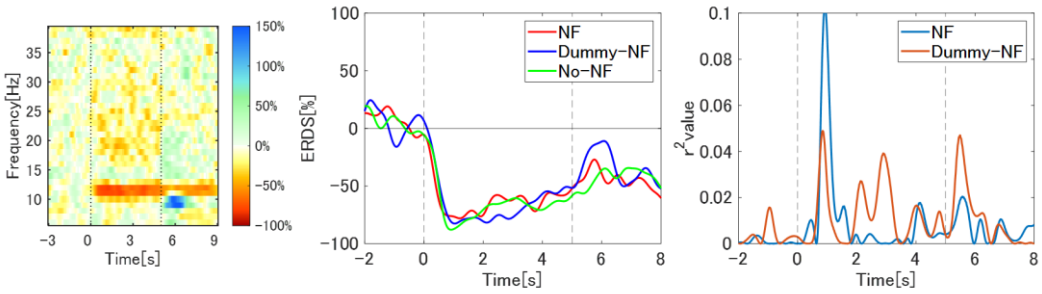
$$r^2 = \frac{\mathrm{cov}(x, y)^2}{var(x)var(y)}$$

x: signals y: class of signals

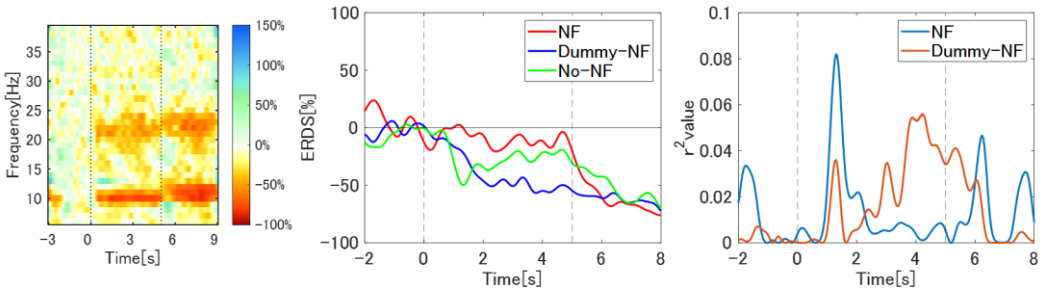
Results

■ Result of NF and comparison with Dummy-NF and No-NF

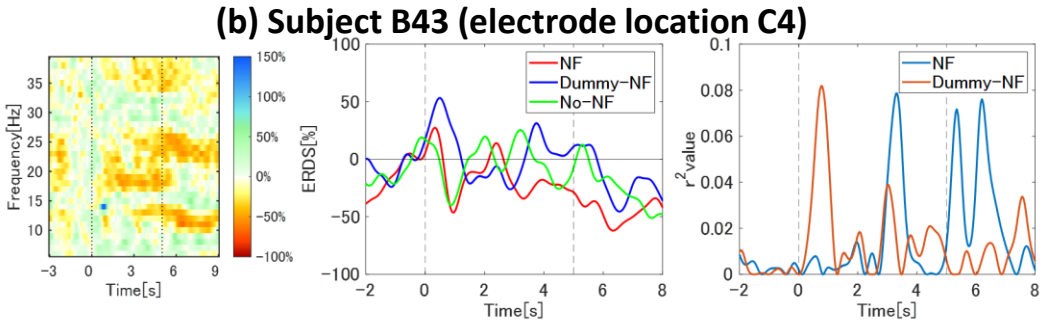
- The result showed differences during ERD of NF task and ERD of Dummy-NF task, No-NF task.



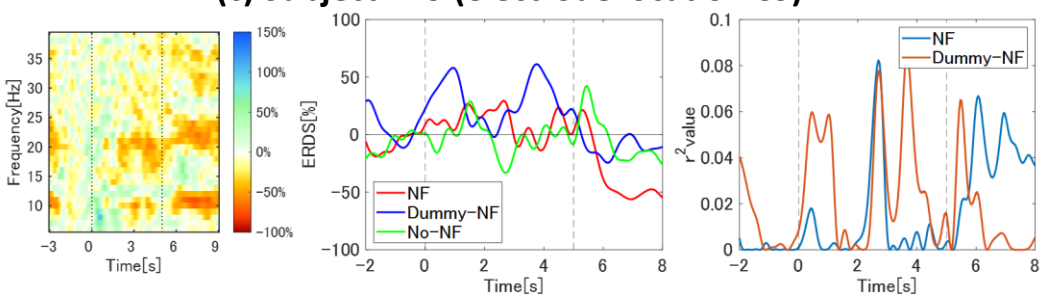
(a) Subject B43 (electrode location C3)



(b) Subject B43 (electrode location C4)



(c) Subject B49 (electrode location C3)



(d) Subject B49 (electrode location C4)

Fig.3 ERD of the NF task (left), ERD in the three conditions (middle), and r^2 value of NF and Dummy-NF task against No-NF task (right)

Discussion and Further works

- ERS/ERD of NF task was better than that of Dummy-NF and No-NF.
- Three out of five subjects showed the increase in ERD on contralateral side.
- Two out of five subjects showed the decrease in ERD on ipsilateral side.

◆ Further works

- Examination of frequency bands used for feedback indicators
- Investigation of the long-term effect of this NF system

References

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3. S. Kanoh, R. Scherer, T. Yoshinobu, G. Pfurtscheller, "Effects of long-term feedback training on oscillatory EEG components modulated by motor imagery", Proceedings of the 4th International Brain-Computer Interface Workshop and Training Course 2008, pp. 150-155, 2008.

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