（様式乙 4）

SUMMARY OF Ph.D. DISSERTATION

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Title

A Study of Optical Topography for Imaging Human Brain Functions: Evaluation of Activation Signals and Its Methodological Improvement

Abstract

Optical topography (OT) is a noninvasive modality that is used to image human brain functions. This technique is based on near-infrared spectroscopy (NIRS), and involves the measurement of two hemoglobin (Hb) signals ($\Delta C'_{oxy}$ and $\Delta C'_{deoxy}$). Although this technique has been validated under certain specific conditions based on simulation and phantom studies, a number of random factors may cause fluctuations in the activation signals during practical measurements in the human brain. This study evaluates the activation signals measured by OT under the present conditions and aims to reduce the effects of some random factors on the signals, thereby improving the existing OT system to a more practical and complete imaging method.

Chapter 1 presents an introduction OT and outlines the random factors that could probably cause fluctuations in the activation signals under the present conditions.

Chapters 2 and 3 provide information on the reproducibility of the activation signals, which is considered as an overall signal that may include fluctuations caused by all the random factors. First, chapter 2 reports the within-subject reproducibility of the activation signals during the imaging of sensorimotor activations in the same subject, 6 months after the initial session. This study demonstrates a high reproducibility of the fundamental activation pattern (a positive $\Delta C'_{oxy}$ and a negative $\Delta C'_{deoxy}$), the location of the activation area, and the temporal dynamics (time courses) of the activation signals; however, the signal amplitudes were not consistent between the two sessions. The results emphasize that the time course of the activation signal is a particularly useful parameter for assessing activation. Second, chapter 3 reports the reproducibility (generality) of the fundamental activation pattern in 31 subjects by applying the same paradigm as described in chapter 2. In this case, 90% of the subjects with similar locations of the activation area showed a positive $\Delta C'_{oxy}$, thereby suggesting that a positive $\Delta C'_{oxy}$ is the most useful common parameter for detecting activation signals in different subjects. In addition, the high reproducibility of the location of activation areas observed in these two studies demonstrates the efficacy of the 10–20 system in determining the locations of the probe positions.

Chapters 4 and 5 present studies describing possible solutions for the effects of some random factors. Chapter 4 describes a solution for the fluctuation caused due to background functions such as attention. The fluctuation that is caused due to background functions rather than due to the targeted function is a serious problem because rest periods essentially serve as the baseline, although there is no inherent baseline state in the brain. In this study, the dichotic-listening task controlling the subject’s attention is used at every period to detect the intact activation signals from the targeted cognitive process of the speech recognition. The results showed a localized activation signal that is consistent with the results from a previous cognitive study; this demonstrates the efficacy of a devising task-paradigm in reducing the fluctuation due to background functions in OT. Chapter 5 reports a study that examines the practical relevance of wavelength selection in reducing the system-related noise of activation signals. Although optimal wavelength pairs can be proposed on the basis of theoretical estimations, the wavelength range should be limited based on the actual optical properties of the subject’s head. To identify the optimal wavelength for pairing with a wavelength of 830 nm, the activation signals were practically examined at the possible wavelengths of 678, 692, 750, and 782 nm. The results demonstrate that the 692- and 830-nm pair produces the highest common signal-to-noise ratio.

Finally, the findings obtained from studies reported in chapters 2–5 are summarized in chapter 6 as the conclusion. Moreover, I have proposed a novel approach for improving the OT system in order to render it more useful and effective.