KYUSHU UNIVERSITY

Neuroimaging and Biomedical Engineering Laboratory (Iramina's Lab)

Graduate School of Systems Life Sciences
Graduate School of Information Science and Electrical Engineering

Our lab was founded in Apr 2005. Our lab is under the administration of the Faculty of Information Science & Electrical Engineering, Kyushu University, and Graduate School of Systems Life Sciences which is a unique organization. Some explication is necessary here. Unlike other National Universities, Kyushu University has divided the previous "Graduate School" into the "Graduate School" and "Faculty". Such change is a certain produce to adapt flexibly to the quick change of the times and keep a high level of education and research. However, the management of the Graduate School to which the teachers belong and the Faculty to which the students belong is nearly same with that of the previous Graduate School. As a result, our lab is under the administrations of both the Faculty of Information Science and Electrical Engineering and the Graduate School of Systems Life Sciences. The Graduate School of Systems Life Sciences is an interdisciplinary graduate school which aim is to train researcher with two majors. The teachers, who belong to the Graduate School of Science, Graduate School of Bioenvironmental Sciences, Graduate School of Medical Sciences, Graduate School of Mathematics, Graduate School of Engineering and Graduate School of Information Science & Electrical Engineering, are in charge of education. For this reason, the students who study in the graduate School of Systems Life Sciences can learn the knowledge of not only the life science but also engineering and information engineering.

There are two major research fields in our lab. One is brain function imaging which aims at the elucidation of human brain function; the other one is brain function modeling which is applied to various fields by constructing the model of brain activation. In details, we study in the fields of the measurements of brain function by EEG (Electroencephalography), MEG (Magnetoencephalography), MRI (Magnetic Resonance Imaging), NIRS (Near-Infrared Spectroscope) and TMS (Transcranial Magnetic Stimulation), the development of measurement technology and the simulation of brain activation. The elucidation of the mechanism of brain function is one of foundations of life science, and it can be applied to almost all the fields. Have a deep understanding of brain information processing, and apply the research results to fields of life science, medicine, engineering and education is the purpose of our study.
Since we are studying in an interdisciplinary domain, we take into account the collaboration of medicine, biology, pedagogy and psychology is important in our study.

Major research topics

- **Study of brain function with non-invasive functional dynamics neuro-imaging**
- **Study of the mechanisms of visual perception using TMS**
- **Investigation of the electrical activity in the brain, using simultaneous TMS and EEG measurement**
- **Analysis of the induced eddy current during TMS with finite element method**
- **Study of brain information processing during visual perception using EEG and MEG**
- **Measurement of brain function using NIRS**
- **Study on BCI (Brain Computer Interface) and BMI(Brain Machine interface)**
- **Development of the educational support system for children with disabilities, based on BCI**

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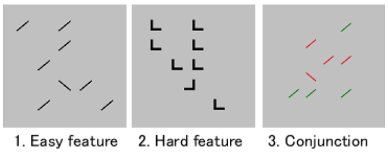
TMS: An useful tool for the functional brain dynamics imaging

It is possible to investigate the brain function through directly stimulating the cerebral nerve using magnetism. We called such stimulation TMS, which allows electricity passing through the coil placed on the scalp, generating a magnetic field that penetrates the skull and stimulates the cerebral nerve cells with the induced eddy current. For instance, if we stimulate a subject at his/her motor area of the brain that controls motion, we can possibly flex his/her finger regardless of the will of him/her. Magnetic stimulation can modify the excitability of the cerebral nerves, activate or inhibit them temporally and spatially, via controlling the frequency and intensity of the pulse. With such characteristics, the method of so-called virtual lesion, which temporarily disables the brain function, can help to investigate the cerebral nerve network. In addition, magnetic stimulation is also applied in examination of nerve conduction and mapping of brain functional region. Especially recently, it is beginning to be used in the treatment of Parkinson's disease and depression.

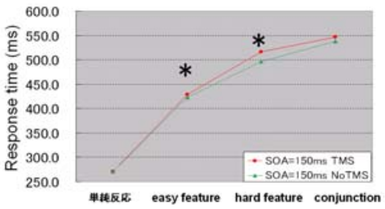
TMS using figure-of-eight coil

A study on the visual perception mechanism using TMS

Temporal characteristics of visual search



Visual search task

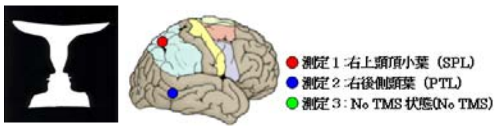


The difference in discrimination time by the complicated degree of the task

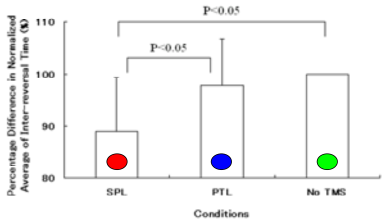
Visual search, one kind of visual attention, requires the subjects to search for the target element from the interference elements. Although it is suggested that the right posterior parietal cortex (PPC) is involved in visual search, the understanding of the characteristics of the brain information processing is not enough yet. In this study, we investigated the temporal aspects of visual search using TMS. We found that, when we applied TMS at the right PPC at 150ms after the visual search stimuli presentation, a delay in the response time was observed in both the easy feature task and the hard feature task. However, in the conjunction task, in which subjects were instructed to determine not only the shape but also the color of the visual stimuli, we observed no statistically significant difference in response time between TMS and no-TMS conditions. Therefore, we thought that the spatial processing of visual information possibly starts around 150ms after the visual search stimuli presentation, at the right PPC. Nevertheless, the process of color information processing (conjunction feature task) is different from the task that needs spatial processing only (easy and hard feature task).

Effects of repetitive TMS on perceptual reversal

Ambiguous figures are visual stimuli that can be interpreted in multiple ways by the human visual system. For a given ambiguous figure, the perception will switch spontaneously among several possible interpretations even while the figure remains unchanged, but simultaneous perception of plural interpretations is not possible . This process is called perceptual reversal. In this study, we investigated the brain functional regions that involve in the perceptual reversal using rTMS. As a result, on the one hand, we found that when we applied rTMS (1Hz, 60s) over the right superior parietal lobule, statistically significant facilitatory effect was observed on perceptual reversal. On the other hand, when we applied rTMS over the right posterior temporal lobe, no statistically significant facilitatory effect was observed on perceptual reversal.



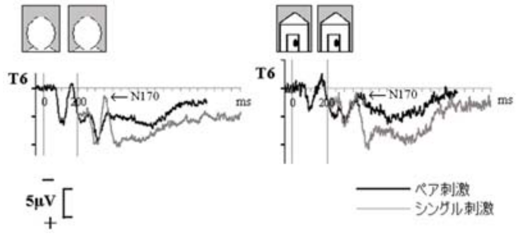
Example of ambiguous figures (left）Stimulation region (right)



Response time at different stimulation regions

Study of brain information processing during visual perception using EEG and MEG

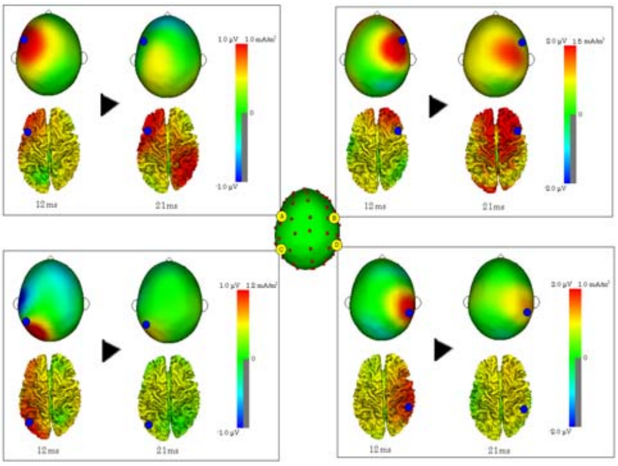
We studied on the process of brain information processing during face perception using EEG and MEG. With a focus on the negative ERP (event-related potential) component at a latency of 170ms (N170), using a paired stimulus paradigm (two visual stimuli presented successively), we investigated the suppressive phenomenon of N170 component evoked by the second stimulus. We found that near the fusiform gyrus of the inferior temporal lobe (T6 of the 10-20 international system), the suppressive phenomenon of N170 component evoked by the second stimulus was more obvious in the face-face pair than in the building-building pair. Therefore, we supposed that this area (T6) is more involved in face information processing.



Suppression of ERP in a paired stimulus paradigm

306ch SQUID system

Investigation of the electrical activity in the brain, using simultaneous TMS and EEG measurement

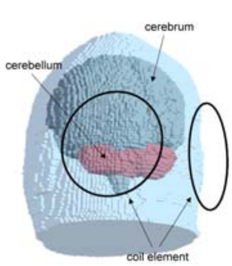


Although TMS is very useful in functional brain studies, however, quantitatively, how much electric current it can induce in the brain remains unknown. Neither do we understand how the electric current acts actually. Therefore, in this study, through performing magnetic stimulation, measuring the induced EEG thereby and analyzing the EEG, we visualized the state of excitement propagation in the brain, and examined the influence of magnetic stimulation on the brain. The picture showed the propagation of the activation region in the brain after cerebellum magnetic stimulation.

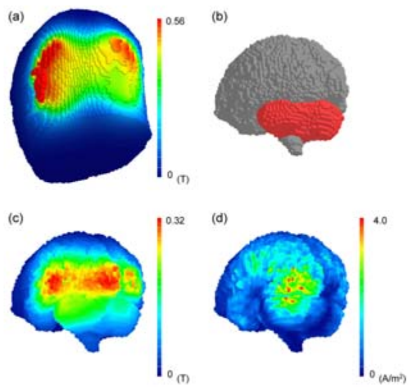
Propagation of the brain activation region due to stimulation of different regions (EEG topography, current density distribution)

Analysis of the induced eddy current during TMS with finite element method

To evaluate the strength and localization of the eddy current in TMS, it is necessary to obtain the eddy current in the brain generated by TMS. Therefore, head modeling and numerical analysis using the finite element method is requisite. In this study, using numerical analysis, we obtained the spatial distribution of the induced eddy current in the cerebellum after TMS.



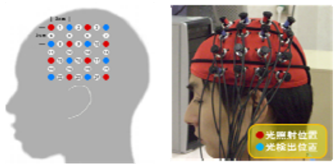
Head model



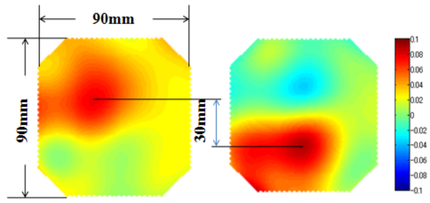
Distribution of magnetic field on the scalp (a); Calculation model (b); Distribution of magnetic field on the cortex (c); distribution of current (d)

Measurement of brain function using NIRS

NIRS (near-infrared spectroscopy) is a new emerging distinguished measurement method utilizing the NIR light. With high bio-tissue permeability aspects, the NIR light irradiates from the outside, passes through the tissue and is partially reflected back. By analyzing the reflected NIR light and basing on the intrinsic optical absorption of blood, NIRS instrument enables non-invasive measurement of regional relative hemodynamic state in bio-tissues. Since cortical activation is closely associated with the hemodynamic state of blood, it is possible to image the brain function by monitoring the hemodynamic state of the blood in the brain. Given its merits of safety, easiness and compactness, NIRS is promising in future brain function research. However, the physiological meaning of its obtained signal remains ambiguous yet. We are performing a study to investigate the relationship between the neural activation and the evoked hemodynamic responses.

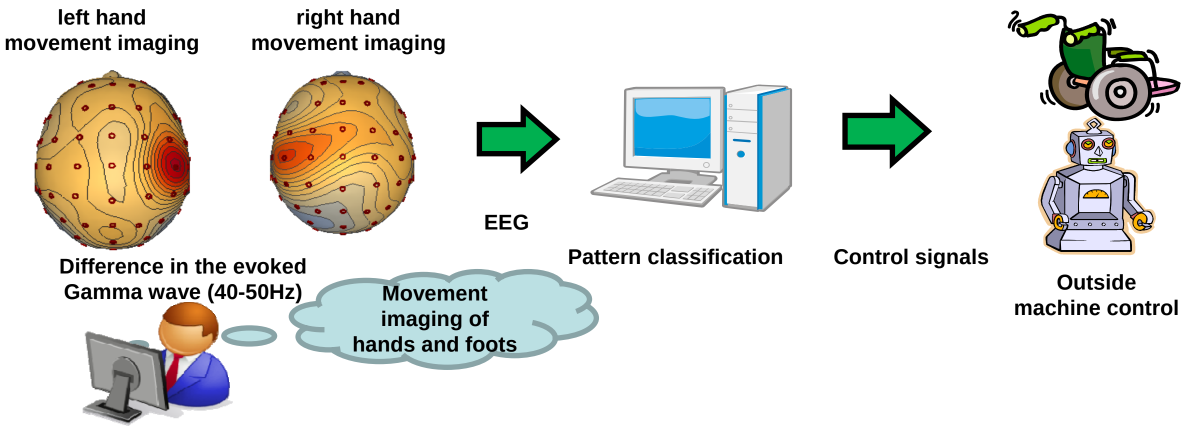


Measurement probe of NIRS



NIRS topography
Ring finger stimulation (left), thumb stimulation (right)

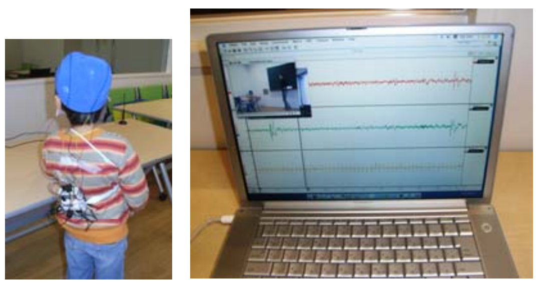
Study on BCI (Brain Computer Interface) and BMI(Brain Machine interface)



Brain Computer Interface (BCI) or Brain Machine Interface (BMI) is an interface that transmits the information from the brain to the outside utilizing methods other than the existing neural network and muscles. For instance, it is possible to move the wheelchair or operate the computer by only thinking! In our lab, our research aims at the application of BCI technique to the mental status monitor and communication support equipment of developmental disorders, such as LD (learning disorder), ADHD (attention deficit hyperactivity disorders) and so on.

Development of the educational support system for children with disabilities using wireless EEG and NIRS

Nowadays, education for children with developmental disabilities such as autism, learning disorder (LD) and attention deficit hyperactivity disorders (ADHD) has become a social problem. In our lab, with the purpose of constructing an educational support system for these children employing the neuroscience, we are developing a system to monitor the state of mind, tension and learning of these children, using unstrained wireless EEG and NIRS to measure the electrical and blood information of the brain.



Measurement of EEG and ECG (electrocardiogram)
by wireless EEG instrument