KYUSHU UNIVERSITY

Graduate School of Systems Life Sciences

Neuroimaging and Neuroinformatics Laboratory (Iramina's Lab)

Our laboratory 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 educational 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.

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), 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, welfare 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
- Analysis of the induced eddy current during TMS with finite element method
- Study of brain information processing during visual perception using EEG and MEG
- EEG and NIRS measurement of brain function
- Development of Neuro-rehabilitation system based on BCI (Brain Computer Interface
- Evaluation System for Minor Nervous Dysfunction by Pronation and Supination
- Development of the educational support system for children with disabilities, based on BCI

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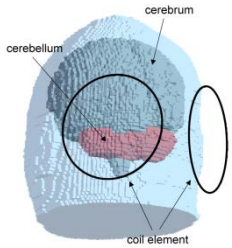
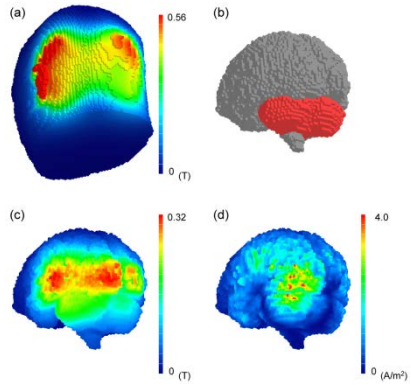
Simulation of the induced eddy current by TMS with finite element method

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.



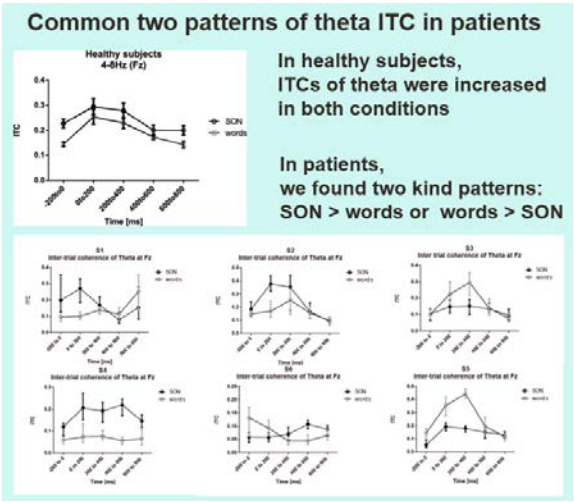
Head model



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

Neuronal Response to Hearing Names for Patients with Severe Motor and Intellectual Disabilities

Sever motor and intellectual disabilities (SMID) patients can't express their feelings with languages. We can't understand what they think about or how they feel. From this reason, iIt is important to infer their feelings and measure by measuring and analyze analyzing their brain activity. We tried to investigated the brain response to hearing of SMID patients in order to reveal the residual function. We found that theta phase-locked activity of patients with SMID in response to subjects' own name at theta was increased after stimuli specifically while that of healthy control subjects was increased in response to speech stimuli, not only their own name but also other control words, using inter trial coherence analysis.

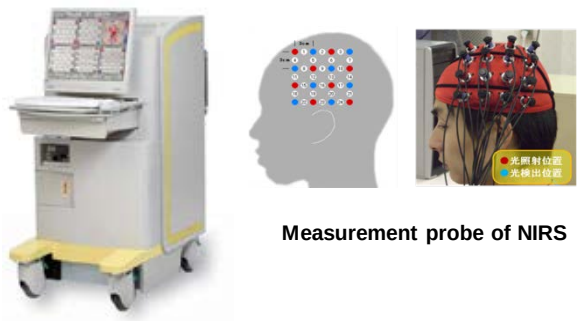


Measurement of brain function by NIRS and its application

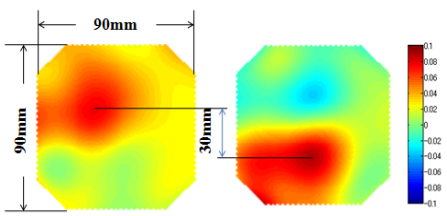
NIRS (near-infrared spectroscopy) is a new emerging distinguished measurement method utilizing the NIR light. With high bio-tissue permeability aspects, the NIR light irradiates from the outside, passes through the tissue and is partially reflected back. By analyzing the reflected NIR light and basing on the intrinsic optical absorption of blood, NIRS 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.

In our laboratory, pain related response is measured and try to estimate the pain sensation quantitatively. We are developing the NIRS based BCI which will be applied to the rehabilitation of stroke patients.

We also try to measure brain response of autistic spectrum children to evaluate the effect of drug or treatment.



Measurement probe of NIRS



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

TMS and tDCS An useful tool for control of brain electrical activity

Transcranial Magnetic Stimulation (TMS) is the application of a brief magnetic pulse or a train of pulses to the skull, which results in an induction of local electric current in the underlying surface of the brain, thereby producing a localized axonal depolarization. As a non-invasive and effective method to make reversible lesions in the human brain, Now it has become a major tool of cognitive neuroscience and a treatment method for various neurobehavioral disorders. Because TMS has high temporal and spatial resolutions, it can investigate not only the spatial localization but also the time course of mental processes. We applied TMS to investigate temporal aspect of the functional processing of the visual attention. We also focused on the effect of repetitive transcranial magnetic stimulation (rTMS) on neuronal excitability. As an active approach of brain function, rTMS can make artificial excitatory or inhibitory activation in a pinpoint region of the brain. Thus the function of this region can be clarified with the minimum influence of other related activity.

tDCStranscranial direct current stimulatiuon) can also modulate cortical activity just as rTMS. tDCS is a method of the brain stimulation with direct current generated at electrodes attached on the subject's scalp. Depending on the current polarity, duration or strength, tDCS can induce after effects selectively. The cathodal stimulation shows inhibition of cortical activity and anodal stimulation shows facilitation of cortical activity.

We investigate the effects rTMS and tDCS on neuronal activity and also on cognition.

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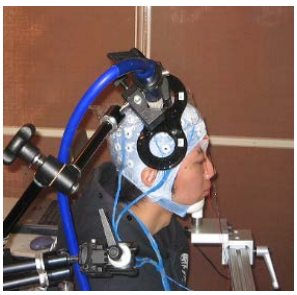


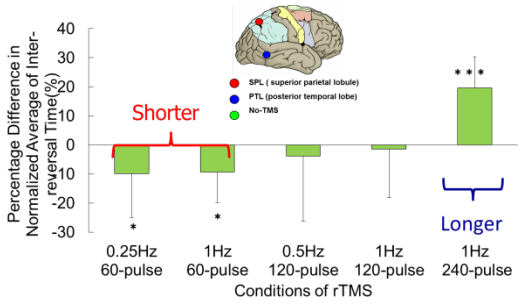
Simultaneou measurement of EEG and TMS

tDCS(transcranial direct current stiumulation

Effects of repetitive TMS on perceptual reversal

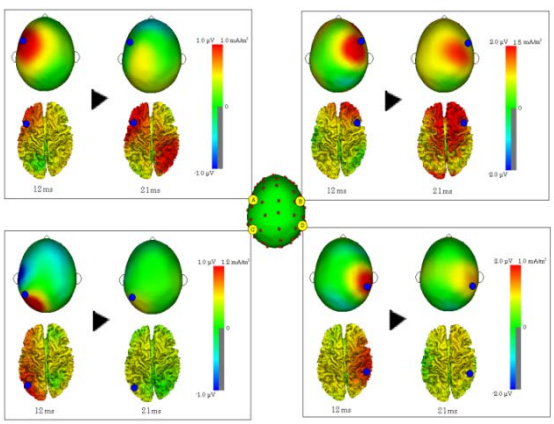
Ambiguous figures are visual stimuli that can be interpreted in multiple ways by the human visual system. For a given ambiguous figure, the perception will switch spontaneously among several possible interpretations even while the figure remains unchanged, but simultaneous perception of plural interpretations 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.

Examples of ambiguous figure)



Results of SPL stimuli (Baseline : No TMS experiment)
Wilcoxon signed-ranks test, ∗ : P<0.05 ∗ ∗ ∗ : P<0.001
Response time at different stimulation regions

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

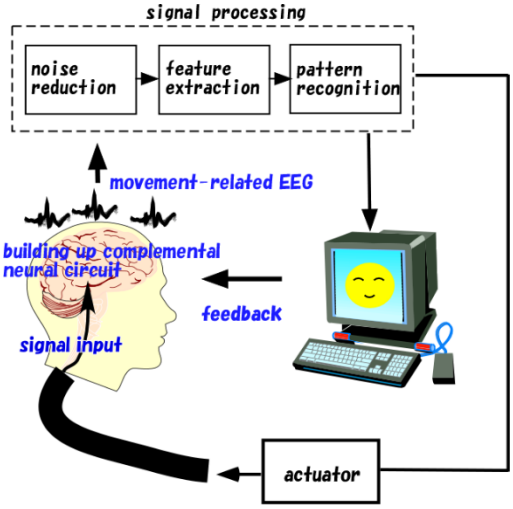


Although TMS is very useful in functional brain studies, however, quantitatively, how much electric current it can induce in the brain remains unknown. Neither do we understand how the electric current acts actually. Therefore, in this study, through performing magnetic stimulation, measuring the induced 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)

Innovation of Neuro-Rehabilitation by combined Neuro-feedback and Brain Stimulation

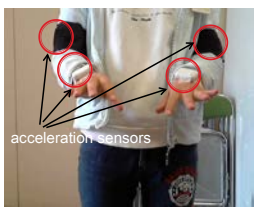
Neuro-feedback treatment based on EEG can strengthen the neuronal network in the brain. On the other hand, repetitive TMS(transcranial magnetic stimulation) or tDCS(transcranial direct current stimulation) can change the excitability of neuronal activity and cause the plasticity of the damaged brain. We try to combine these two methods and apply to the rehabilitation of paralyzed patients.



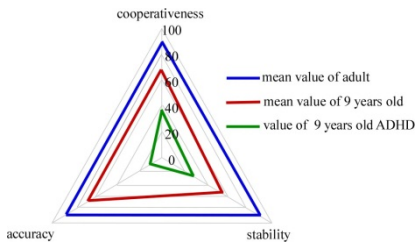
Neuro-rehabilitation system

Evaluation System for Minor Nervous Dysfunction by Pronation and Supination

An increasing of the child with developmental disorder like LD, ADHD has been a social problem. It is important to find the child with such a developmental disorder at the early stage, and to do an appropriate caring for his development. It is difficult to check the abnormalities of the child with the developmental disorder even if a doctor diagnoses by the neurological method for the paralysis and the sensory disorder. However, when the symptom that is called minor nervous dysfunction is checked, it is possible to obtain medical diagnosis from minor dysfunction which shows the developmental delay and the maturity of the central nervous system. We developed a simple and easy system to measure the motion of pronation and supination of the forearm using wireless acceleration and angular velocity sensors. The aim of this system is evaluation of minor nervous dysfunction. It is helpful for the screening of the developmental disorder child.

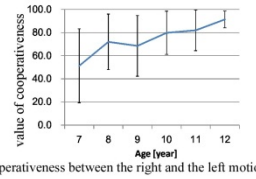


wireless acceleration and angular velocity sensors

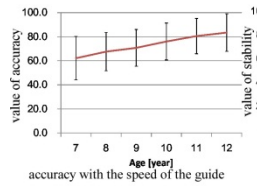


Radar chart of theneuromotor function in adult, average of 9 years old, and 9 years old ADHD patient

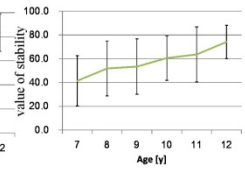
The reference curves of the cooperativeness between the right motion and the left motion, the accuracy of comparison with the speed of the guide, and the stability of the postural when the speed of rotation was 120 times a minute.



cooperativeness between the right and the left motion



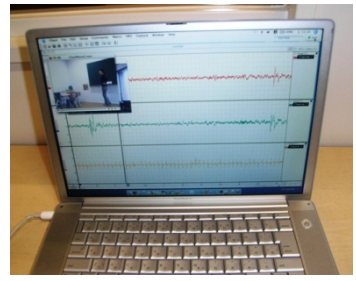
accuracy with the speed of the guide



stability of the posture

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