Here begins our new MIRAI
MOONSHOT RESEARCH & DEVELOPMENT PROGRAM

Protecting children's intellectual curiosity and individuality to realize a dynamic society

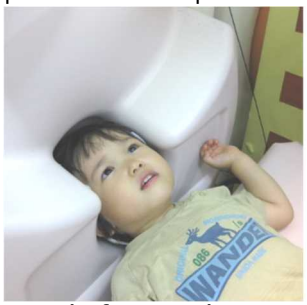
R&D Theme

Visualization of Children's Mental Well-being

Progress until FY2025

1. Outline of the project

The role of the research and development project "Assessment of Brain Individuality and Evaluation of Intervention Effects" is to explain the inherent characteristics of conditions such as Autism Spectrum Disorder (ASD) using both cognitive psychology and neuroscience (e.g., infant magnetoencephalography), enabling caregivers to view children in a more objective manner. The objective is to build scientific evidence to dispel misconceptions such as "developmental disorders caused by parenting" among families struggling with child-rearing and to prevent disharmony within the home (including parental maladaptation and abuse).



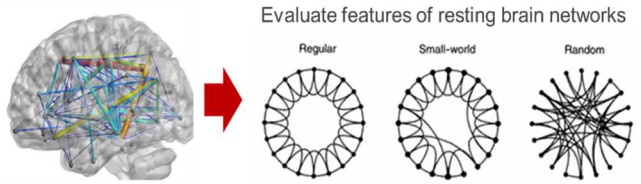
(Infant MEG)

(OPM sensor)

The role of the research and development project "Advanced Element Development of Brain-Measurement System Optimized for Children" is to explore the feasibility of applying optically pumped magnetometers (OPM) to infants in order to make the ASD diagnostic system more affordable and practical. It aims to verify whether OPM-MEG can replicate the results of previous studies conducted with SQUID-MEG.

2. Outcome so far

In "Evaluation of Brain Individuality and Intervention Effects," we have started recruiting participants and accumulating data. To facilitate smooth recruitment for this project, we have created a website and a dedicated site for participants. We have been analyzing brain network characteristics using graph theory to obtain brain indices reflecting the individuality of children.



Using this analytical method, we have reported a decrease in small-worldness in children with ASD tendencies compared to typically developing children (Shiota et al., 2022, Front Psychiatry). By applying similar analysis techniques, we conducted preliminary analysis of data from clinical trials of transcranial direct current stimulation (tDCS) in the past and demonstrated the potential to predict responders to working memory enhancement in adult males (Hirosawa et al., 2023, Front Psychiatry).

Regarding the "Advanced Element Development of Brain-Measurement System Optimized for Children," we have set up an OPM measurement environment within a magnetically shielded room and conducted tests to confirm the basic operation and stability of the sensor (Quspin QZFM Gen.2). We examined the possibilities and challenges of measuring brain magnetic fields on the order of several hundred femtotesla (100 fT = 10^-13 T). As a result, we found that the current measurement environment is within the range where brain magnetoencephalography (MEG) is possible. However, we also discovered that the spatial gradient of environmental magnetic fields remaining within the magnetic shielding, estimated to be around 0.1 nT/cm, can significantly affect the measurements.

3. Future plans

We will leverage the high temporal resolution of MEG data and characterize brain networks using metrics such as node degree, node efficiency, clustering coefficient, average path length, small-worldness, and network vulnerability to elucidate their relationship with individual traits, including children.

To achieve a lower cost for MEG measurements, we will continue optimizing OPM measurements. We will install 14 sensors of the 3D sensor type (Quspin QZFM Gen.3) and validate their potential for measuring brain activity in infants and exploring future applications. To accomplish this, we will develop techniques to eliminate various sources of noise, such as spatial distribution of magnetic fields in the measurement room, noise originating from peripheral devices, and electromyography signals. Utilizing spatial and temporal characteristics from the data collected by multiple sensor arrays, we will develop methods to remove noise and signal components unrelated to brain activity originating from magnetic field distributions.

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