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

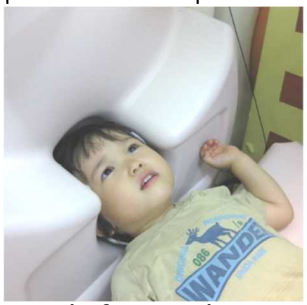
R&D item

1. Visualization of Children's Mental Well-being

Progress until FY2023

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)

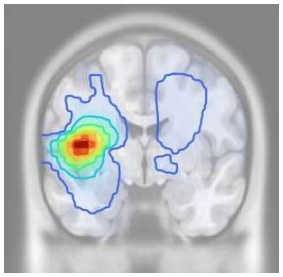
The role of the research and development project "Advanced Element Development of Brain-Measurement System Optimized for Children" is to explore the feasibility of applying optically pumped magnetometers (OPM) to infants in order to make the ASD diagnostic system more affordable and practical. It aims 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 "Development of Advanced Elements for an Optimized Brain Magnetic Measurement System for Children," sensory responses such as auditory evoked responses were detected in adult subjects using the latest generation of OPM sensors (Qspin's QZFM Gen.3). Furthermore, by developing a method for aligning sensor positions with brain structural data, we succeeded in pinpointing the locations of brain activity even with a significantly smaller number of sensors (12) compared to conventional MEG, by adopting an estimation algorithm that effectively utilizes the information (left figure). Additionally, anticipating measurements in children, we are also working on the development of a magnetic field gradient control system to accommodate body movements during measurement. We have built a system to cancel the residual magnetic field gradients, which persist even after shielding environmental magnetic fields such as geomagnetism with a shielded room, by applying a cancellation field through current coils introduced inside the shielded room. This system evaluates the effectiveness of this approach and has successfully demonstrated the principle of magnetic field gradient cancellation.



3. Future plans

Moving forward, we will continue to maximize the advantages of the high temporal resolution of magnetoencephalography (MEG) data and the higher spatial resolution compared to electroencephalography (EEG). We will advance the analysis of brain networks through graph analysis, expressing network features with metrics such as node degree, nodal efficiency, clustering coefficient, average path length, small-worldness, and network vulnerability. By doing so, we aim to clarify the relationship between these network characteristics and individual traits, including those of children.

Additionally, we will further optimize OPM measurements to make MEG more suitable for children. Specifically, we will focus on building a system to suppress magnetic field gradients and temporal variations. To achieve this, we will monitor spatial and temporal variations within the shielded room using auxiliary sensors, and simultaneously cancel magnetic field gradients in all directions. This will enable the stable operation of OPMs and the extraction of signals originating from brain neural activity by combining methods for signal processing and source estimation. These technologies will also be demonstrated for measurements in children.

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

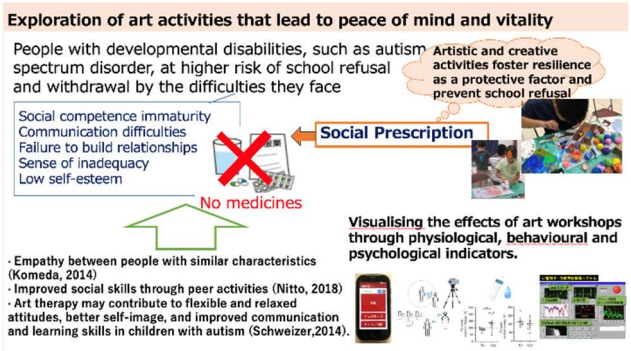
R&D item

2. Visualizing the Effects of Art Intervention

Progress until FY2023

1. Outline of the project

The aim of this study is to establish objective endocrine and psychophysiological indicators that capture the improvement in mental well-being and social curiosity resulting from artistic activities, with the goal of providing art activities that allow children and adolescents with challenges in social skills and characteristics associated with Autism Spectrum Disorder (ASD) to enhance their sociability while feeling at ease.

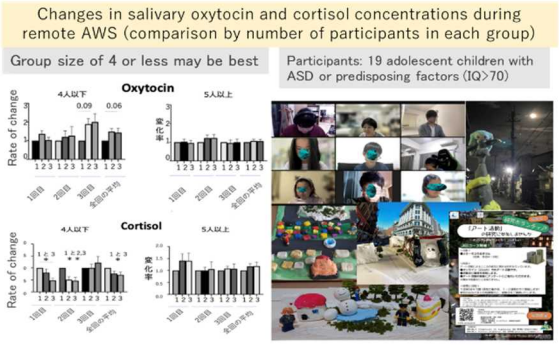


- Prepare the field for conducting face-to-face/remote Art Workshop Sessions (AWS) targeting children and begin collecting data on hormonal fluctuations in saliva.
- Develop a wearable small-scale electrocardiogram measurement system.
- Develop a face-to-face detection app and a motion visualization system.
- Initiate heart rate measurement in face-to-face AWS sessions targeting adults and accelerometer measurement using the face-to-face app, and evaluate the implementation protocol.
- Conduct a questionnaire survey on art activities and enhance the content.

2. Outcome so far

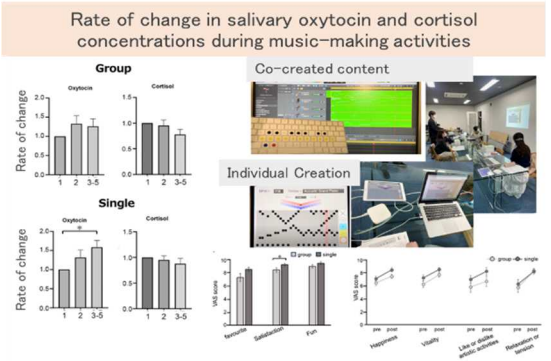
<Art Workshop>

Compared to typically developing children of the same age, children with ASD (Autism Spectrum Disorder) have shown larger changes in salivary oxytocin and cortisol concentrations when participating in face-to-face or remote AWS (Art Workshop Support) sessions up to the fiscal year 2022. Based on this, in the fiscal year 2023, we continued collecting data on changes in salivary oxytocin and cortisol concentrations during AWS sessions for children with ASD. As a result, it was suggested that for children with ASD, conducting remote AWS sessions with four or fewer participants can reduce stress and provide a higher sense of satisfaction. This indicates that creating an environment conducive to interaction in small groups can enhance the secretion of endogenous oxytocin



during art-making activities.

Additionally, we conducted two types of face-to-face AWS sessions using music content (Desktop Music): individual and collaborative creation. In both individual and collaborative creation sessions, participants reported increased happiness and relaxation on the Visual-Analog Scale administered before and after the activities. There was also an observed increase in salivary oxytocin concentrations and a decrease in cortisol concentrations. Notably, in individual creation activities, where participants



engaged deeply and interacted more with the facilitator, there was a significant increase in salivary oxytocin concentrations. These results have been compiled and submitted as a paper.

3. Future plans

The results so far suggest that fluctuations in salivary hormones may reflect interactions and bonds among participants during AWS (Autism Work Support). While continuing to develop AWS to be more suitable for children with ASD, we will also investigate whether the addition of content such as music appreciation can capture the stress-relieving effects, satisfaction, and sense of accomplishment from artistic activities. By doing so, we will continue to evaluate the usefulness of these indicators in demonstrating the effects of artistic activities. In addition, we will strengthen collaboration with community halls and other venues to promote the implementation of these activities in schools and society.

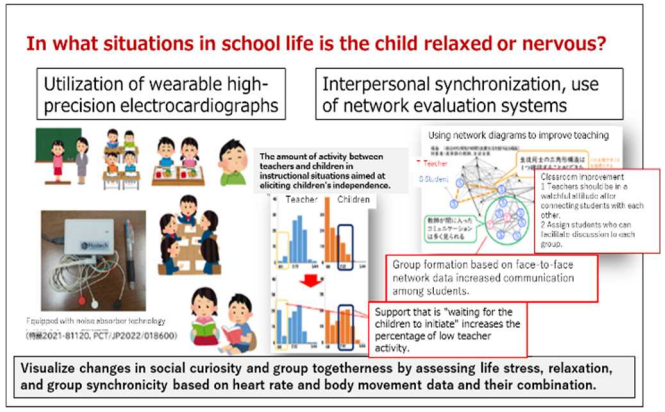
R&D item

3. Realization of schools that protect individuality

Progress until FY2023

1. Outline of the project

This project focuses on "schools," where diverse children live together, to promote learning based on inherent curiosity and to achieve a high level of mental well-being for children. Kanazawa University and Kaga City are collaborating on this research project with three main themes: "visualization of children's mental well-being and intellectual curiosity in schools," "examination of educational systems," and "ELSI for developmental disabilities.



○Target

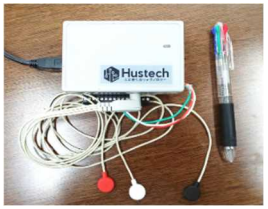
Students enrolled in regular elementary school classes and special-needs classes

○Method

Students will be asked to wear a wearable high-precision electrocardiograph and face-to-face detection application while at school to acquire heart rate data and activity volume data.

2. Outcome so far

Device 1: Wearable high-precision ECG



A prototype device was created to improve the accuracy of heart rate and autonomic nerve measurement in daily life and to enable long-term measurement.

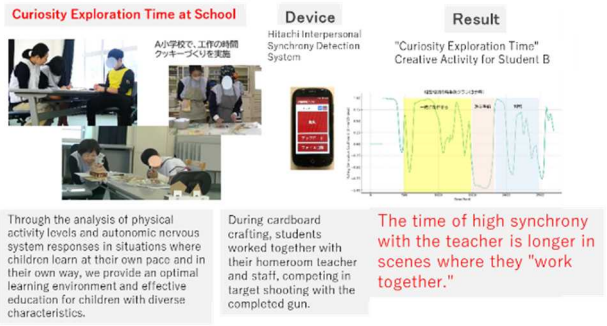
Device 2: Face-to-Face Inspection Synchronicity Detection Application

A system was introduced to evaluate the body movements during individual body activities and group synchronization by means of an acceleration sensor built into a small smartphone.

Analysis of Children's Activity Levels During "Curiosity Exploration Time" Using a Face-to-Face Synchrony Detection App

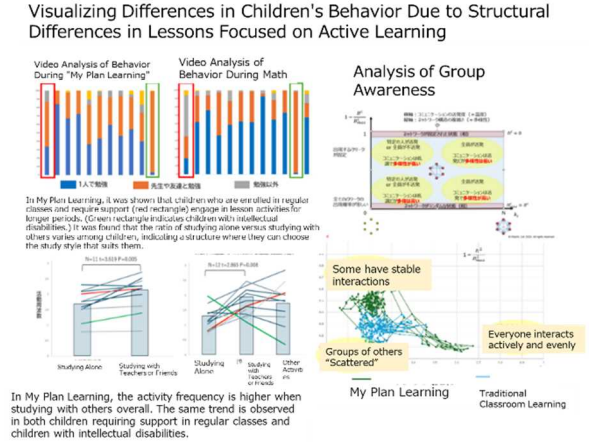
The activities of children with developmental disabilities, especially those in which they had a particular interest or enthusiasm, were conducted and their physical activity during these activities was measured.

As a result of the analysis, it was shown that the synchrony between the teacher and the student increased significantly during activities where they worked together, such as crafting.



"Learning Proactively"
Visualization of Differences in Children's Behavior Due to Differences in Class Structure

An analysis was conducted using video analysis and accelerometer data to compare "My Plan Learning" (individual-paced and form learning within a unit) adopted in Kaga City, Ishikawa Prefecture, and the usual class style. The network index of accelerometer data, "Group Awareness," indicated a state of interaction and individual concentration in the individual-paced learning compared to regular classes, showing a broad distribution of network characteristics.



3. Future plans

We are working on building a platform to create an educational system that fosters children's growth at school, nurturing their curiosity, self-esteem, and promoting the healthy development of their minds and brains. We will hold regular information-sharing meetings involving Kaga City and university representatives to discuss the state of support for education and developmental disabilities in the region and to share findings obtained from measurement data. We will engage in discussions with citizens about research and technology related to children's mental health, providing opportunities to promote understanding of inclusive education.