R&D Item

1. Data-driven modeling

Progress until FY2025

1. Outline of the project

We expanded the High-Low Mixed Database to construct a data-driven model of personality subtypes related to peace of mind and vitality. We collected and preprocessed questionnaire, smartphone/EMA, MRI, cognitive, and decision-making data, and developed an algorithm for applying a pretrained clustering model to new samples.

2. Outcome so far

Item 1: Data-driven modeling

(1) Construction and curation of the High-Low Mixed Database

With Research Task 2 and the Social Implementation Team, the second-phase survey collected 17,413 cumulative online questionnaire samples and behavioral monitoring data from 781 participants. After curation, 10,834 valid samples and 520 intervention-study samples were integrated for external validation.

(2) Data-driven construction of a model for classifying personality subtypes related to peace of mind and vitality

For "low" data, we implemented a variational-posterior scoring algorithm for a pretrained clustering model with Gaussian and categorical features. Applying it to 10,834 new samples and 520 Social Implementation samples reproduced the View 1-3 subtype distributions, supporting generalizability.

Subtype interpretation identified an integrated positive subtype with high interdependent happiness and compassion, self-critical/socially anxious or depressive subtypes with lower self-compassion, and a View 1 subtype with lower FFMQ acting with awareness, suggesting weaker attention to ongoing actions under stronger intrusive thoughts and impulsivity (Figures 1-2).

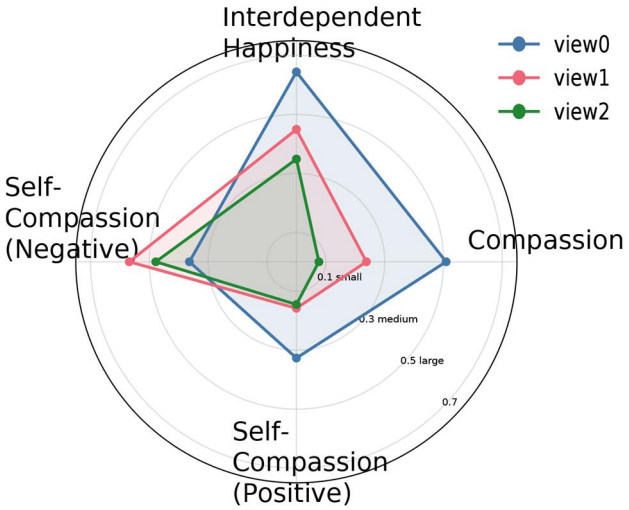

Figure 1: Subtypes and compassion-related indices

For "high" MRI data, structural, diffusion-weighted, resting-state fMRI, and field-map data were collected from 141 cumulative participants using the HCP-CRHD protocol and stored in XNAT. Preprocessing used an HCP-style pipeline with 36p + spike regression denoising.

For preprocessed MRI data, hierarchical supervised/unsupervised learning using 160 functional connectivity features identified a stable, non-extreme optimal model. Frontoparietal and somatosensory networks contributed strongly to subtype identification.

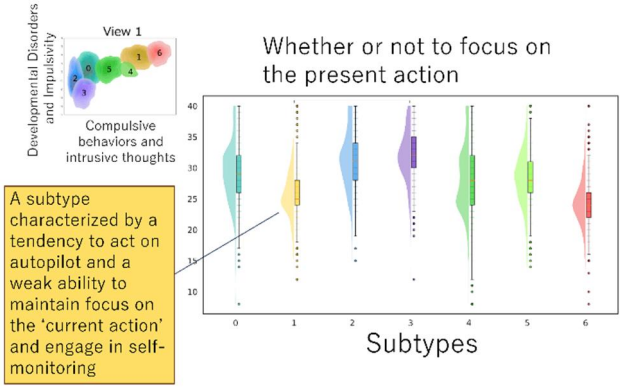

Figure 2: Mindfulness-related differences across subtypes

Item 2: Large-scale survey using the Internet and smartphones

We continued a large-scale survey combining online questionnaires, smartphone logs, actual behavior, and ecological momentary assessment. The dataset was designed to evaluate peace of mind, vitality, interdependent happiness, outward compassion, self-compassion, psychiatric symptoms, and daily behavior in an integrated manner (Figure 1).

3. Future plans

We will complete curation of the full second-phase survey dataset and identify stable personality subtypes by integrating low-burden and high-burden data. For FY2025 MRI data, clustering will proceed as preprocessing is completed, and relationships with peace of mind, vitality, and compassion will be examined. We ultimately aim to identify five or more stable personality types for intervention and social implementation.

R&D Item

2. Neurofeedback

Progress until FY2025

1. Outline of the project

In this project, we are developing technology aimed at creating a new society where machines coexist with humans. To achieve this goal, we have developed visualization devices capable of sufficiently capturing the transition of mental states. Furthermore, by utilizing this neurofeedback system, we aim for participants to acquire a balance of dynamism and stability in brain networks, unaffected by external influences.

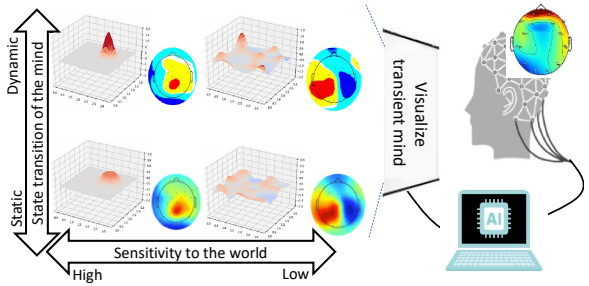

Figure 2: Schematic diagram of this R&D proposal

2. Outcome so far

"Realtime detection of EEG state-dynamics"

EEG microstates are an EEG analysis technique that has recently regained attention. By first extracting common EEG templates that capture the spatiotemporally continuous dynamics, brain state transitions can be represented as transitions between these templates. We have previously developed a system for real-time detection of state transitions corresponding to vertical and horizontal rotations in a spherical EEG state space (Figure 2).

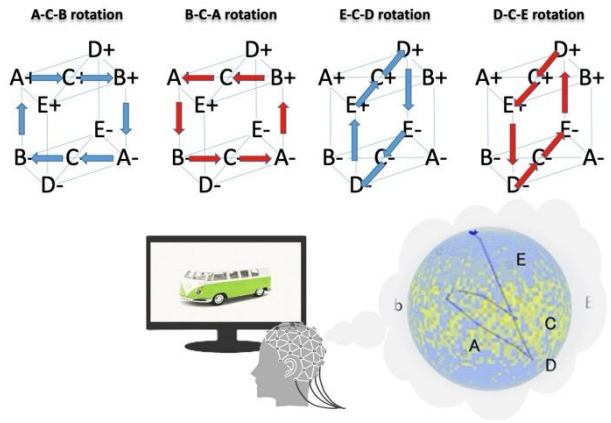

Figure 1: Real-time detection and feedback of state transitions corresponding to vertical and horizontal rotations in a spherical state space

Among participants who underwent neurofeedback training using the system we developed, repeated training was found to modulate the plasticity of EEG states toward the intended direction (Figure 3), and no adverse events were observed.

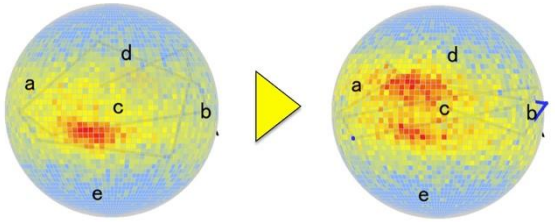

Figure 3: Learning effect by using neurofeedback system

"Machine Learning of Brain State Transitions"

Using a multi-task EEG dataset, we extracted five source-localized attractors with a hidden Markov model. These attractors are highly replicable both spatially and temporally. Resting state was characterized by relatively high frequencies of the two attractors on the left side and low frequencies of the middle attractor.

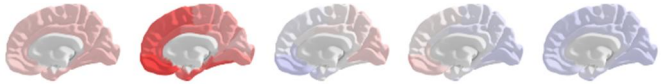

Figure 4: Five highly replicable, source-localized attractors of EEG

3. Future plans

Based on the achievements obtained up to this fiscal year, we found that training with the EEG neurofeedback system we developed to induce brain-state transitions can improve the ability to achieve brain states in a specific direction. We also identified attractors associated with resting state, which might be useful when training "the peace of mind" with neurofeedback. Going forward, it will be necessary not only to clarify what positive effects can be obtained through the continued application of this type of neurofeedback training, but also to develop strategies for implementing it in society. By integrating these findings, we aim to establish a practical neurofeedback framework that promotes mental well-being and, ultimately, to generate outcomes that can be broadly returned to society.

R&D Item

3. Social Implementation

Progress until FY2025

1. Outline of the project

Based on Buddhist literature, we recorded guided meditation narrations and completed a prototype version of the app. We implemented a system that categorizes human personality types based on the "defilements" mentioned in Buddhist scriptures and assigns foundational meditation practices tailored to each type. This approach ensures that users can select meditation methods suited to their individual characteristics. To faithfully incorporate the insights derived from the literature survey, the app also includes video content for walking meditation. Furthermore, the system was designed to support large-scale intervention experiments involving several hundred participants. We have also finalized multiple meditation training programs, established an experimental design, and commenced large-scale experiments to collect and analyze scientific data.

Figure 1. Excerpt from the MiruApp UI design

2. Outcome so far

R&D 1: Buddhist Textual Survey and Meditation Design

(1) Development of Meditation App Content

The primary goal of the meditation app is to suppress automatic mental reactions (reactivity) through "awareness" (mindfulness) while simultaneously cultivating "loving-kindness". A key feature of the app is the creation of four distinct meditation courses tailored to specific personality types—Greed, Anger, Delusion, and Balanced—providing a structure and sequence rooted in traditional practices. We contributed to the completion of the prototype version. Furthermore, to achieve R&D goals such as alleviating "loneliness/anxiety" and fostering a "positive mindset," we integrated the app with the Oriental Meditation Archive.

To enhance reliability and validate the efficacy of app-based meditation compared to in-person or Zoom-based sessions, we conducted three main experiments using biological data, digital biomarkers (DBM), and questionnaires. These included a six-week Zoom-based program, long-term measurements in a Zen monastery, and a one-week in-person retreat. In collaboration with Professor Kalisch and Dr. Puhlmann of the Leibniz Institute for Resilience Research (Germany), we began collecting and analyzing data on changes in facial expressions and interpersonal communication—indicators described in Buddhist texts as meditation outcomes. Additionally, to explore changes in brain states during meditation, we conducted pilot EEG measurements on an experienced monk.

(2) Creation of a Meditation Literacy Archive Integrated with the App

The Oriental Meditation Archive provides titles reflecting contemporary interests, offering commentaries alongside translations of original texts. In addition, we organized information on Taoist and Christian meditation practices related to Eastern views of humanity. The modern translations of the original texts are categorized in alignment with "Well-going" goals. By enriching the glossary, we aim to contribute to the improvement of users' meditation literacy.

R&D 2: Large-Scale Intervention Experiment

In this project, we implemented five meditation practice courses into our newly developed app, "MiruApp." These include four courses tailored to specific personality types and one modern applied practice course known as mindfulness. For comparison, we also included a control group that focused solely on measurements without meditation practice, testing the effectiveness across a total of six courses. By analyzing data from 562 participants, we evaluated the specific effects of each course, which revealed distinct outcomes in areas such as relaxation and well-being.

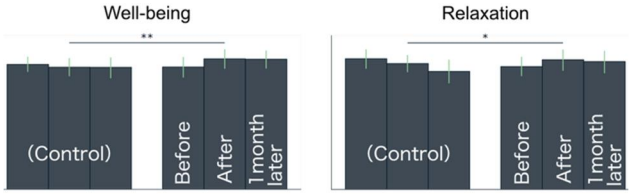

Figure 2. Effects in one of the meditation practice courses

Furthermore, we conducted an analysis using a personality-typing algorithm developed by our data-driven modeling team. The results indicated a significant interaction between personality types and the effectiveness of specific courses, identifying which types of individuals benefit most from particular practices. However, several challenges remain, such as the fact that the number of participants to whom the typing algorithm could not be applied was higher than anticipated.

Regarding the one-week in-person retreat, we conducted physiological assessments, including the measurement of urinary hormones. The results revealed a significant correlation between the psychological benefits of the retreat and changes in oxytocin levels.

3. Future plans

Moving forward, we will further strengthen our collaboration with the Leibniz Institute for Resilience Research. We aim to synthesize our findings regarding the relationship between changes in psychological states or traits induced by meditation and corresponding changes in facial expressions and voice.

We plan to conduct another large-scale intervention experiment using MiruApp to address the challenges identified this year. Additionally, we will continue our physiological validations using indicators such as oxytocin.

Through these efforts, we will multifacetedly examine the impact of tailoring meditation practices to the individual. We also intend to advance the development of behavioral indicators to objectively measure the effects of meditation, laying the groundwork for further research.