R&D irtem

3. Developing technology for inter-personal comparison of pleasure and aspiration by human brain indicators

Progress until FY2023

1. Outline of the project

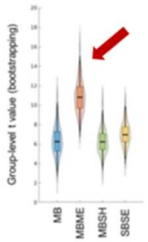
We need to measure the "goodness" of each policy at the group and societal level to make our society free and fair. However, it is known that such an index cannot be successfully created without methods for comparing “happiness” (or utility) of different people (Arrow's impossibility theorem; Arrow, 1963). It is also known that it is impossible to compare utility across individuals using classical methods based solely on behavioral data. In our project, we propose methods to measure “happiness” in an interpersonally comparable manner by combining various physiological indices. Rich happiness (such as "pleasure" and "aspiration") arises from being guaranteed the freedom to move (mobility) and the freedom to choose. In such an environment, people feel a sense of "belonging" and achieve a good state of mental and social well-being. Therefore, in normative economics, the goal of society is to ensure that individuals can lead lives they have reason to value, that is, to guarantee substantial freedoms for each person (Sen, 1999).

We aim not only to improve "happiness" at the individual level but also to aggregate it at the societal level and achieve equality. We are developing innovative technology to measure indicators of "happiness" from brain activity, making it possible to compare happiness across individuals. By achieving the projects, we will bridge detailed neuroscientific findings on brain indicators of "pleasure" and "aspiration" as felt by individuals to real-world activities, such as evaluating mobility policies in smart cities. This will contribute to the creation of societal technologies that enhance "well-being" through brain indicators.

2. Outcome so far

(1) Quantification of “pleasure” using brain indices

● We conducted experiments to investigate how to reduce fMRI noise, which is essential for interpersonal comparisons, and found that our method reduces noise better than existing ones.



●The analysis of the neural representation of utility was conducted using a large scale fMRI database (ABCD study), and we obtained quantitative data showing that the “marginal utility of money” diminishes with income level across individuals.

● We investigated the dynamic process by which utility is computed in the human brain using MEG (magnetoencephalography) with high temporal resolution. We examined the decoding of reward prediction errors and their relationship to socio-economic status, exploring whether it is possible to compare individuals based on brain indicators of "pleasure" derived from MEG signals.

(2) Quantification of the “aspiration” using brain indices

● The relationship between the two concepts of utility (experiential utility and decision utility), which are considered to be the basis of “pleasure” and “aspiration”, was investigated, and we found decision utility is constructed by integrating the “pleasure” provided by rewards.

● We investigated the dynamic process underlying the sense of controlling one's actions and their outcomes ("sense of agency") using MEG (magnetoencephalography) with high temporal resolution. By employing Q-learning, a type of reinforcement learning, we calculated the prediction errors and the transitions of expectations for action outcomes, decoding these from brain activity data.

●To elucidate the neural circuitry underlying the "sense of agency," we conducted electrocorticogram (ECoG) in marmosets during self-initiated vocalization. We observed the functional connectivity between the frontal and temporal lobes, focusing on the causality in the top-down direction (from the frontal lobe to the temporal lobe) within specific frequency bands during vocalization.

● To study the dynamic process of "autobiographical memory" which drives "aspiration," we developed an experimental system using virtual reality (VR) for mobility virtual experiences and measured the brain activity through MEG.

● By recording single neurons from epileptic patients, we have found that abstract context information is represented by human hippocampus.

3. Future plans

If we succeed in quantifying and socially aggregating the diverse "pleasure" and "aspiration" of people, it could become a significant well-being indicator that complements GDP, as envisioned by the OECD and the United Nations ("Beyond GDP"). Moving forward, we will scientifically identify what constitutes a "rich environment" and "freedom of action" crucial to "happiness" in modern society. Using VR technology and other methods to create controlled rich experimental environments, we will measure brain activity and validate our findings through various approaches to ensure the legitimacy of our developments. (MATSUMORI Kaosu: Tamagawa University, MATSUMOTO Madoka: Kyoto University, Ralph Adolphs: Caltech)