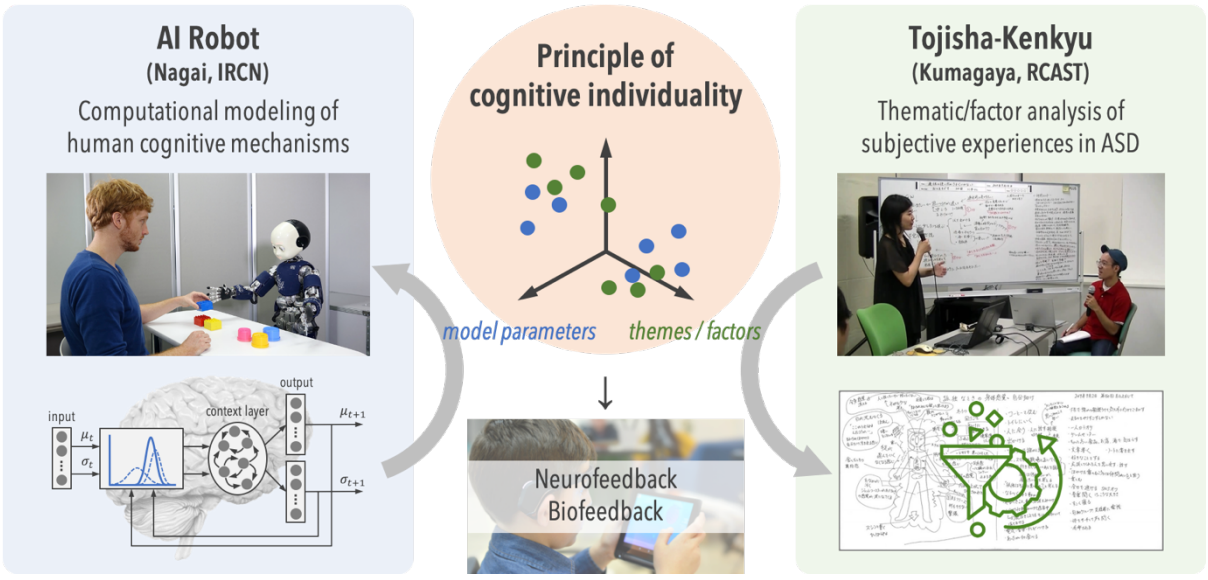
Beyond AI Project
"AI x Tojisha-Kenkyu: Computational Neuroscience for Systematic Understanding of Cognitive Individuality"

Project Leader
Yukie Nagai (Project Professor, IRCN, The University of Tokyo)

This project has integrated two approaches to explore cognitive individuality: AI research, which investigates individuality from a constructivist approach, and Tojisha-kenkyu, which analytically examines it from a first-person perspective.

Tojisha-kenkyu has involved a new hypothesis-testing type of research based on the predictive coding theory. We conducted a thematic analysis of narrative data obtained from Tojisha-kenkyu meetings and reviewed existing studies on autism spectrum disorder to formulate a hypothesis and develop new questionnaires for later studies. To expand the community and further refine the hypothesis, we established the Tojisha-kenkyu Episode Bank (https://token.episodebank.com) and the Introductory Lecture on Tojisha-kenkyu (https://www.utokyo-ext.co.jp/ids/top). The former enables users to provide and search their own episodes, whereas the latter enables them to learn how to conduct first-person studies. These initiatives have already been implemented in many companies and shown to improve psychological safety and inclusion in the workplace.

In AI research, we have developed neural network models that imitate the functions of the human brain and demonstrated that diverse cognitive individualities can be explained by modifications of specific parameters in the predictive coding processing. Our findings suggest that an imbalance in the precision of predictive and sensory signals can lead to learning difficulties or overlearning for a particular experience, resulting in unstructured or biased internal models. This result implies that hypersensitivity and hyposensitivity, which have bipolar characteristics, are inextricably linked due to modulations of a specific function in the brain. We have also designed and conducted drawing



and composition tasks with children and adults to test the hypothesis obtained in the model study. Our results demonstrated that parameter fluctuations as described above cause the individuality appearing in these tasks. Our further experiments showed that variations in the predictive encoding processing can explain cognitive individuality in various cognitive behaviors such as language ability, speech, and tactile and visual perception.

The above findings from Tojisha-kenkyu and AI research have enabled us to develop prototype systems that manifest cognitive individuality. Users can visualize their cognitive individuality by using smartphone applications, virtual reality, and robots. We believe that these systems will contribute to the improvement of inclusion and the realization of a neurodiverse society, in the same way as Tojisha-kenkyu at companies.

Selected Publications

1. Philippsen and Y. Nagai, "A predictive coding account for cognition in human children and chimpanzees: A case study of drawing," IEEE Transactions on Cognitive and Developmental Systems, 14(4):1306-1319, 2022.
2. Philippsen, S. Tsuji, and Y. Nagai, "Quantifying developmental and individual differences in spontaneous drawing completion among children," Frontiers in Psychology, 13:783446, 2022.
3. M. Tsfasman, A. Philippsen, C. Mazzola, S. Thill, A. Sciutti, and Y. Nagai, "The world seems different in a social context: A neural network analysis of human experimental data," PLoS ONE, 17(8):e0273643, 2022.
4. Philippsen, S. Tsuji, and Y. Nagai, "Simulating Developmental and Individual Differences of Drawing Behavior in Children Using a Predictive Coding Model," Frontiers in Neurorobotics, 16:856184, 2022.
5. J.-J. Hsieh, Y. Nagai, S. Kumagaya, S. Ayaya, and M. Asada, "Atypical Auditory Perception Caused by Environmental Stimuli in Autism Spectrum Disorder: A Systematic Approach to the Evaluation of Self-Reports," Frontiers in Psychiatry, 13:888627, 2022.
6. K. Asada, S. Itakura, M. Okanda, Y. Moriguchi, K. Yokawa, S. Kumagaya, K. Konishi, and Y. Konishi, "Understanding of the Gricean maxims in children with autism spectrum disorder: Implications for pragmatic language development," Journal of Neurolinguistics, 63:101085, 2022.
7. K. Kasai, S. Kumagaya, Y. Takahashi, Y. Sawai, A. Uno, Y. Kumakura, M. Yamagishi, A. Kanehara, K. Morita, M. Tada, Y. Satomura, N. Okada, S. Koike, and S. Yagishita, ""World-Informed" Neuroscience for Diversity and Inclusion: An Organizational Change in Cognitive Sciences," Clinical EEG and Neuroscience, 2022.
8. M. Wada, Y. Umesawa, M. Sano, S. Tajima, S. Kumagaya, and M. Miyazaki, "Weakened Bayesian Calibration for Tactile Temporal Order Judgment in Individuals with Higher Autistic Traits," Journal of Autism and Developmental Disorders, 2022.
9. M. Tsujita, M. Ban, and S. Kumagaya, "The Japanese Multidimensional Attitudes Scale Toward Persons With Autism Spectrum Disorders," Japanese Psychological Research, 63(3):129-139, 2021.

Homepages

- https://beyondai.jp/contents/projects/nagai/?lang=en
- https://developmental-robotics.jp/en/past_projects/beyond-ai/