IRCN
International Research Center for Neurointelligence

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The University of Tokyo Institutes for Advanced Study

How does human intelligence arise?

IRCN
International Research Center for Neurointelligence

Message from Director Takao K. Hensch

Human intelligence (H.I.) arises on two vastly different timescales. On the one hand, the brain quickly and flexibly absorbs new skills and experiences in infancy and childhood to outperform any modern-day computer. Yet, the biological basis for this remarkable capacity was honed over the long, slow arc of evolution. While animals may share certain core features – like learning, prediction, or intrinsic activity like sleep or thought – the diversity of H.I. spanning from creativity to mental illness is unparalleled. The wonders of this final frontier within our inner universe are likely matched only by the expanse of the outer universe.

Language and literacy first expanded our collective knowledge across individual brains and physical distances. Now another threshold moment in our evolution is upon us – the only species capable of creating a truly artificial intelligence (A.I.). A faithful digital copy of H.I. could expand our horizons into unforgiving terrain like deep sea or space. It may better predict mental well-being and provide optimal assistance to those who suffer infirmity. Communication with A.I. in society must surely also be approached in a fair and fruitful manner to further cooperation and not bias. To date, genuine neuro-inspired A.I. still eludes us.

The International Research Center for Neurointelligence (WPI-IRCN) was established with a fusion research mission of opening the black box of H.I. to cultivate an A.I. in its likeness. Our ecosystem at the intersection of life science (biology) and information science (mathematics and computation) offers a platform for discovery to be shared with diverse colleagues from around the world and even broader social science disciplines. Together, we probe the underlying principles of neural circuit development and unravel the etiology of brain disorders. Based on these insights, innovative A.I. will not only enrich our daily lives, but help us to answer whether the human brain can ultimately understand itself.

Raised multi-culturally, I have long been fascinated by how our identity and neurodiversity are profoundly shaped during critical periods of brain development. This fundamental feature of our biology has so far been neglected in modern A.I. We seek to establish neuro-intelligence at the interface of H.I. and A.I. as a new field of inquiry and applied science. The journey to reveal how H.I. arises and goes awry is perhaps the greatest challenge for the brain, which will drive its own evolution forward.

Please join us!

Takao K. Hensch
Director, International Research Center for Neurointelligence
September 30, 2022

Scientific Mission

Neurointelligence for Science and Society

The human brain is the pinnacle of biological evolution in the known universe, and higher brain cognitive abilities continue to surpass those of the largest and fastest supercomputers. As impressive as the brain is, its development is equally complex and mysterious: progressing from a single embryo to millions of synaptic circuit connections in a process that computer science cannot even begin to imagine. Within this dynamic neural network matrix lies the origins of cognition and intelligence. The mission of WPI-IRCN is to understand the core principles of brain development and leverage that knowledge to build a hybrid field of human and novel artificial intelligence called neurointelligence.

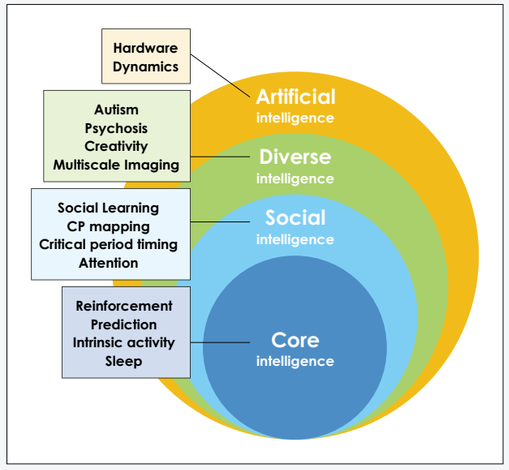
Exploring the Origins of Human Intelligence

The Child Brain: a Biological Learning Machine

How does human intelligence arise? The answer lies in the myriad neural circuits that emerge in the developing brain. The capacity for intelligence begins with neural stem cells that power prenatal brain development and their genetic and epigenetic control. Next is the elaboration of neural processes that define the synaptic microcircuits and their precise structural plasticity. Early sensory experience then actively sculpts these circuits during circumscribed temporal windows called critical periods that help to crystallize the network. Finally, the child's social and cultural environment consolidates higher cognitive functions like language, learning, and memory. Not surprisingly, brain development trajectories can go awry at any of these stages, resulting in disorders that may impair cognition. WPI-IRCN seeks to explore novel principles of brain development and function from these diverse perspectives and then apply them to benefit society.

Navigating the Landscape of Intelligence Research

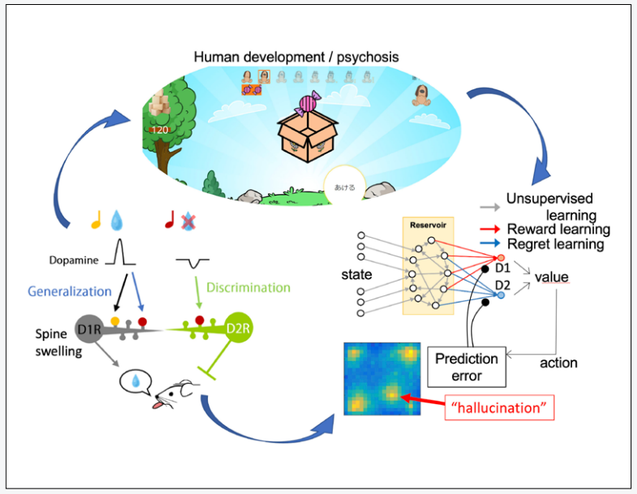
Layered Structure of Intelligence



Human intelligence (H.I.) comprises three concentric categories formed naturally by brain evolution. Core Intelligence consists of the brain's ability to perform basic cognitive functions like learning from experience, predicting the environment, and generating spontaneous activity. These core functions allow individuals to interact and support Social Intelligence through attention to others, shared experience during early critical periods, and social learning. Social and Core Intelligence define the normal range of cognition, which in humans may span a broad spectrum of capacities – from creativity to psychiatric conditions – an added dimension called Diverse Intelligence. From there, Artificial Intelligence (A.I.) is a stage beyond natural human intelligence, enabling H.I. to acquire additional capabilities to better shape our future.

Opening Frontiers via Interdisciplinary Collaboration

Creating Research Field Fusion through Team Science

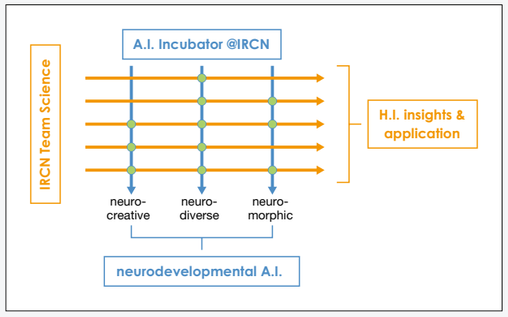


The mission of WPI-IRCN requires an integration of the natural sciences, social sciences, medicine, mathematics, engineering, and computation/information science, seamlessly linking fundamental research on the development of neural circuits and their advanced measurement technologies to drive brain development-inspired A.I. research. WPI-IRCN convenes researchers from all these disciplines who work together in a Team Science collaboration framework to facilitate interdisciplinary research with applied innovation and find solutions to human and clinical goals. Each team is self-governing and coordinated by center leadership, tackling ambitious and complementary research projects in human intelligence. WPI-IRCN brings together faculty and postdoctoral fellows from the University of Tokyo with researchers from partner institutions worldwide.

Strengthening Society One Brain at a Time

Neural Development-Inspired Applications

Team Science-driven research applications are emerging along two principal axes: human intelligence, including discovery and hypothesis-driven science for clinical and social benefits, and neural development-inspired A.I., based on a synthesis of computational algorithmic engineering, incorporating insights from the child's brain. WPI-IRCN's overarching innovation mission is the creation of a neurointelligence ontology for human wellness and happiness with the resilience to solve society's significant challenges. A large part of this goal will be predicting and alleviating debilitating brain disorders. WPI-IRCN is building the foundation for a new generation of brain development–inspired A.I. technologies.



Research Core Facilities

Comprehensive Technical Support for the IRCN Research Community

WPI-IRCN features five state-of-the-art research core facilities to power the scientific exploration of neurointelligence. The ES-Mouse/Virus Core, Imaging Core, Human fMRI Core, and Data Science Core provide advanced technological platforms for researchers to develop novel reagents, make observations, and collect and analyze data for both hypothesis and discovery-driven research. A unique feature of WPI-IRCN, the Science Writing Core, supports and trains global standard communication.

Generating

ES-Mouse/Virus Core

Producing Genetically Modified Reagents with Novel Technologies for Enhancing the Speed and Efficiency of Experiments

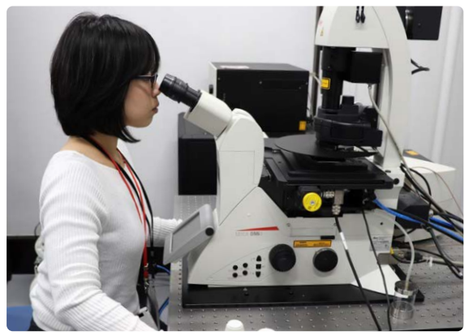
The ES-Mouse/Virus Core houses facilities and services for the generation of genetically modified mice, and the production of viruses for studies with genetically modified mice.

The core has developed an efficient, rapid, and simple procedure for the production of genetically-modified mice enabling the production of multiple knock-in ES cells in about 1 month. The core can also create multiple parallel lines of knock-in ES-mice without a need for breeding, thus shortening the production time from a year to 2-3 months. Virus engineering for neural circuit experimental applications is also supported by the core.

Observing

Imaging Core

Harnessing an Array of High-Performance Microscopes for Fine-Scale Spatiotemporal Observations and Image Analysis



The Imaging Core enables comprehensive data acquisition on brain structure and function at multiple spatial and temporal resolution with advanced optical equipment.

The Imaging Core houses an advanced array of microscopes and imaging devices for the efficient observation of biological samples, including the visualization of neuronal activity in the mouse brain at single micron or whole brain scale. The facility also offers a wide range of data collection schemes for great versatility in experimental design. New technologies are continuously adopted and refined by the core to serve its users.

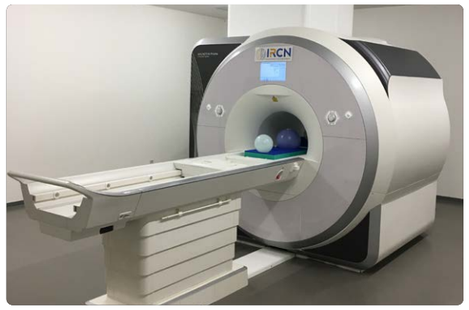
Observing

Human fMRI Core

Measuring and Mapping Brain Structure and Activity for Building Models of Brain Cognition and Biomarkers for Disorders

The human fMRI core serves as a research facility for scientists to conduct studies that will probe the origins of intelligence and help to understand pervasive brain disorders.

The core employs a Siemens Prisma 3T MRI allowing flexibility and interoperability with multiple forms of human functional imaging experiments including task-based and resting state measurements. Basic and clinical studies will be conducted to examine brain function in the healthy and disease-impaired state. Coordination with national, regional and global brain imaging projects is emphasized.



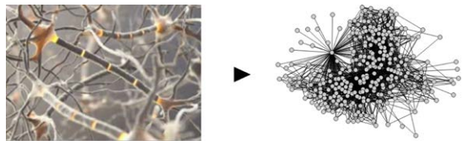
Analyzing

Data Science Core

Conducting Statistical Analyses of Physiological Data with Computational Methods, Mathematical Modeling, and Novel A.I.

The Data Science Core processes and stores data on brain structure and function and uses statistical analyses and mathematical modeling to derive fundamental properties.

The core promotes interactions between numerical and empirical experiments. Data analysis is conducted with mathematical tools and software using observations from IRCN member laboratories, with the aim of deriving fundamental properties of the brain, developing novel data analysis methods, and building mathematical models for a quantitative perspective on brain development, and human and machine intelligence.



Communicating

Science Writing Core

Supporting and Training Researchers and Students to be International Leaders in Scientific Writing, Communication, and Facilitation

The Science Writing Core provides communications services, consulting, training, and resources for grants and manuscripts supporting world-class interdisciplinary research.

The core provides bilingual support and training for the production of research manuscripts, grants, oral presentations, public/media outreach, web/multimedia, and other forms of science communication. Working with the WPI-IRCN management, core staff contributes to powering transdisciplinary collaboration, community engagement, internationalization, and advancing a neurointelligence field.

IRCN Research Ecosystem:

leveraging the power of transdisciplinary collaboration, communication, and community building to explore human and artificial intelligence.

Global Partners

Building a global network of partner institutions and researchers for international engagement in projects to discover the origins of intelligence and repair brain disorders.

1	Max-Planck Florida Institute for Neuroscience (MPFI)	MAX PLANCK FLORIDA INSTITUTE FOR NEUROSCIENCE	2	Boston Children's Hospital	Boston Children's Hospital Until every child is well
3	Agency for Science, Technology & Research, Singapore	Agency for Science, Technology and Research SINGAPORE	4	Fondazione Istituto Italiano di Tecnologia	iit ISTITUTO ITALIANO DI TECNOLOGIA
5	RIKEN Center for Advanced Intelligence Project RIKEN Center for Biosystems Dynamics Research RIKEN Center for Brain Science	理化学研究所	6	NCCR "SYNAPSY – The synaptic bases of mental diseases"	synapsy
7	Edwin O. Reischauer Institute of Japanese Studies, Harvard University	REISCHAUER INSTITUTE OF JAPANESE STUDIES HARVARD UNIVERSITY	8	Asian Consortium on MRI studies in Psychosis	ACMP
9	Okinawa Institute of Science and Technology Graduate University	OIST	10	The University of British Columbia	THE UNIVERSITY OF BRITISH COLUMBIA
11	The Hong Kong University of Science and Technology	香港科大 HKUST	12	The Chair of Morphogenetic Processes of the Collège de France	COLLÈGE DE FRANCE 1530
13	Canadian Institute for Advanced Research: CIFAR	CIFAR	14	Stockholm University	Stockholm University
15	KTH Royal Institute of Technology	KTH	16	Karolinska Institutet	Karolinska Institutet
17	Chinese Academy of Science Center for Excellence for Brain Science and Intelligence Technology		18	Tsinghua University	
19	Bielefeld University	UNIVERSITÄT BIELEFELD	20	École normale supérieure	ENS | PSL

Organization

As of September, 2022

Support IRCN

WPI-IRCN addresses an ultimate question in science and society - “how does human intelligence arise?”.
By conducting transdisciplinary research, WPI-IRCN aims to understand the principles of the developing brain with the ultimate goals of solving mental illness and brain disorders and developing next-generation artificial intelligence (A.I.) technologies for the benefit of humanity. To achieve this ambitious goal, it is necessary for WPI-IRCN to have sufficient funding to conduct world-leading research and recruit researchers internationally. We would appreciate any support you can provide to help us achieve our mission. Please contact us for further information on our donor programs and benefits.

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The University of Tokyo Institutes for Advanced Study

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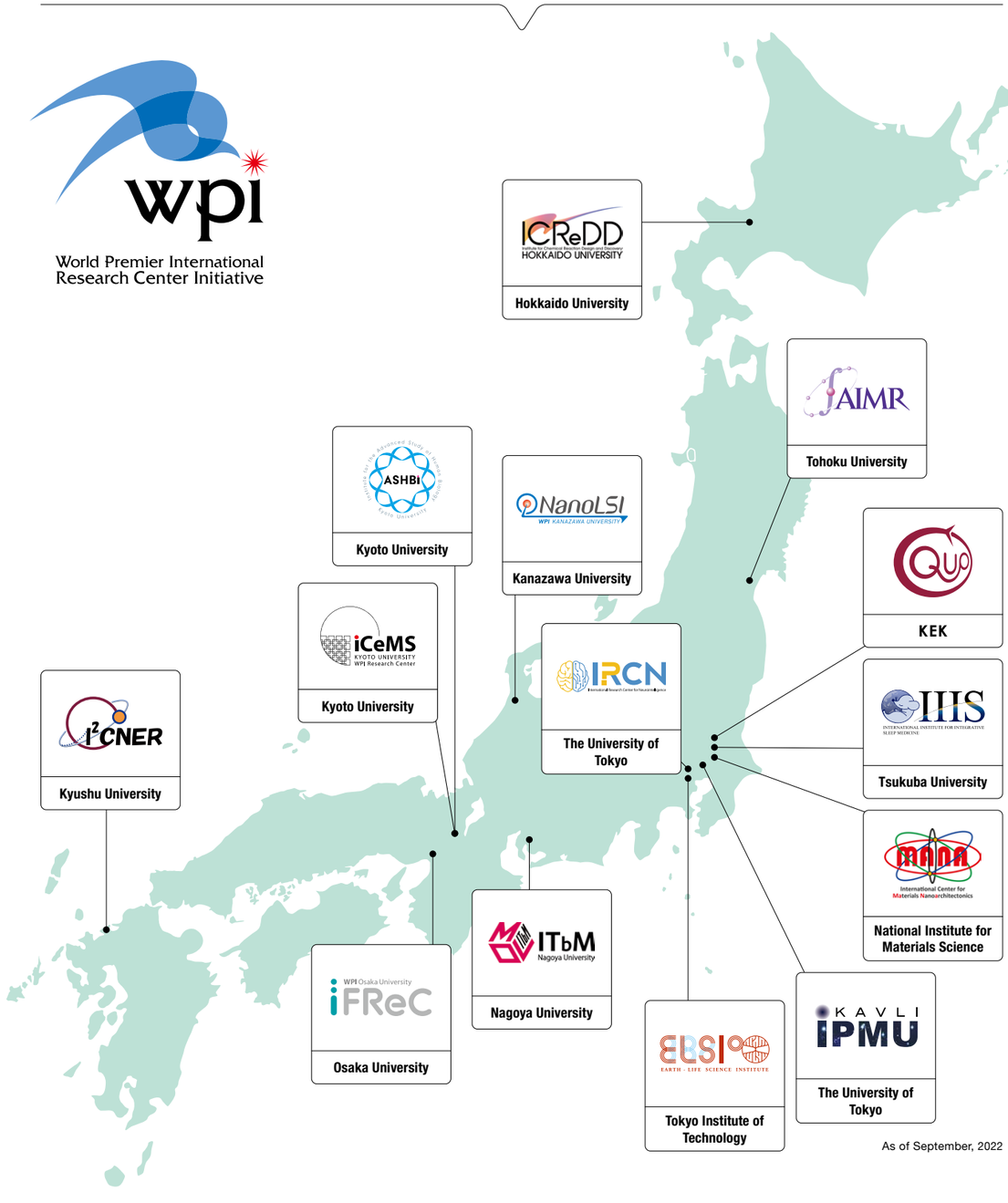
About the WPI

World Premier International Research Center Initiative

The World Premier International Research Center Initiative (WPI) was launched in 2007 by the Japanese Government's Ministry of Education, Culture, Sports, Science and Technology (MEXT) with the aim of building globally visible research centers.
WPI research centers have four requirements: achieving the world's highest research standard, establishing an international research environment, reforming the research system, and the creation of interdisciplinary research. The International Research Center for Neurointelligence (WPI-IRCN) was founded on November 1, 2017 and is undertaking ambitious reforms including inviting frontline researchers from around the world to establish a global research environment.

World Premier International Research Center Initiative



As of September, 2022

IRCN
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wpi
World Premier International Research Center Initiative

ACCESS

- 8 minute walk from Hongo-sanchome Station on the Tokyo Metro Marunouchi Line
- 6 minute walk from Hongo-sanchome Station on the Tokyo Metro Toei Oedo Line

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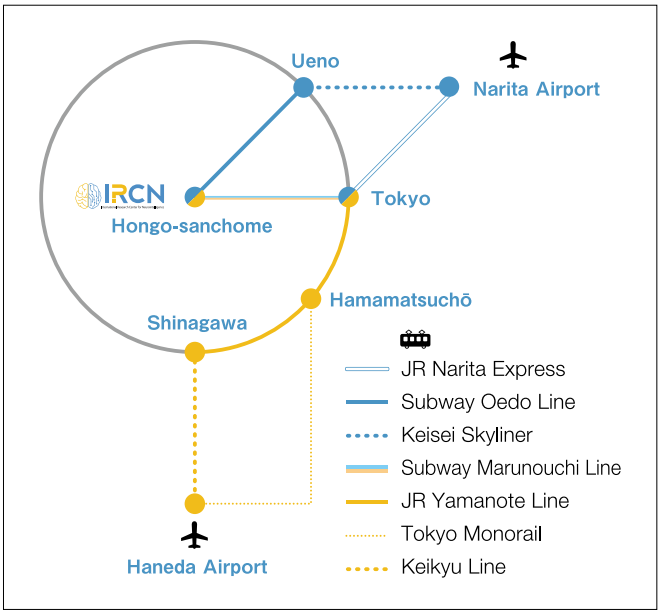

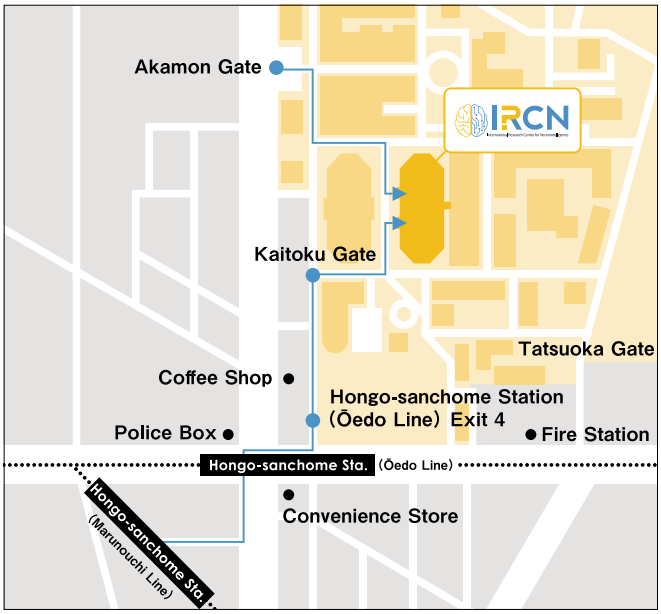

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https://ircn.jp/en/

September 2022

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IRCN Executive Director / Principal Investigator

University Professor

Mathematical Modeling of Complex Systems and Applications to Neurointelligence

Computation

Zenas C. Chao

Principal Investigator

Associate Professor

Predictive and Creative Brain

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Development

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Graduate School of Pharmaceutical Sciences, The University of Tokyo

Neural Development, Neural Stem/Progenitor Cells, Epigenetics, Signal Transduction

Human/Clinical

Takao K. Hensch

IRCN Director / Principal Investigator / Project Professor

Professor of Neurology, Harvard Medical School, Boston Children's Hospital / Professor of Molecular & Cellular Biology, Center for Brain Science, Harvard University

Critical Periods in Brain Development and their Clinical Applications

Technology

Haruo Kasai

Principal Investigator

Project Professor

Neural Circuit and Synaptic Mechanisms of Learning and Memory

Human/Clinical

Kiyoto Kasai

Principal Investigator

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Graduate School of Medicine, The University of Tokyo

Neuroimaging and Clinical Neurophysiology in Psychiatric Disorders

Computation

Yukie Nagai

Principal Investigator

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Understanding and Assisting Human Intelligence Through Cognitive Developmental Robotics

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Functional Organization and Development of The Visual System

Technology

Yasushi Okada

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Technology Development for In Vivo Imaging of Cell Dynamics

Technology

Shoji Takeuchi

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Biohybrid Systems, Micro Electro Mechanical Systems, Microfluidics, Tissue Engineering, Artificial Cell Membrane

Human/Clinical

Takamitsu Watanabe

Principal Investigator

Professor

Brain Network Dynamics of Unstable Cognition and its Clinical Applications

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Computations in Decision-Making by Natural and Artificial Intelligence

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Nonlinear Dynamics, Reservoir Computing

Hideki Nakayama

Affiliated Principal Investigator

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Multimodal Generative AIs Based on Deep Neural Networks

Raymond Ng

Affiliated Faculty

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Natural Language Processing, Health Informatics, Genomics

Hirokazu Takahashi

Affiliated Principal Investigator

Professor, Department of Mechano-Informatics, Graduate School of Information Science and Technology, The University of Tokyo

Diversity and Plasticity of Neural Information Processing Mechanisms

Gouhei Tanaka

Affiliated Principal Investigator

Professor, Department of Computer Science, Graduate School of Engineering, Nagoya Institute of Technology

Reservoir computing AI and its Application to Neurointelligence

Research Core Facilities

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Core Manager, Data Science Core

Associate Professor,
Graduate School of Medicine, The University of Tokyo

Computational Neuroscience, Neural Data Analysis and its Applications

Satoru Kondo

Core Manager, Imaging Core

Project Associate Professor

Mechanisms and Neuronal Circuits for Information Processing of Vision

Naohiro Okada

Core Manager, Human fMRI Core

Associate Professor,
Graduate School of Medicine, The University of Tokyo

Neuroimaging of Psychiatric Disorders and Adolescent Development

Hideki Ukai

Core Manager, ES-Mouse/Virus Core

Project Associate Professor

Development of Next-Generation Mammalian Genetics

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