DIRECTOR'S VISION

Takao K. Hensch, PhD[1]

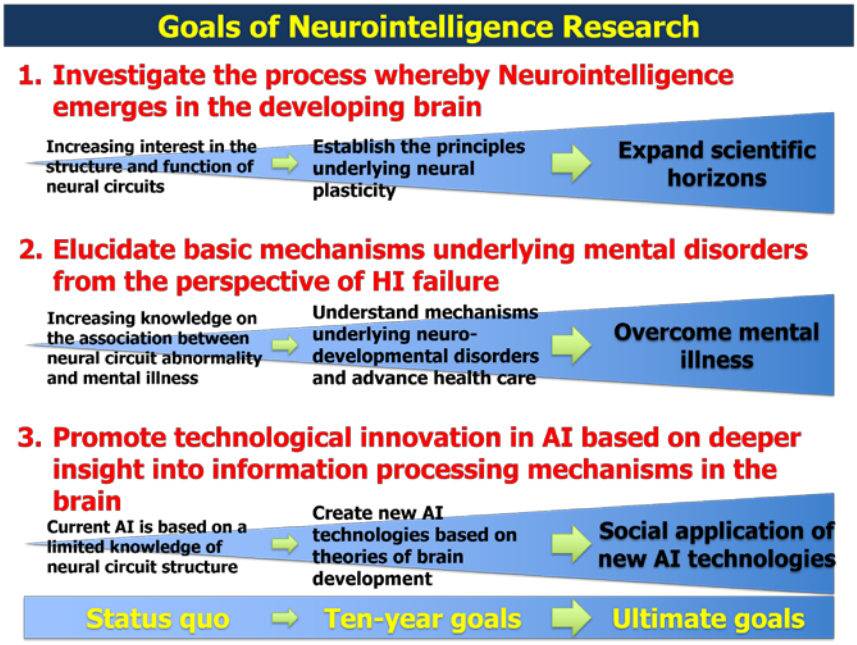
Over the course of evolution, humans have gained a special status in relation to other species. Notably, humans have produced a far more complex and flexible society and tools for driving their own destiny. What is the essence of human intelligence (HI), which is the source of civilization, science, and technology? From a socio-biological perspective, HI can be considered a consequence of humans' superior brain functions, despite the fact that our physical capabilities are far less advanced than those of many other animal species. These mental functions enable social cooperation, long-term planning, and the accumulation and transmission of knowledge through spoken and written language.

With tremendous technological advances, however, modern society is also facing significant challenges in mental health. For example, autism spectrum disorder (ASD), schizophrenia, and other psychiatric conditions are posing tremendous burden on society. Such disorders reflect maladjustment to the social environment created by HI, underscoring the need for innovative solutions.

Artificial intelligence (AI), which the human brain has created, is strikingly outpacing HI in many areas. Through deep learning and other machine learning, AI is increasingly having a significant social impact. Efforts to elucidate how HI emerges, and to link HI and AI within the same framework, are sorely needed. Together, they explore the essential underpinnings of human civilization and culture. **Uncovering principles of the brain basis for HI is the most challenging and urgent scientific frontier.**

To this end, we aim to establish **a new WPI center that pioneers the innovative interdisciplinary study of 'Neurointelligence'** – a novel concept in neuroscience made possible only through a synergistic, multi-disciplinary collaboration with world-class researchers. Never before in human history have the experimental and computational tools for understanding how biological circuits underlie behavior and the potential to emulate their complex dynamics in machines been so perfectly aligned. The team members assembled in this WPI are already recognized world leaders in their individual disciplines, who now jointly seek an integration that promises unprecedented understanding of HI.

1. **Investigate the process whereby Neurointelligence emerges in the developing brain.**
2. **Elucidate basic mechanisms underlying mental disorders from the perspective of HI failure.**
3. **Promote technological innovation in AI based on deeper insight into information processing mechanisms in the brain.**



My research career has focused on the interplay of genes and environment in shaping neural networks in the brain. This work has been recognized for its pioneering insight into "critical periods" of heighted brain plasticity early in life. The basic mechanisms, first identified in the visual cortex, revealed that these windows can be manipulated. They may be shifted earlier or later by drugs or mental illness and even reopened in adulthood. Similar critical period plasticity has been demonstrated across brain regions, including auditory, insular, prefrontal cortices and cingulate gyrus, following similar principles as in visual cortex. Although Harvard provides an optimal environment for such basic exploration, the study of Neurointelligence requires a deeper strategic research program that integrates novel computational and technological approaches. Building on

[1]Takao Hensch, named the first director of the proposed WPI center, spent the early days of his career at UTokyo after graduating from Harvard. Following his PhD at UCSF, he was appointed Group Director in his early 30s at the RIKEN Brain Science Institute. Currently serving as Director of the NIMH Silvio Conte Center at Harvard, he plays a pivotal role there in neuroscience, spanning basic research to human application. Throughout his career, Takao Hensch has gained extensive experience and broad exposure to domestic and international communities of researchers, and fully understands the latest challenges in the field. He is the most promising potential Director of IRCN.

complementary resources and expertise at the University of Tokyo (UTokyo) and specific research institutes overseas, it is now timely to establish an International Research Center for Neurointelligence (IRCN). This new WPI is characterized as follows:

1. Internationally Recognized Research Network

I currently serve as Professor at Harvard University. By shifting my research base to IRCN, we aim for rapid, synergistic progress with global impact. Since returning to the US from RIKEN, I have led student exchange programs between Harvard and Japanese institutions. UTokyo and the Max-Planck Institute, Germany, have also signed neuroscience partnership agreements, stimulating significant research collaboration. Together, this network offers unparalleled training opportunities for scholars worldwide.

2. Integration of Neuroscience with Information Sciences and Clinical Research

The concept of Neurointelligence, the hallmark of this proposed WPI center, is based on a uniquely deep integration of neuroscience and AI research. Hiroki Ueda, Kazuyuki Aihara, and Masashi Sugiyama will lead the Mathematical Information Systems Unit, and all three are well-known, top-tier scientists in systems biology, mathematical neuroscience, and AI research. Importantly, IRCN includes large clinical centers in Tokyo and Boston for active translational research, which cannot be achieved by other brain science institutes without clinical branches.

3. Research Goals with Major and Visible Social Impact

Building on the novel concept of Neurointelligence, IRCN addresses the global scientific challenge of identifying neural mechanisms underlying HI, how it emerges in development, and to better inform medical efforts for overcoming psychiatric and mental health problems. Ultimately, the center will give rise to new AI technologies, their social application and greater social impact.

IRCN will consist of **four core research units**, encompassing 15 principal investigators (PIs) selected from renowned scientists among UTokyo and overseas research institutions. The core units will engage in close cooperation and coordination with each other, and the synergy among them will facilitate breakthrough insights. Specifically, the PIs of IRCN will have a common interest in the structural and functional development of neural circuits as the basis of Neurointelligence.

First, the Developmental Research Unit will include: Yukiko Gotoh, Masanobu Kano, Kazuo Emoto, Rachel Wong, Kenichi Ohki, Haruo Kasai, Kuniyoshi Sakai and myself. They will engage in biological research on the process of neural circuit development, modification and maturation from late fetal to postnatal periods. **Second**, the Technological Development Unit will consist of Yasushi Okada, Haruo Kasai, Arthur Konnerth, and Shoji Takeuchi. The mission of this unit is to develop cutting-edge technologies for research on neural circuit development, such as ultra-high resolution microscopy, functional analysis and manipulation of single synapses, and simultaneous activity measurement of multiple neurons. **Third**, the Neurodevelopmental Disorder Pathology Unit will be jointly headed by myself and Kiyoto Kasai. An understanding of psychiatric pathology arising from the disturbance of neural circuit development will further deepen our knowledge of HI. Kiyoto Kasai will conduct MRI-based structural and functional studies on the brain of patients with ASD and schizophrenia. I will utilize complementary preclinical models to study their circuit pathology and explore novel treatments by manipulating neural circuit plasticity. **Fourth**, the Mathematical Information Systems Unit will be led by Hiroki Ueda, Kazuyuki Aihara, and Masashi Sugiyama (see above). Their studies will give rise to new AI technologies.

Together, these four units will engage in concerted efforts to achieve the center's overall goals. The innovative techniques developed by the Technological Development Unit will support the Developmental Research Unit. The work on preclinical psychiatric models will inform research at the Neurodevelopmental Disorder Pathology Unit. Leveraging the principles underlying both neural circuit development and dysfunction, the Mathematical Information Systems Unit will pursue innovative new AI technologies. Additionally, the WPI center will include joint projects with Harvard, including Boston Children's Hospital for translational research, as well as the Max Planck Florida Institute for Neuroscience to further establish tools and basic research. By incorporating overseas satellite laboratories the WPI will broaden its global footprint and global outreach to train the next generation of Japanese and foreign scientists.

By uniquely integrating biological, medical, linguistic, mathematical, and information sciences, **this WPI will tackle the greatest challenge to mankind: can the human brain understand itself? The center's strategy will herald a new scientific paradigm of Neurointelligence, leading the way toward revealing core mechanisms of HI, correcting its disorders and shaping AI technologies to positively impact our future society.**