Editorial

Kai Yuan, Haoyun Zhao, Yuxin Zhang, Yimiao Gong, Xiaoxing Liu and Lin Lu*

# Progress of the China brain project

https://doi.org/10.1515/mr-2022-0014

The brain is among the most essential organs of human beings. In human brain, there are about 100 billion neurons, and they form the basis of neural activity in the brain through synaptic connections [1]. The higher-level neural functions distinguish us from other animals, yet we still have not achieved a comprehensive knowledge of the brain. Therefore, understanding its structure and function is one of the most substantial and challenging frontier scientific questions of the 21st century.

## Overview of the global brain project

As the representative of the developed countries, the United States has begun to adopt brain science research as a major strategy since the 1990s. The 101st Congress of the United States passed a bill designating the decade starting from January 1, 1990 as 'the Decade of the Brain' [2]. In the summer of 1995, the International Brain Research Organization (IBRO) proposed the 21st century as 'the Century of Brain' at the fourth World Neuroscience Congress held in Kyoto, Japan. The European Union has established a ten-year commission for the European Brain Council, and Japan has launched plans for the Brain/MINDS (Brain Mapping by Integrated Neurotechnology for Disease Studies) project [3]. Brain science has emerged as one of the most prominent and advanced fields of research in the world today.

In 2005, Henry Markram, a scientist at the École Polytechnique Fédérale de Lausanne in Lausanne, Switzerland, proposed the Blue Brain Project [4], which aims to "replicate" all the activity of the human brain, and the various reactions that take place inside, by reverse-engineering the mammalian brain at the molecular level to build a computer model. In January 2013, the European Commission announced the inclusion of Human Brain Engineering in the Future and Emerging Technologies (FET) Flagships, in an attempt to gather various forces to lay the foundation for a new brain research model based on information and communication technology and accelerate the transformation of brain science research achievements [5]. In April 2013, the United States announced the launch of the Brain Project, which aims to accelerate the development and application of new technologies to reveal the dynamic changes of the brain structure and function, investigating how individual brain cells and complex neural circuits interact in time and space [6]. In 2014, Japan launched the Brain Project, which employs a unique non-human primate model and aims to ultimately understand the complex human brain by mapping the structure and function of its neural circuits.

## Overview of the China brian project

In 2006, China also started to construct a forward-looking scheme of brain science research. In the 'Outline of the National Medium- and Long-Term Scientific and Technological Development Plan (2006–2020)', brain science and cognition is listed as one of the eight frontier topics in basic research. In 2017, Brain Science and Brain-Inspired Intelligence (China Brain Project) was listed in the 13th Five-Year Plan as a major scientific and technological project. In 2018, the Chinese Institute for Brain Science in Beijing and

***Corresponding author: Lin Lu**, Peking University Sixth Hospital, Peking University Institute of Mental Health, National Clinical Research Centre for Mental Disorders (Peking University Sixth Hospital), Chinese Academy of Medical Sciences Research Unit (No.2018RU006), Peking University, 51 Huayuan Bei Road Beijing 100191, China; Peking-Tsinghua Centre for Life Sciences and PKU-IDG/McGovern Institute for Brain Research, Peking University, Beijing, China; and National Institute on Drug Dependence, Peking University, Beijing, China, E-mail: linlu@bjmu.edu.cn

**Kai Yuan and Xiaoxing Liu,** Peking University Sixth Hospital, Peking University Institute of Mental Health, NHC Key Laboratory of Mental Health (Peking University), National Clinical Research Center for Mental Disorders (Peking University Sixth Hospital), Chinese Academy of Medical Sciences Research Unit (No.2018RU006), Peking University, Beijing, China. https://orcid.org/0000-0002-3498-8163 (K. Yuan)

**Haoyun Zhao, Yuxin Zhang and Yimiao Gong,** Peking University Sixth Hospital, Peking University Institute of Mental Health, NHC Key Laboratory of Mental Health (Peking University), National Clinical Research Center for Mental Disorders (Peking University Sixth Hospital), Chinese Academy of Medical Sciences Research Unit (No.2018RU006), Peking University, Beijing, China; and Peking-Tsinghua Centre for Life Sciences and PKU-IDG/McGovern Institute for Brain Research, Peking University, Beijing, China

the Frontier Science Center for Brain Science in Fudan University in Shanghai were established successively. In September 2021, the Ministry of Science and Technology released the 'Guidelines for 2021 Annual Project Application of Science and Technology Innovation 2030 – Brain Science and Brain-Inspired Intelligence Research major project', proposing 59 guidelines and allocating more than 3.1 billion yuan. The China Brain Project has several unique advantages when compared to other brain projects around the world, even though they all share similar long-term goals. Based on research on the neural principles of brain cognition, the China Brain Project is structured as 'one body and two wings', with the goal of developing treatments for major brain disorders and promoting the development of a new generation of artificial intelligence. As part of the China Brain project, basic cognitive research on neural circuit mechanisms provides input and receives feedback from brain disorders/intervention and brain-inspired technology (two wings) [7]. China Brain Project aims to develop a deeper understanding of the mechanisms and principles of the brain at multiple levels and promotes deep and close collaboration between neuroscientists and artificial intelligence (AI) researchers (see Figure 1).

## Progress of the China brain research

During the past 15 years of brain research, China has made a series of important progress in the field of brain diseases. The China Kadoorie Biobank (CKB) has published more than 200 articles on the pathogenic factors, pathogenesis, epidemic prevalence and trends of various major chronic diseases that endanger the health of the Chinese population from perspectives of genetics, environment and lifestyle. The Kailuan cohort study, established in 2006, focused on cardiovascular events, including the assessment of psycho-psychological symptoms such as sleep and cognitive function. There have been over 130 published articles. Through the development of analytical tools, the integration of multiple types of data resources and comparative studies of multiple diseases, the Chinese Academy of Sciences' Institute of Psychology created a genetic database of mental illness that reveals a series of internal mechanisms in the development of mental illness. Yang **et al.** first reported that the formation of depression is closely related to the cluster discharge pattern of habenula, an anti-reward center in the brain and proposed a novel rapid anti-depression mechanism of ketamine, namely, blocking the cluster discharge to release the inhibition of reward center [8]. For the first time, the special structure-function relationship between glial cells and the firing mode of neurons was discovered. Furthermore, the idea of blocking cluster discharge provides multiple new molecular targets for the development of novel rapid antidepressants. In collaboration with many other domestic and foreign institutions, Chinese researchers from the Chinese Academy of Sciences Institute of Automation discovered that hippocampal imaging could be used as an imaging marker of Alzheimer's disease based on more than 1900 brain imaging samples [9].

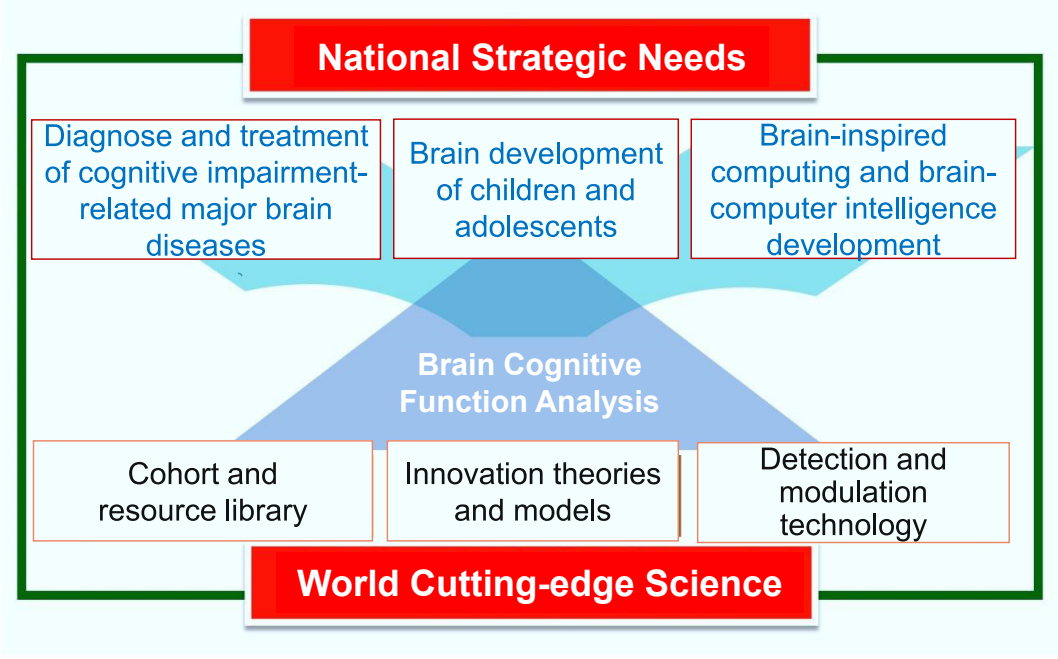


**Figure 1:** Overall layout of China brain project.

## Prospects of the China brain project

In the field of brain science, neuroscience research in China is distinctive in deciphering the neural basis of higher cognitive functions because we have the unique resources of non-human primates, such as macaques, as experimental animal models. At the same time, as the world's most populous country, China has a large population suffering from brain diseases. With strong government support for the China Brain Project, Chinese scientists will be able to establish effective early diagnosis and intervention strategies for a variety of major brain diseases. In the future, through the collaborative efforts of scientists all over the world, brain disease research may make innovative changes in the area of the whole-life cycle analysis of pathogenesis, the simulation of brain disease, biomarkers and personalized treatment strategies, and artificial intelligence-assisted precision medicine.

## Conclusion remarks

The China Brain Project is committed to develop innovative models of neural functions and translative models of disease predictions available to both basic and clinical researchers. This novel multi-channel integrated approach will aid in formulating efficacy evaluation paradigms, in developing ground-breaking early prevention, diagnosis and treatment methods, in understanding the pathogenesis of brain diseases, in utilizing brain-like intelligence technology and in educating and training a new generation of enthusiastic and dedicated neuroscientists. Given the strong governmental support, large patient populations for brain diseases studies as well as abundant animal resources, we envision that the China Brain Project's long-lasting contributions will extend far beyond the discipline of neuroscience and point the way to transdisciplinary research and collaborations.

## References

1. Briscoe J, Marín O. Looking at neurodevelopment through a big data lens. Science 2020;369:eaaz8627.
2. Jones EG, Mendell LM. Assessing the decade of the brain. Science 1999;284:739.
3. Okano H, Miyawaki A, Kasai K. Brain/MINDS: brain-mapping project in Japan. Philos Trans R Soc Lond B Biol Sci 2015;370:20140310.
4. Markram H. The blue brain project. Nat Rev Neurosci 2006;7: 153–60.
5. Amunts K, Ebell C, Muller J, Telefont M, Knoll A, Lippert T. The human brain project: creating a European research infrastructure to decode the human brain. Neuron 2016;92:574–81.
6. Ramos KM, Grady C, Greely HT, Chiong W, Eberwine J, Farahany NA, et al. The NIH BRAIN initiative: integrating neuroethics and neuroscience. Neuron 2019;101:394–8.
7. Poo MM, Du JL, Ip NY, Xiong ZQ, Xu B, Tan TN. China brain project: basic neuroscience, brain diseases, and brain-inspired computing. Neuron 2016;92:591–6.
8. Yang Y, Cui YH, Sang KN, Dong YY, Ni ZY, Ma SS, et al. Ketamine blocks bursting in the lateral habenula to rapidly relieve depression. Nature 2018;554:317–22.
9. Zhao K, Ding YH, Han Y, Fan Y, Alexander-Bloch AF, Han T, et al. Independent and reproducible hippocampal radiomic biomarkers for multisite Alzheimer's disease: diagnosis, longitudinal progress and biological basis. Sci Bull 2020;65:1103–13.