

Korea Brain Initiative: Emerging Issues and Institutionalization of Neuroethics

Sung-Jin Jeong,^{1,2,3,*} In Young Lee,^{3,4} Bang Ook Jun,^{3,5} Young-Joon Ryu,^{3,6} Jeong-woo Sohn,^{2,3,7} Sung-Phil Kim,^{2,8} Choong-Wan Woo,^{2,9,10} Ja Wook Koo,^{1,2} Il-Joo Cho,^{2,11} Uhtaek Oh,^{2,11} Kyungjin Kim,¹² and Pann-Ghill Suh^{1,2}

¹Korea Brain Research Institute (KBRI), Daegu 41062, Republic of Korea

²Korea Brain Initiative

³Korea Neuroethics Research Group

⁴Hongik University, Seoul 04066, Republic of Korea

⁵Gangneung-Wonju National University, Gangwon-Do 25457, Republic of Korea

⁶Kangwon National University, Gangwon-Do 24341, Republic of Korea

⁷Catholic Kwandong University, Gangwon-Do 25601, Republic of Korea

⁸Ulsan National Institute of Science and Technology (UNIST), Ulsan 44919, Republic of Korea

⁹Center for Neuroscience Imaging Research, Institute for Basic Science (IBS), Gyeonggi-Do 16419, Republic of Korea

¹⁰Department of Biomedical Engineering, Sungkyunkwan University, Gyeonggi-Do 16419, Republic of Korea

¹¹Brain Science Institute, Korea Institute of Science and Technology (KIST), Seoul 02792, Republic of Korea

¹²Daegu-Kyungpuk Institute of Science and Technology (DGIST), Republic of Korea, Daegu 42988, Republic of Korea

*Correspondence: sjjeong@kbri.re.kr

<https://doi.org/10.1016/j.neuron.2019.01.042>

Neuroscience research has become a national priority for the Korean government. Korean scholars have dedicated interest in the societal ramifications of neurotechnologies; neuroethics is an integral component of the Korea Brain Initiative and to the formation of its growing neuroscience community.

Introduction

The Korean Brain Initiative (KBI) focuses on basic studies to decipher the mechanisms underlying decision making, clinical studies on neurodegenerative diseases such as Alzheimer's disease (AD) and Parkinson disease (PD), and the development of novel neurotechnologies to apply to basic and clinical studies (Jeong et al., 2016). KBI is led by three research entities, including the Korea Brain Research Institute (KBRI), the Brain Science Institute (BSI) of Korea Institute of Science and Technology (KIST), and the neuro-tools development group comprised of many individual scientists from several universities (Figure 1). KBI aims to construct maps of the brain at multiple scales based on the structural and functional network in the prefrontal cortex (PFC) and basal ganglia. Nano- and meso-scaled mapping and single-cell transcriptome analysis will be adapted for multiple scales and integrated to create a more detailed and sophisticated brain connectome. This project also utilizes the mouse model and will be extended to human brains at the last stage of the project. Clinical studies of neurodegenerative disease within the initiative aim to understand the progression of neurological disorders based on

functional mapping using fMRI and deep brain stimulation. In addition to brain mapping, the development of neuro-tools for multiscale brain mapping will include innovations in brain-machine interface (BMI) and neural devices combined with artificial intelligence (AI) technologies.

Historical and Cultural Issues of Neuroscience in Korea

The history of the country and, in particular, the post-industrialized culture contribute to making brain research and neuroethics in Korea unique. Interest in brain diseases in Korea is well established and dates back to the 17th century. In the Treasured Mirror of Eastern Medicine (DongUiBoGam), Heo Joon reported the practice of traditional procedures to address mental disorders such as epilepsy, schizophrenia, and hysteria; however, these symptoms were not appropriately attributed to the brain (Rhi, 2001). The brain was not considered as an independent or supervisory organ. In fact, according to the worldview of the Yin-Yang and Five Elements School, human organs are categorized into five viscera and six entrails, which exclude the brain (Song et al., 2011). While the literatures after the Yuan Empire viewed the brain

(or more accurately, the head) as influencing mental activity in an auxiliary capacity to the heart—which was viewed to be the seat of the soul and to oversee consciousness by controlling vision and hearing—compared to other organs, independent research and clinical testing were hardly conducted on the brain. As in many other countries, neuroscience research became possible after the introduction of modern medicine wherein medical practitioners related several symptoms to certain lesions of the brain.

Brain research in Korea has been slow partly because of the legacy of Confucian culture, one that gives special respect to the body, similarly to other East Asian countries including Japan and China (Yum, 1988). Even today, surgical treatment and postmortem autopsies are not yet considered an important part of mainstream fields in traditional medicine. Recent data from a survey by Gallup Korea on the public acceptance of brain donation demonstrate that the impact of Confucian culture may be strong but possibly changing in today's society: among the total respondents (1,028), 55.4% expressed they had no religion, 19.7% were Protestants, 13.1% were Buddhists, 10.7% were Catholic, and 0.3% practiced Confucianism. Overall,



Figure 1. Strategy and Action plans of Neuroethics Associated with the Korea Brain Initiative

The Korea Brain Initiative is a Korea national brain project under Korea Brain Innovation 2030 and Korea Brain Promotion Act. Since the Korea Brain Initiative was launched in 2017, the multidisciplinary Neuroethics Research Group (NRG) has been organized, and the establishments of National Neuroethics Committee and Neuroethics Research Policy Center are being considered. The main strategies and action plans are focusing on the education of the general public, the training of scientists, and the strengthening of international cooperation.

Abbreviations: PFC, prefrontal cortex; BG, basal ganglia; IBI, International Brain Initiative; NRG, Neuroethics Research Group; GNS, Global Neuroethics Summit; BWA, Brain Awareness Week; R&E, Research and Education.

51.5% of respondents indicated that they do not intend to donate their brain. Negative answers were expressed by all groups (55.7% of those with no religion, 44% of Protestants, 51.4% of Buddhists, 45.7% of Catholics, and 33.8% of Confucianism). This suggests that religion is not a determining factor in this decision, but Confucian funeral practices possibly affect people's views about brain donation. According to the Confucian tradition, the funeral takes place on the third day after death. However, this delay is not compatible with brain donation for the purpose of research, as this requires an autopsy within hours of death to preserve tissue integrity. While Korean citizens' views on the brain, the spirit, and donation practices are changing, Confucianism is still the guiding code for ethics, which causes feelings of guilt and fear about brain donation in the population. We therefore need to promote brain donation by providing information through public engagement. Future studies into public perceptions of neuroscience should include cultural conceptions of neuroethical questions and how the neuroethical issues have been ad-

ressed and explored alongside these formative stages of cultivating neuroscience in Korea. In addition, establishing public awareness campaigns might improve public engagement by encouraging brain donation and honoring brain donors. According to the Organ Transplant Act, it is stipulated that the donor's love for neighbors and their sacrifice for organ transplants should always be respected. Recently, the revision bill on the Brain Research Promotion Act establishes a provision that the state may provide appropriate respect and support for those who agree to the provision of brain research resources and their bereaved families, considering their commitment to the development of national brain research. It is necessary to include this kind of provision in the public campaign in the future.

Major Neuroethical Issues in KBI

In this section, we explore the three major fields of research of the KBI and highlight particular Neuroethics Questions (NeQNs) to Guide Ethical Research in the International Brain Initiatives (Rom-melfanger et al., 2018).

1. Public Reluctance to Brain Donation: A Hurdle for Multiscale Brain Mapping Using Postmortem Human Brain

For our first aim of the KBI, we will analyze the multiscale mapping and epitranscriptomics at the single-cell level in mouse and human brain. Brain function is affected and changed by environment, and the transcripts in neurons are altered as a consequence. In this way, epitranscriptomes can be considered reflections of one's life. This raises issues related to NeQN 2b: Should special regard be given to brain tissue and its donors due to the origin of the tissue and its past? For the mapping study at the single-cell level utilizing the postmortem brain, brain donation still has a negative public perception and is thus subject to cultural issues, especially in East Asian regions, including Korea, Japan, and China, as stated above. To tackle the cultural issues of neuroethics, we are exploring the creation of a trilateral consortium, especially concentrated on sharing resources, such as postmortem brains, through the brain bank network and discussing strategies for public engagement to better understand the concerns of the publics. For example, the EU Brain Bank Network enforces the sharing of the human brain resources and provides guidelines to handle them appropriately. The Asian Brain Bank Network will conduct a workshop and a conference annually to collaborate at the early stage, which is expected to expand.

2. Functional Brain Mapping Using fMRI

A key goal of the KBI is to develop a sophisticated multiscale connectome that can be used to understand the neural mechanisms of decision making and brain disease pathology and to predict future brain health. Neuroimaging techniques have been developing tremendously, and functional magnetic resonance imaging (fMRI) is one of the most frequently used imaging modalities in the clinic. Both structural and functional MRI techniques have become increasingly powerful, enabling examination of the brain functions and connections with high spatiotemporal resolution. With this project, many of the NeQNs are relevant for further exploration. For example, NeQ1—What is the potential impact of a

model or neuroscientific account of disease on individuals, communities, and society?—is particularly important for KBI as new insights will be learned and shared with the public about the link between brain and mental functions, particularly mental health. New findings on mental health could be a highly sensitive matter to some community members as Korean people tend not to openly talk about their mental health issues. However, neuroscientific explanations of mental disorders may benefit many Korean people by helping patients not to blame themselves and their families and relieving some pressure of them. Considering the high suicide rate (1st in Organization for Economic Cooperation and Development [OECD] member countries for the last 13 years) in Korea, the issue related to stigmatization and discrimination should be carefully addressed. In addition, the project also aims to collect clinical data, which raises a privacy issue since Korea has very strict privacy policies. Therefore, we need to carefully explore NeQN 2a: How can human brain data and the privacy of participants from whom data is acquired be protected in case of immediate or legacy use beyond the experiment?

3. Innovative Neurotechnologies Using Brain Device

One of the major future directions for KBI is to develop interface techniques between the human brain and AI. The BMI is the direct communication channel between the brain and artificial devices by which, for example, paraplegic patients have been able to move a robot arm by thoughts. In brain AI interfaces (BAIs), AI replaces artificial devices, such as robot arms, drones, computer cursors, etc., with a “thinking” intelligent machine. As the BMI is now used for helping a patient with paralysis, in the future BAI may be used for cognitive improvement. Although it is not easy to predict when or if such a technology will ever be available, it is undeniable that neuroscientists and neuroethicists need to collaborate in the entire process of BAI development from early design to application.

These kinds of technologies can raise issues related to safety, identity, autonomy, and responsibility (Burwell et al., 2017). Since high-performance BMI currently requires implantation of electrodes in the brain, the possible complica-

tion versus benefit should be explained to the individuals involved carefully. As we develop these technologies, we will be exploring NeQN 4: How could brain interventions impact or reduce autonomy? When interfacing human with AI that may in some ways function independently and without conscious effort of the user, will such devices undermine the human user’s autonomy? And related to NEQN 4b: Who will have responsibility for effects of these human machine interface/AI relationships? For instance, when BAI causes damage, it would be highly challenging to single out the precise source of problems among related parties, including BAI developer, the human user, AI, system manufacturers, or unknown external sources. Finally, many other issues may also arise if these technologies are used beyond the clinical realm, such as for cognitive enhancement of normal people.

It becomes clear that the public is highly interested in cognitive enhancement, especially since Korean adolescents and their parents are extremely invested in their competitiveness in the academic sphere. If cognitive enhancement technologies are developed by the KBI, it is possible that they will be used in the public domain. Therefore, we will be carefully considering NeQN 5—In which contexts might a neuroscientific technology/innovation be used or deployed?—and further, as NEQN 5b states: Does this research raise different and unique equity concerns? If it becomes possible to change cognitive performance with such a device, we believe that equity concerns will become more trenchant and the fundamental qualities of being human may be challenged.

Efforts to Institutionalize Neuroethics

To guarantee the sustainability of an organization, the neuroethics study group was organized by KBRI, contributing not only to neuroethics research but also to public outreach. In addition, the neuroethics committee is under consideration to be established under the governmental structure. The Korean government has created a website (<https://www.epeople.go.kr/>) on which citizens can share their opinions and complaints about a variety of issues. As a result, the voice of citizens has been amplified, and they

have concerns about neurotechnology and demands for the conduct the research on brain science and AI to ensure safety. There have previously been attempts to build organizations concerning neuroethics in Korea. From 2009 to 2012, the Neurohumanities Research Group conducted research on the ethical, legal, and societal implications of neuroscience by the support of the Brain Research Center of the 21st Century Frontier Research Program, but the group disbanded when the project ended.

Since the KBI was launched, the KBRI initiated the Neuroethics Research Group (NRG), consisting of neuroscientists, doctors of psychiatry and psychology, philosophers, ethicists, law scholars, and social scientists gathered to address the ethical, social, and legal issues relevant to the development of neuroscience. NRG will collect and review information about neuroscience and neurotechnology related to important social implications and provide relevant consultations. In this regard, the NRG acts as an institutional governance agency that provides guidelines for ethical conduct of neuroscience research. Another crucial function of the NRG is to provide public recommendations or to build public consensus that reflects public opinion on neuroethical issues. The tasks of the NRG also include international collaboration and exchange with institutions related to the OECD and the Global Neuroethics Summit (GNS).

The Bioethics and Safety Act of Korea prescribes that in the case of research on human participants and human-derived materials, the person in charge of the research should receive a review by the institutional review board (IRBs) of the institution where the research is being conducted. IRBs may not be equipped to explore the unique ethical concerns raised by neuroscience due to the absence of neuroethics expertise as noted in the 5 NeQNs (Rommelfanger et al., 2018). In recognition of this need, the Korean government took initiative to establish a National Neuroethics Committee (NNC). The Ministry of Science and ICT (Information Communication Technology) will establish NNC based on the third 10-year brain research promoting basic plan, titled “Korea Brain Innovation 2030” (Figure 1).

The bill that established the NNC also noted the need to address regulatory

issues and, when passed, stated the need to form a Neuroethics Research Policy Center (NRPC). The NRPC will be dedicated to the promotion of public awareness, exchange of information, survey, and research, and international cooperation on issues regarding neuroscience and neuroethics. There are already successful cases in the fields of bioscience and biotechnology, such as the Biological Research Information Center (<http://www.ibric.org>) and the Korea Biosafety Clearing House (<https://www.biosafety.or.kr>), after which the NRPC will be modeled.

Implementation of Neuroethics in Education and Outreach

The priority of implementing neuroethics is to establish an education and training program due to the absence of neuroethics expertise. Neuroscience programs in some universities include neuroethics classes as a part of the curricula, and medical schools in major universities now have bioethics curricula. The neuroethics courses in neuroscience programs and medical school curricula will be able to provide future neuroscientists and physicians with the knowledge and proficiency needed for addressing complex ethical issues in neurosciences and neurotechnologies. Importantly, these courses will be developed with a cross-cultural lens to neuroethics—as outlined by Rommelfanger et al. (2018)—in collaboration with the Neuroethics Working Group and other brain initiative partners of the International Brain Initiative. The neuroethics research program will be officially available from 2019 through the R&D program of National Research Foundation (NRF), which is the national funding agency managed by the Ministry of Science and ICT of Korea. NSG will conduct the research. In addition, the trilateral neuroethics program of Emory-Yonsei-KBRI will be started from 2019,

enabling faculty exchange and student training.

The introduction of neuroethics into the public can be another consideration. Flyers have been provided as outreach during Brain Awareness Week to educate the public, including high school students, about brain science and related neuroethical issues. The NRG is planning to publish educational flyers, booklets, and movies for this program (Figure 1).

Summary and Conclusion

Since the KBI was launched in 2017, the Korean government and scholars from the national institutions and universities have been trying to embed neuroethics modules into the national brain project and the Brain Research Promotion Basic Plan (Figure 1). Scholars of humanities and neuroscientists have formed the multidisciplinary NRG to study the brain science and neuroethical perspectives. They reviewed and discussed several agenda associated with neuroethical issues and governance, which reflected the national policy, such as the establishment of NNC and NRPC and the strengthening of international cooperation, such as the GNS.

Here, we outline three strategies to expand neuroethical considerations under the national brain project.

First, we will educate the general public to increase understanding of brain science and neuroethics through Brain Awareness Week and the Research and Education (R&E) program for high school students. NRG is planning to publish educational flyers, booklets, and movies for this program.

Second, we will train neuroscientists to conduct safe and responsible research. The workshop has been held annually since 2017, and discussions are in progress to design the neuroethics training program and to prepare the guidelines for researchers. Lastly, it is also important

to communicate effectively to government officials to suggest neuroethical issues that can be formulated into policy.

At the initial stage of the neuroethics field in Korea, collaborative efforts have been made to establish governance and institutionalize the official organization associated with KBI. These efforts should contribute to the development of neuroscience and neuroethics through global collaboration.

ACKNOWLEDGMENTS

We thank Hyunjung Kim, Heon Seok, and Hae Ryoung Jung to assist Global Neuroethics Summit. Korea Brain Initiative is the Korea Brain Research Program supported by the Ministry of Science and ICT (Information and Communications Technology), Korea (2017M3C7A1048086, 2017M3C7A1048089, 2017M3C7A1048092, 2017M3C7A1043838, 19-BR-04-03, and 2016M3C7A1904986). Neuroethics Research Group is the neuroethics program supported by Brain Research Policy Center of KBRI.

REFERENCES

- Burwell, S., Sample, M., and Racine, E. (2017). Ethical aspects of brain computer interfaces: a scoping review. *BMC Med. Ethics* 18, 60.
- Jeong, S.J., Lee, H., Hur, E.M., Choe, Y., Koo, J.W., Rah, J.C., Lee, K.J., Lim, H.H., Sun, W., Moon, C., and Kim, K. (2016). Korea Brain Initiative: integration and control of brain functions. *Neuron* 92, 607–611.
- Rhi, B.Y. (2001). The concepts of mental illness in traditional medicine – with the special reference to Cheon-Kwang, Sasu, and Changzo-Chung. *J. Kor. Neuropsychiatr. Assoc.* 40, 1001–1017.
- Rommelfanger, K.S., Jeong, S.J., Ema, A., Fukushima, T., Kasai, K., Ramos, K.M., Salles, A., and Singh, I.; Global Neuroethics Summit Delegates (2018). Neuroethics questions to guide ethical research in the International Brain Initiatives. *Neuron* 100, 19–36.
- Song, J.C., Moon, Y.O., Keum, K.S., and Eom, D.M. (2011). A review on quotations of formulae of chapters related to five viscera and six bowls in “DongEuiBoGam”. *J. Kor. Med. Class.* 24, 1–8.
- Yum, J.O. (1988). The impact of Confucianism on interpersonal relationships and communication patterns in East Asia. *Commun. Monogr.* 55, 374–388.