East Asian Science, Technology and Society: an International Journal (2010) 4:137–144
DOI 10.1007/s12280-010-9121-6

Towards the Governance of Neuroscience: Neuroethics in Japan with Special Reference to Brain–Machine Interface (BMI)

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Received: 7 December 2009 / Accepted: 7 December 2009 / Published online: 10 June 2010

Abstract Neuroscience in Japan has been rapidly growing during this decade. Interdisciplinarity and application oriented approach are two major tendencies of that. These are clearly observed in the recent launched big projects of neuroscience organized by departments and/or agencies of the Japanese government such as MEXT, NEDO and JST. We report the details of the project of Brain-machine Interface (BMI) as the typical example, which include research teams of ELSI and public relation besides the R&D bodies. Out trial of Benchside Research Ethics Consultation shows it is an effective and constructive way to realize mid-stream modulation of emerging technology. We also discuss how to bridge the gap between the expert and public perception for BMI.

Keywords Neuroscience · Brain-machine interface (BMI) · Interdisciplinarity · Research ethics consultation · Public communication

1 Present State of Neuroscience in Japan

This article will focus on the following three aspects in recent features of neuroscience: neuroscientists, interdisciplinary research with the humanities and social sciences, and public relations.

First, one of the most important developments in Japan was the establishment in 2008 of the Strategic Research Program of Brain Sciences (SRPBS) or "Brain-Project," organized and sponsored by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) in Japan.[1] This program is part of the ambitious plans for the promotion of neuroscience over the next decade which will include research and development of the brain–machine interface (BMI), model strains of experimental animals, and the social activity of brains. Some 30 institutions and 200 researchers are

[1] http://brainprogram.mext.go.jp/ (in Japanese, confirmed on 13 October, 2009)

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involved within the program which had a total budget in 2008 of 1.7 billion yen and 2.7 billion yen in 2009. This means that 4% or 5% of Japanese neuroscientists are engaged in the Brain-Project if we go by the membership of the Japan Neuroscience Society as an indicator of the total number of neuroscientists (about 5,000). The program includes two research groups devoted to neuroethics and public communication.

Core Research of Evolutional Science and Technology and Precursory Research for Embryonic Science and Technology, both of which are funded by the Japan Science and Technology Agency (JST), also deal with some aspects of neuroscience,[2] with interdisciplinary areas such as neuroeconomics, neuroethics, and neuroesthetics. New Energy and Industrial Technology Development Organization (NEDO) also has shown strong interest in the industrial application of neuroscience including neuro-economics and neuromarketing. NEDO established a committee to assess the feasibility of such research in 2008. The committee's report helped attract support for neuroscience from the Ministry of Economy, Trade, and Industry (MITI), Japan (Industrial Technology Development Organization 2009).

Summarizing such recent movements in academia and science policy in neuroscience, we can say that the interdisciplinary approach and an application-oriented approach are two major tendencies.

This leads us to the second topic of interest regarding the current state of neuroscience in Japan, namely the strong "neuroscience conscious" movement in the humanities and social sciences in Japan. The philosophy of mind has a rather long tradition in Japan since the 1980s, and more recently neuroethics has come to be an active field (Fukushi et al. 2007; Sakura and Fukushi 2007; Fukushi and Sakura 2008; Nobuhara and Hara 2008). The Neuroethics Research Group was formed in conjunction with a large-scale research project on child development in Japan which was funded by JST from 2004 to 2008 (Fukushi et al. 2007; Sakura and Fukushi 2007). This was the first research effort involving neuroethics in Japan, and since then, several centers have been launched at, major universities including Tokyo, Kyoto, Kumamoto, and Tamagawa.

As previously mentioned, the Brain-Project also supports neuroethics research units. One of the characteristics of neuroethics in Japan is its strong emphasis on communication and engagement with the public and mass media. One of the reasons for this is the strong public interest in neuroscience in Japan. This can be seen in the popularity of the "Brain Training" video game.

This is the third point that we would like to discuss. "Pop" neuroscience is quite a big issue in Japan, as well as in many other countries. The Brain Training series is a type of video game software designed for use in "Nintendo DS" apparatus (small-sized mobile-type game machine). The Brain Training game was created by Nintendo under the supervision of Ryuta Kawashima, MD, a professor of neuromedicine at Tohoku University. He developed a Learning Therapy Theory in which he argues that reading aloud and mathematical calculations can, to some extent, improve senile dementia. Some have argued that his theory lacks scientific

[2] See "http://www.jst.go.jp/kisoken/crest/en/research_areas.html#life_sciences" and "http://www.jst.go.jp/kisoken/presto/index_e.html" for the list of research projects of CREST and PREST (confirmed on 13 October, 2009)

evidence, but despite such doubts, Nintendo sold more than five million copies of the software in 2008.

That is just the tip of the iceberg. Neuroscience is now a kind of bandwagon in Japan. Many people seek out some neuroscientific basis for business, education, and the nursing of children. In order to satisfy such needs, an enormous amount of "scientific" information is made available in the mass media and on the internet and, in some cases, with the backing of neuroscientists as was the case with Brain Training. As a result, some neuroscientists have become media stars who regularly dispense neuroscientific information and advice on education, on how to maintain a healthy mind, how to succeed in business, personal relationships, and so on. Some authors criticize such "pop" neuroscientific information as pseudoscience (e.g., Kouno 2008), while others defend the popularization of neuroscience.

We have concluded from all this that it is necessary to establish effective frameworks for public participation and engagement in neuroscience. Neuroscience now has a stronger influence on the public sphere, but we have yet to establish a valid way to ensure the reliability of scientific information in this sphere. Peer review and expert scrutiny of this activity are often not effective, perhaps because expert scientists are preoccupied with their own activity within the scientific community. Serious scientists may not have enough resources (time, money, and knowledge) for public communication and that may allow "pop" or "pseudo" neuroscience to prevail in the public consciousness.

If this hypothesis is correct, we may need another strategy for neuroethics and the public communication of science. Many of the previous studies and frameworks focus on either relations between scientists and the public or public attitudes towards science and scientists. However, we may need a wider framework which includes the scientific community itself because one of the key issues is how experts can respond to the spread of pseudoneuroscience.

2 Brain–Machine Interface: A Test Case for Building a Strategy

To devise a new strategy for neuroethics and public communication, we need to examine actual ongoing cases. In the latter part of this article, we focus on the BMI as a typical example of neurotechnology and discuss the relationship between neuroscientists, the public, and neuroethics. Based on our preliminary investigations, we discuss characteristics of BMI researchers, neuroethical debates, and public relations.

2.1 Brain–Machine Interface

The BMI (or brain–computer interfaces) is a technology which bridges the human brain and external devices, making a pathway for direct and bidirectional communication (Center for Research and Development Strategy (CRDS), JST 2006, p.i.). In the 1950s, it was possible to implant single or multiple electrodes into the cortex of humans and animals for recording or stimulation (Friehs et al. 2004). In the decades that followed, key studies were conducted to establish the communication pathways between the brain and external devices, postulating algorithms that correlated the firing patterns of motor cortex neurons with specific muscular responses (Donoghue 2002; Berger et al. 2008). Research into BMIs has grown dramatically since the first experimental demonstration in 1999 that ensembles of cortical neurons could directly control a robot arm in real time (Chapin et al. 1999). Nowadays, BMI technology is advancing in invasive (implanting the electrodes into the brain) and noninvasive (using externally measured activity of human brain) ways in many countries in the West (Lebedev and Nicolelis 2006). However, most of the invasive BMIs have only been tested in experimental animals; clinical trials have started with some devices. For example, the first human trial of "BrainGate" which was developed by Cyberkinetics Neurotechnology Systems was reported in Nature, in July 2006. This BMI system was implanted in severely paralyzed patients and allowed them to control a robotic arm as well as a computer cursor (Hochberg et al. 2006). In this way, BMI technology has made rapid progress in recent years and is expected to make revolutionary changes in the area of modern prosthesis.

2.2 Neuroethical Arguments About BMI

As well as other neurotechnologies, there are several interdisciplinary arguments about BMI which are related to neuroethics, roboethics, philosophy, engineering ethics, IT ethics, and clinical ethics. A much-discussed ethical issue relating to BMI is "manipulation." In the 1960s, Jose M. Delgado, a professor of physiology at Yale University, publicized a series of studies using electronic devices that were able to manipulate behavior with radio-equipped electrode arrays by receiving and transmitting signals to neurons (Delgado 1964). He implanted an electrode in cats, monkeys, bulls, and even humans and showed that he could control the subjects' behavior with the push of a button. His research caused a great sensation and became controversial both in public and within the community of neuroscientists after the New York Times Magazine introduced his research in a cover story in 1970 (Foster 2005; Hogan 2005). After Delgado moved to Spain in 1974, not only his reputation but also the controversy over manipulation faded from view. Though current researches using implanted devices into the brain are more elaborate (for example, Talwar et al. 2002), concern in regard to manipulating humans against their will still continues. In particular, the potential usage of this technology by the military is considered to be a serious problem.

Other issues such as the "enhancement" of human ability are also controversial. Even though the potential dangers associated with machine-based enhancement are still unclear, there are hopes of expanding future applications such as storage devices for external memory or technology for direct communication between brains. Though many problems are by other areas of neuroscience and technology such as fMRI or neuroregenerative medicine (Grunwell et al. 2009), McGee and Maguire (2001) indicated in their early arguments about the ethical and political implications of implanted brain chips that these devices have the capacity to cause substantial changes in human nature and lead to invasions of privacy and the control or monitoring of citizens by commercial interests or governments (McGee and Maguire 2001).

2.3 BMI Studies and Policy in Japan

BMI has attracted the attention of researchers and policymakers in Japan, as well as elsewhere, over the last decade. In the middle of the 2000s, the Ministry of Education (MEXT) identified BMI as an important subarea of neuroscience, which could inspire collaboration in science, technology, medicine, and industry in Japan. In 2008, MEXT decided to promote the research and development of BMI through the creation of a national project for neuroscience that would last until 2013. Two research groups specializing in neuroethics and ELSI were established within the BMI project. The establishment of ELSI sections within national science projects is quite rare in Japan (cf. Genome Project in USA and Japan). Our team (PI: O. Sakura, professor of the University of Tokyo) took charge of neuroethics.

Before launching this national project, a workshop was held by the CRDS for planning national strategy in this intensive R&D area.[3] At the workshop, neuroscientists and scholars in the social sciences and humanities as well as media representative were gathered and had a comprehensive discussion. They concluded that, in the near future, it is expected that BMI will be made available for limited medical use in areas such as the control of neuroprosthetic devices based on yes/no judgments or in the provision of artificial eyesight. And they also concluded that BMI would generate more social and economic benefits in the long term (CRDS 2007, p. 7).

Several researchers of BMI pointed out the ethical and social concerns around BMI technology and its social applications in their presentation at the workshop. The report of the workshop concluded that the construction of a "social consensus" is essential and should be at the forefront of concerns when BMI is introduced into society.

2.4 Public Perceptions and Expert Perceptions

To construct a social consensus, we need to know current public perceptions of neuroscience and neurotechnology. In 2008, a large-scale survey was conducted to investigate public attitudes to neuroscience research (Fukushi et al. 2008). Questionnaires distributed nationwide in Japan, and 1,041 men and women aged 20—69 responded (response rate=41.7%). While the respondents showed strong agreement regarding the importance of research progress in medical areas such as "new methods for treatment (>95%)," there was relatively low agreement regarding research on neuroengineering in areas such as "mind reading" or "the manipulation of the brain" (20–40%). Support for neuroprosthetics research including BMI technology was much higher (about 80%) than other neuroengineering technologies. That is, respondents had a positive attitude towards BMI technology for medical purposes.

We are currently conducting a more detailed survey of the general public and experts in order to understand how they see BMI. According to preliminary

[3] "Strategic workshop for prospect the future of science and technology. – a report of Brain Machine Interface domain" (in Japanese), Center for Research and Development Strategy Japan Science and Technology Agency, March, 2007.

hearings, we found similar tendencies regarding public perceptions of BMI. Most interviewees agreed regarding the development of BMI for medical applications such as rehabilitation. But they saw the development of BMI for the enhancement of human ability as needing to be restricted. Though some expressed concern regarding "ethical aspects of animal trials for BMI" or "regional/financial disparities in the utilization of BMI," the interviewees did not express strong disagreement.

While most experts also recognized and understood public concern, they felt that they made the results of their research public not only through academic publication but also via press releases and reporting on the web site of their institutions. They also considered most public concerns as being able to be resolved by spreading more accurate scientific information. For example, the enhancement of human ability by BMI is impossible at current levels of technology and public concerns can be allayed. On this point, there has been a mismatch of information. Though both experts and the public shared a perception of the important role of scientists in providing scientific information, the public are generally unfamiliar with academic publications provided by scientists.

Furthermore, there is a difference in perception regarding experts. The public expected that experts can cover all areas of neuroscience whereas experts tend to consider their areas of responsibility as being more limited. Experts cannot answer all questions about the brain or neurotechnology whereas the public tend to think that experts can.

At the nascent stage of new technology such as BMI, even experts lack sufficient data to respond to all areas of public concern (Brown 2009). Given this, we should consider how experts show behavior from the viewpoint of social responsibility and how and who can negotiate these gaps towards achieving a consensus or effective communication. Support for experts might also be necessary, in addition to that for the public. At least, there is no doubt about the need for a new approach to negotiate these gaps in perceptions between the public and neuroscientists.

2.5 Research Ethics Consultation for Researchers

As another approach to working with experts, we conduct research ethics consultations or "Benchside Ethics Consultations," for researchers who engage in research into BMI in Japan. These consultations are part of a system in which researchers can hold an individual or team-based consultation about emerging ethical concerns related to their research. It aims to maximize benefits and minimize the potential harm of research to society. The system facilitates the involvement of nonexpert actors in the development of research. This kind of consultation has already been implemented in the life sciences.

We modified the Stanford model of Benchside Ethics Consultation, developed by the Stanford Center for Biomedical Ethics (Cho et al. 2008). A protocol for consultation is activated by a request for consultation by either the team or a team member. The contacted team member gathers basic case information. The team discusses whether a team meeting and additional expertise are necessary. Then, core team members have a team consultation, with additional expertise if necessary.

During a year of preliminary trials, we consulted nine cases.[4] In these consultations, it was revealed that researchers encountered ethical problems at various stages of their research, from research planning to postpublication. Researchers who conduct BMI studies which do not involve human subjects also have ethical problems in their research. Researchers felt that some problems are difficult to deal with if they are left alone to decide, and some are not clear whether their work is ethical or not. Researchers wanted to know public opinions and viewpoints about ethical aspects of their research.

There are certain kinds of ethical issues which Institutional Review Boards (IRBs) and informed consent (IC) do not cover. We need to consider ethical approaches for scholars whose research does not include human subjects. To cope with those problems, the Benchside Ethics Consultation, which works around the problems in research steps, deals with problems that other ethical organizations (such as IRB and IC) cannot cover.

3 Conclusion: Towards the Effective Governance of Neuroscience

From the point of view of the public, not only BMI technology but also neuroscience itself is an emerging field. It is necessary to bridge the gap between neuroscience and the public more effectively even in the upstream stage of research and development. Our preliminary research on BMI reveals several points that need to be taken into account.

During the emerging stage of neurotechnology, information gaps might pose problems in terms of achieving a social consensus. Though the "deficit model" of scientific communication has been criticized in the area of Science, Technology, and Society (STS) studies, both experts and the public themselves tend to think that, with enough accurate scientific information, most public concerns can be allayed (Brown 2009). The mass media tends to complicate matters. A new approach for scientific communication is urgently needed to deal with the early stages of the development of a scientific field.

Our research on BMI also reveals that perceptions of what constitutes the major concerns on BMI are different for neuroethicists and the public. Debates in neuroethics should be more sensitive to public concerns and should be publicized widely.

According to our research on BMI researchers, neuroscientists can have ethical and social concerns during their research. Existing protocols such as IRBs and IC do not capture such issues. To address the researchers' concerns, some other measures should be introduced in combination with existing methods. As regards the governance of science, new connections or collaboration, such as public participation in the Benchside Ethics Consultation, might be the key to developing an effective procedure. Since there are few programs which are available to researchers, this field should be tackled more by scholars of neuroethics and STS.

In conclusion, we can say that neuroscience has started to reflect ethical debates in neuroethics. We need to promote improved governance of science, enhance public engagement, and include more experts if we are to utilize emerging technology of BMI and many other knowledge from neuroscience. BMI provides a good model to

[4] Note added at the gallery proof: The number increased to eleven (May 20, 2010).

explore a new approach for the governance of neuroscience and/or of other emerging technologies.

Acknowledgements A part of this study is the result of "Brain Machine Interface Development" carried out under the Strategic Research Program for Brain Sciences by the Ministry of Education, Culture, Sports, Science and Technology of Japan. This work is also supported by Grant-in-Aid for Scientific Research(B) #21300321. We thank to Taichi Isobe, Junichi Ushiba, Masayuki Hirata for helpful comments and discussion.

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