Ethics Education Needed for “Responsible Research and Innovation” of BMI/Neurotechnology

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***Abstract*— Brain-Machine Interface (BMI), as a fundamental technology of neurotechnology, has increased its contact with computer science, precision mechanical engineering and information and communication engineering. Reflecting this trend, neuroscience courses used to exist mostly in "wet science" departments such as medical and science ones, are now being established in "dry science" departments such as engineering and information science ones. In addition, the market for neurotechnology is expanding in this couple of years due to the fusion of big data and AI technologies, as well as the lightweight and sophisticated devices for measuring brain activity. Indeed, major companies such as Google and Apple are continuing to invest in neurotechnology.**

Thus, the social implementation of neurotechnology has become a reality, and the development of an international code of ethics as well as international standard to conduct "responsible research and innovation (RRI)" that contributes to the ethical development, use, and diffusion of neurotechnology is now actively discussed from the perspective of neuroethics [1].

Stakeholders of neurotechnology are now needed to participate in such activities and progress capacity building to support appropriate development and diffusion of neurotechnology containing BMI. It is particularly required to develop human resources who understand the elemental technologies of neuroengineering and have knowledge of neuroethics and RRI. However, it is not clear what kind of engagement and educational opportunities should be provided in undergraduate and graduate school education [2].

In this presentation, the author investigated the current situation of undergraduate and graduate education on neuroethics in Japan and the United States. For the survey in Japan, the author examined the public syllabi of all universities and graduate schools that fall under the 86 national and 94 public universities and 20 private universities and graduate schools. For the selection of private universities and graduate schools, based on the idea that it is desirable to select the ones that have at least one faculty member who is engaged in research and education related to neuroscience, the author selected the top 17 universities in terms of the number of academic research papers published in the field of neuroscience based on information in the academic literature database Scopus (Elsevier). In addition, two universities that have a graduate school of neuroscience (Tamagawa University and Doshisha University) were selected. The author also added one university (Ritsumeikan University) because the above 17 universities based on the academic literature information were biased toward medical schools. Thus, a total of 20 schools were included in the current survey. In case of the United States, the course catalogs of 35 public universities and 28 private universities that are members of the Association of American Universities were examined.

The results revealed that undergraduate and graduate schools specializing in engineering in both Japan and the United States have not yet established educational courses related to neuroethics and RRI. In the United States, around 30% of universities offer education courses specialized in neuroethics, but most of them were offered by the philosophy department. In Japan, on the other hand, there were no universities or graduate schools offering specialized courses in neuroethics either RRI. Neuroethics was only covered in applied ethics courses in the general education curriculum.

The author also conducted a web-based survey of Japanese students, graduate students, and faculty regarding desirable educational topics and learning formats. The survey was approved by the "Ethics Committee for Research Involving Human Subjects" of the Tokyo University of Communications (TU Rinken No.202207). When the survey asked how educational opportunities in neuroethics should be provided, most respondents preferred "a course specialized in neuroethics" or "a part of a bioethics course". Regarding a question of the format of course offerings, respondents tended to desire self-directed learning through online materials, in addition to face-to-face lectures and exercises (in the poster presentation, the author will introduce the latest results based on responses received by September 2023).

A series of studies suggest that the introduction of neuroethics and RRI into engineering education requires appropriate awareness-raising and educational opportunities based on more advanced technological development trends and the formulation of international rulemaking, which might be different from the conventional structure of educational courses in philosophy and general education.

Keywords*— *Neurotechnology, Neuroethics, Responsible Research and Innovation, Education

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Japan using Scopus (Elsevier). A part of this study was also presented in the conference proceeding of 23rd biennial international conference of the Society for Philosophy and Technology (SPT2023) [3]

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