Chapter 15

Neuroethics and Implanted Brain Machine Interfaces

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ABSTRACT

Transformations of humans through advances in bioelectronics, nanotechnologies, and computer science are leading to hybrids of humans and machines. Future brain-machine interfaces will enable humans not only to be constantly linked to the Internet, and to cyber think, but will also enable technology to take information directly from the brain. Brain-computer interfaces, where a chip is implanted in the brain, will facilitate a tremendous augmentation of human capacities, including the radical enhancement of the human ability to remember and to reason, and to achieve immortality through cloning and brain downloading, or existence in virtual reality. The ethical and legal issues raised by these possibilities represent global challenges. The most pressing concerns are those raised by privacy and autonomy. The potential exists for control of persons, through global tracking, by actually "seeing" and "hearing" what the individual is experiencing, and by controlling and directing an individual's thoughts, emotions, moods, and motivations. Public dialogue must be initiated. New principles, agencies, and regulations need to be formulated and scientific organizations, states, countries, and the United Nations must all be involved.

INTRODUCTION

Hybrids of humans and machines, facilitated by advances in bioelectronics, computer science and nanotechnologies promise to transform the nature of humankind. In the future, brain- machine interfaces will permit the emergence of humans who are essentially connected to bioelectronic devices. Brain machine interfaces (BMI), those technological interventions that establish direct communication pathways between the brain and an external device, are also referred to as brain

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computer interfaces (BCI), or neuromotor prostheses (NMP). The interface interprets signals from an array of neurons and uses computer chips and programs to translate the signals into a desired action. Thus, increasingly, in the future man will have an intimate relationship with machines and become cybernetic organisms, science fiction's "cyborgs", humans who are intrinsically coupled to bioelectronic devices.

The purpose of this paper is to examine the history of the development of brain-machine interfaces in order to demonstrate the feasibility of these brain implants, to present some examples of the state of the art in this field, and lastly to elucidate the ethical and social challenges arising from this technology. The ethical issues delineated here fall within the growing field of neuroethics, "a term used to describe the study of the ethical, legal, and social implications of new technologies from neuroscience Inasmuch as neuroethics is a subfield of bioethics, it has adopted the principles and rules commonly utilized in the field of bioethics and applied them to the issues arising in the neuroethical domain. Thus, as in bioethics, the primary working principles employed are nonmaleficence, beneficence, justice and autonomy (Beauchamp and Childress, 1979). Nonmaleficence is concerned with the responsibility not to intentionally harm another, beneficence is the requirement that if one can do good one has an obligation to do so, justice refers to the fair allocation of scarce resources and autonomy emphasizes the duty to respect the self-direction of persons. Thus, anxieties arising from safety and efficacy, which fall under both maleficence and beneficence, will be addressed, as well as those of fairness and justice. In particular, the ramifications of brain-computer interfaces for privacy and autonomy, for ubersurveillance, will be explored. Finally, the chapter will conclude with suggestions for means to address the concerns raised, including principles, standards, a regulatory framework and a forum for discussion.

BRAIN COMPUTER INTERFACES

Two kinds of interfaces can be identified – those that input to the neural base and those that output or record electrical brain signals. Interfaces that input to the neural base include clinical devices that aim to restore function to body systems.

This type of interface is comprised of three varieties that are presently undergoing research: non-invasive, partially invasive and invasive. Non-invasive neural interfaces record brain activity from an external device mounted on the scalp. Recording of electrocorticographic activity from the cortical surface has been used to create games that read alpha and beta waves, and to allow patients, after extensive training, to detect, modify and use a computer to direct a cursor on a screen or to control lights, TV and stereo sound (Donoghue, 2006). EEG recording is the most widely studied non-invasive Brain Computer Interface; in addition, magnetoencephalography and functional magnetic resonance imaging are employed. These non-invasive methods suffer from poor signaling resolution due to interference from the skull, and the intensive and demanding training needed to operate the technology. Nevertheless, several commercial models are available to control gaming systems, educational applications and investigative medical applications (www.emotiv.com, www.neurosky.com). The company InteraXon has created a suite of brain training games, and has introduced a device called MUSE which measures brainwaves, and "allows you to control games, reduce stress, improve memory and concentration, and eventually to control devices directly with your mind." (Interexon) The first commercial effort of a computer interface designed for patients with locked-in syndrome, the *Intendix* lets users input text using only their brains; another application lets users create paintings. (Intendix)

Somewhat better results have been achieved using partially invasive brain computer interfaces. In this type, the device is implanted inside the