A NEW WAY TO REVOLUTIONIZE BRAIN FUNCTION: COMPUTER CHIPS ARE THE NEW HIPPOCAMPUS

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THE GRAND ENGINEERING CHALLENGE OF REVERSE-ENGINEERING THE BRAIN

Many challenges exist for engineers. They have the responsibility to be inventive thinkers and create new technologies to improve the quality of life for the public. One such technology is to reverse-engineer the brain. This innovation has become one of fourteen Grand Challenges, according to the National Academy of Engineering (NAE) [1]. A specific application of this grand challenge that is important right now is creating and implanting a computer chip to place in the brain in order to restore the function of a faulty hippocampus. This problem occurs in patients with Alzheimer's disease. Their hippocampus progressively malfunctions as they grow older, inhibiting their ability to form and store memories [2]. This chip will allow them to live a comfortable life, restore memory, and save our healthcare system money. This engineering innovation is the perfect solution that demands our attention.

Not only do engineers have the duty to be creative in the ways they combat obstacles in society, they must do so in an ethical way that also upholds their integrity as a professional. Engineers are known for their infallibility. They are a reliable group of people that the public can count on to make the best choices. The National Society of Professional Engineers (NSPE) Code of Ethics outlines many fundamental canons and professional obligations an engineer of any discipline must follow with their new innovations [3]. One such canon that the creation of a computer chip adheres to is that engineers shall advise their clients or employers when they believe a project will not be successful [3]. Specific to bioengineering, the Biomedical Engineering Society (BMES) also has their own code of ethics, in terms of animal and human experimentation as well as dealing with the confidentiality of patients [4]. These are only a few of many ethical codes that are crucial to uphold under the focus of the computer chip innovation. This computer chip causes a slight concern regarding the codes of ethics in terms of animal use during experimentation, but for the most part, it fully abides by their standards.

There is a huge connection between ethics and engineering, whether on the job or in a research lab. Analyzing the ethics behind engineering is not only significant to people who currently work as engineers, but is of great potential and educational value to a freshman engineering student. The process of researching a grand challenge, focusing on a specific innovation that uses that challenge, and being well-educated about the engineering ethics prepares the student for real life. It educates them about what values to have as an engineer, and not just any kind of engineer, but one dedicated to the protection of public health, safety, and welfare.

BRAIN CHIPS DO ENHANCE MEMORY, AS SHOWN IN RATS

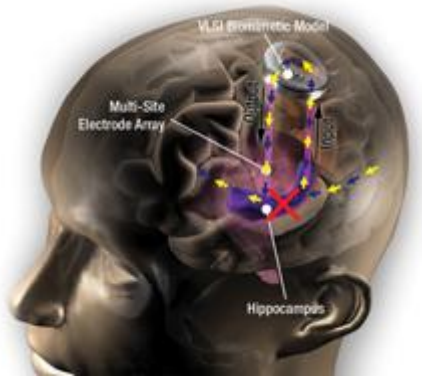
Before bioengineers and neuroscientists can implant a computer chip into the human brain, they first have to test it on a smaller and less complex scale. They need a microcosm of the human brain. Lab rats are the ideal candidates because their brain is made up of only two kinds of tissue – CA1 and CA3 [5].

The experimenting began just a few years ago with Professor Theodore W. Berger, Director of the Center for Neural Engineering at the University of Southern California [6]. His team of bioengineers and neuroscientists trained rats to remember which of two levers to press to receive water.

The two kinds of tissue present in a rat's brain communicate with each other as the brain learns and stores the information about which lever to press. This exchange of information was transmitted onto a computer chip by studying the mathematical models of the rat brain circuits [6]. Once the memory of which lever to press was stored in the rats' biological brain, they used a drug to shut down the activity of CA1 [5]. This, in turn, resulted in the rats' memory loss of which lever to press. To fix this problem, Berger's team implanted the chip in the rat's brain, which acted as CA1, taking over the normal function and restoring memory [5]. Essentially, it replaced the inactive CA1 tissue with an electronic model.

The research team also kept a control group of rats. Memories faded 40% after a long distraction period, while those who had signals using the implant had only 10% memory erosion [5], so the chip was shown to have better results in memory sustainability. This engineering achievement can even travel a longer and more extensive route into the human mind, providing endless benefits to people with impaired memory capability. The future human version of this computer chip is shown in Figure 1.

FIGURE 1 [7]
MODEL OF IMPLANTED ELECTRONIC DEVICE IN HIPPOCAMPAL REGION



The Next Step: Leaping from Rats to Humans

Unlike the brains of rats, human brains consist of millions of neurons embedded in the tissue [8]. Remembering a piece of information is a much more complex neural process than just two slivers of tissue communicating with each other [9]. Human trials are several years away for this reason. Berger's research team is possibly looking at successfully implanting a chip into a monkey's brain in about seven or eight years and then onto clinical applications in humans in about ten to fifteen years [6].

Ethics behind Animal Research and the Approval Process

In bioengineering, one of the biggest ethical issues that raise a lot of concern is that of animal and/or human experimentation during research [10]. The use of animal models in research and in the testing of implants is crucial. Implants are intended to be used within the human system and can't be insured without testing within a living system. According to BMES, one fundamental canon states, "An engineer must comply fully with legal, ethical, institutional, governmental, and other applicable research guidelines, respecting the rights of and exercising the responsibilities to human and animal subjects, colleagues, the scientific community and the general public" [4]. They are to treat subjects in a humane manner and get approval for research projects that follow ethical guidelines.

With that said, animal testing is allowed and adheres to this canon. One just has to get their project approved. The approval process varies from state-to-state and also depends on whether research is being conducted in a campus versus a lab. In Pittsburgh, the Division of Laboratory Animal Resources (DLAR) facilitates research regarding laboratory animal science [11]. DLAR coordinates efforts to provide a humane, quality animal care program in compliance with legal and regulatory requirements [11]. The pain and distress categories cannot be inappropriate and the number of animals requested has to be justified adequately or else the project will not be granted approval [11].

This idea comes into context with the computer chip. Berger's experiment involved using slices of rat brain as well as live rats. Berger went through the approval process, which is proof that he upheld that particular canon. His experiment paves way for doing similar trials in a monkey's brain and then the final installment of a successful implant in a human. As a final note, Berger's experiment illustrates the importance of making sure one's research project coincides with the ethical codes.

Importance of Learning Ethical Decision-Making amongst Freshman Engineers

The ethical aspect is behind-the-scenes of engineering. A freshman engineering student, like myself, would never have thought the approval process of Berger's experiment took that much time and effort. From my own research, I learned much more about what an engineer has to consider in the thought process while on the job and getting his project approved. Learning about ethics as a freshman engineer highlights responsible citizenship and shows the students it is a natural part of professionalism [12]. It will be helpful to me when interning or doing a co-op. In the same way a bioengineer moves an innovation from bench to bedside, engineering students will take the skills in ethical decision-making from the classroom and incorporate them into the workplace. Ethical decision-making is essential to professionalism in engineering [12].

IMPROVING THE QUALITY OF LIFE

Imagine taking several different medications several times a day, or getting prescriptions switched back and forth by the doctor. Now, imagine having Alzheimer's disease and forgetting to take your daily medications. However, as of right now, no cures for Alzheimer's disease exist. Doctors are trying different medications but haven't found one that works. Having to take a daily regimen of medications can become quite cumbersome and expensive to patients of Alzheimer's.

Having a computer chip implanted in the brain would not only save the patient money, but it would make some major improvements in the quality of life. The patient wouldn't have to depend on others for daily life fulfillment. Memory and forgetfulness would no longer be an issue for them, and so, the computer chip would improve their standard care of living, as they remember where the bathroom is or where they've placed their keys [5], instead of relying on someone else to help them remember things.

Concern for Confidentiality

From another standpoint, engineers have to uphold the confidentiality of the patient. BMES states that engineers should "regard responsibility toward rights of patients,

including those of confidentiality and privacy, as a primary concern" [4]. This is important because bioengineers are heavily involved in health care activities. The National Committee on Biomedical Engineering states that, unlike the other branches of engineering, bioengineers work with their patients and are responsible for their well-being [10]. Adding patients to the mix brings more ethical debate into the work environment. As an engineer, one cannot reveal any information about a patient just implanted with a chip. The engineer or the hospital could get sued by the patient, if they didn't adhere to this canon. If there was a ground-breaking, successful surgery attempt, they would need consent from the patient before airing it on television, releasing it to the press or publishing it in a scientific article.

SAVING OUR HEALTHCARE SYSTEM MONEY

The hope is that this chip could help a patient who suffers from hippocampal damage and, in turn, prolong loved ones from entering a nursing home. Since Alzheimer's patients have no memory and cannot live alone, their family resorts to placing them in a nursing home.

Alzheimer's disease is progressing across the elderly and sweeping the nation as the baby boom generation gets older. More and more people are living in nursing homes, escalating our nation's healthcare cost. Richard Alonso-Zaldivar from ABC News claims that the main reason that health care spending keeps growing is due to an aging society that consumes increasing levels of service [8]. Thus, this computer chip innovation would help tremendously in this area as well. Overall, fewer people would be in nursing homes at an earlier age, which would cut back spending in the healthcare department.

Making Patients Aware of Unbiased Truths

Let it be noted, that not just anyone who wants a computer chip can receive and undergo the implantation of the chip. The NSPE Code of Ethics applies here. Canon number four states that an engineer must "act for each employer or client as faithful agents or trustees"[3]. In other words, "Engineers shall advise their clients or employers when they believe a project will not be successful" [3]. This ethical code is crucial because engineers cannot just please the patient by having a doctor implant a computer chip if underlying conditions exist as dangerous to their health. For example, surgery to implant a chip could fix a person's Alzheimer's disease. However, if they have a heart condition, surgery is not ideal. It might put them at a further risk for a heart attack. If it is a simple, minor issue, then it should not be a problem. The pros always have to outweigh the cons. The public holds engineers in high regard and look to them for ethical, unbiased truths. If they don't abide by these standards, their credibility could be lost.

STUDY PROVES EARLY EXPOSURE TO ETHICS IS BENEFICIAL: TURNING FRESHMAN ENGINEERING MAJORS INTO SOCIETY'S ETHICAL ENGINEERS

How can we make sure that engineers in the future uphold these codes of ethics? Expose them to ethical-decision making and allow them to put it into context with a technological innovation. According to one study conducted by Michael C. Loui and Golnaz Hashemian, three groups of students were interviewed [13]. The first group completed a specific course on engineering ethics. The second group had registered for the course, but had yet to start it. Finally, the third group had not taken or registered for the course. The students were questioned what they would do, as an engineer, if they were in a situation that posed moral problems. This study, conducted just last year, showed that students who completed the ethics course considered more options before making a decision [13]. Even though the situation did not directly involve them, they were more inclined to feel responsible and take moral action than the other groups of students who showed less responsibility, saying that the problem was not any of their business [13]. This study demonstrates that education in ethics can increase awareness of responsibility, knowledge about how to handle a difficult situation, and confidence in taking action, which are desirable traits for the nation's future generation of engineers.

COMPUTER CHIPS ARE TOMORROW'S HOPEFUL PROMISE

While the demand for engineers is increasing, so is the demand for smart, ethical decisions. Having a freshman engineering class research their own engineering innovation and the ethics behind it is an important start to securing our future and guiding it on a moral pathway. This is especially the case for bioengineers when dealing with innovations that will be implanted into the body, such as a computer chip. This 'reverse-engineering the brain' technology will help cure neurodegenerative diseases such as Alzheimer's [6]. Patients will receive the benefit of a restored memory, a comfortable lifestyle, and have less financial worry about healthcare.

Patients also don't have to worry about whether they are in good hands or not, since the team of engineers has been trained in ethical decision-making. They have a professional reputation to uphold. Patients need not worry about confidentiality, for it is protected by the BMES's fundamental canon [4]. Engineers working with the computer chip implantation also adhere to another canon.

They will advise their clients or employers when they believe a project will not be successful [3]. If it is not in the patient's best interest, they will not receive the implant. Finally, it is up to the bioengineers to make sure they are conducting approved research with animals [4].

All of these are examples of codes of ethics that the public expects engineers to honor and uphold no matter the situation. Thus, with a mix of ethical practices in engineering and educating the youth, America's society has a bright future ahead of it.

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