SEMINAR PAPER

ON

BRAIN CHIPS

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CERTIFICATION

This is to certify that this research work titled Brian Chips has been carried out by **FATUASE OPEYEMI RUTH** with the matric number HCSF/15/0010 in computer science department, **OGUN STATE INSTITUTE OF TECHNOLOGY, IGBESA OGUN STATE.**

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DEDICATION

This project work is dedicated to Almighty God. Also to my parent Mr & Mrs FATUASE for giving me a formal education at all cost.

ACKNOWLEDGEMENT

My utmost gratitude, thanksgiving and appreciation go to the almighty God; I also give thanks to my parent Mr. & Mrs. FATUASE for their moral and financial support for this study to come to completion. I would like to thank my supervisor Mrs OJO and the HOD computer science department Mrs OLADEJO RACHEAL for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my friends and course mates who helped me as i went through my seminar work and helped to modify and eliminate some of the irrelevant and unnecessary stuffs.

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ABSTRACT

The evolution and development of mankind began thousands and thousands of years before. And today our intelligence, our brain is a resultant of this long developmental phase. Technology also has been on the path of development since when man appeared. It is man that gave technology its present form. But today, technology is entering a phase where it will outwit man in intelligence as well as efficiency. Man has now to find a way in which he can keep in pace with technology, and one of the recent developments in this regard, is the brain chip implants.

Brain chips are made with a view to enhance the memory of human beings, to help paralyzed patients, and are also intended to serve military purposes. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable "recognition" of previously unmet individuals. The progress already made in therapeutic devices, in prosthetics and in computer science indicates that it may well be feasible to develop direct interfaces between the brain and computers. This technology is only under developmental phase, although many implants have already been made on the human brain for experimental purposes. Brain chips are made with a view to enhance the memory of human beings, to help paralyzed patients, and are also intended to serve military purposes. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable "recognition" of previously unmet individuals. The progress already made in therapeutic devices, in prosthetics and in computer science indicates that it may well be feasible to develop direct interfaces between the brain and computers. This technology is only under developmental phase, although many implants have already been made on the human brain for experimental purposes.

CHAPTER ONE

1.0 INTRODUCTION

The evolution and development of mankind began thousands and thousands of years before. And today our intelligence, our brain is a resultant of this long developmental phase. Technology also has been on the path of development since when man appeared. It is man that gave technology its present form. But today, technology is entering a phase where it will outwit man in intelligence as well as efficiency. Man has now to find a way in which he can keep in pace with technology, and one of the recent developments in this regard, is the brain chip implants (Anderson, 2009).

Brain chips are made with a view to enhance the memory of human beings, to help paralyzed patients, and are also intended to serve military purposes. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable "recognition" of previously unmet individuals. The progress already made in therapeutic devices, in prosthetics and in computer science indicates that it may well be feasible to develop direct interfaces between the brain and computers. This technology is only under developmental phase, although many implants have already been made on the human brain for experimental purposes.

Brain chips are made with a view to enhance the memory of human beings, to help paralyzed patients, and are also intended to serve military purposes. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable recognition of previously unmet individuals. The progress already made in therapeutic devices, in prosthetics and in computer science indicates that it may well be feasible to develop direct interfaces between the brain and computers. This technology is only under developmental phase, although many implants have already been made on the human brain for experimental purposes. The study of the human brain is, obviously, the most complicated area of research. Brain implants, often referred to as neural implants, are technological devices that connect directly to a biological subject's brain usually placed on the surface of the brain, or attached to the brain's cortex. A common purpose of modern brain implants and the focus of much current research are establishing a biomedical prosthesis circumventing areas in the brain that have become dysfunctional after a stroke or other head injuries. This includes sensory substitution, e.g., in vision. Other brain implants are used in animal experiments simply to record brain activity for scientific reasons. Some brain implants involve creating interfaces between neural systems and computer chips. This work is part of a wider research field called brain-computer interfaces. (Brain-computer interface research also includes technology such as EEG arrays that allow interface between mind and machine but do not require direct implantation of a device.)

1.1 BENEFITS OF IMPLANTABLE CHIPS

The future may well involve the reality of science fiction's cyborg, persons who have developed some intimate and occasionally necessary relationship with a machine. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable recognition of previously unmet individuals

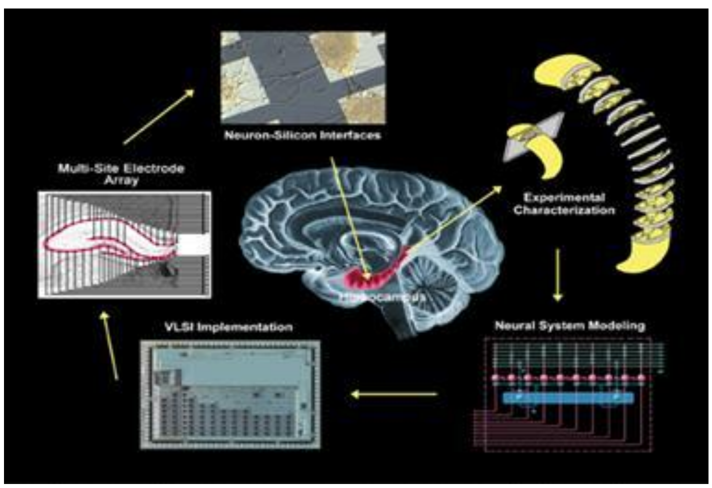

Fig 1.2 Implantable Chips

The progress already made in therapeutic devices, in prosthetics and in computer science indicates that it may well be feasible to develop direct interfaces between the brain and computers. Computer scientists predict that within the next twenty years neural interfaces will be designed that will not only increase the dynamic range of senses, but will also enhance memory and enable cyber think invisible communication with others. This technology will facilitate consistent and constant access to information when and where it is needed.

The linkage of smaller, lighter, and more powerful computer systems with radio technologies will enable users to access information and communicate anywhere or anytime. Through miniaturization of components, systems have been generated that are wearable and nearly invisible, so that individuals, supported by a personal information structure, can move about and interact freely, as well as, through networking, share experiences with others. The wearable computer project envisions users accessing the Remembrance Agent of a large communally based data source.

1.2 ADVANTAGES OF BRAIN CHIPS/ IMPLANTS

As intelligence or sensory amplifiers, the implantable chip will generate the following benefits:

1. It will enhance memory.
2. It will enable cyberthink invisible communication with others when making decisions.
3. It will enable consistent and constant access to information where and when it is needed.
4. Giving light to blind and giving paralyzed patients full mental control of limbs.
5. No genetic modifications in the next generation.
6. Rescue missions (remote controlled rat).
7. The advantage of implants is that they take the decision making power away from the addict. Chips take away one's free will. It enables a person to make a better choice not to take drugs at all.

For many these enhancements will produce major improvements in the quality of life, or their survivability, or their performance in a job. The first prototype devices for these improvements in human functioning should be available in five years, with the military prototypes starting within ten years, and information workers using prototypes within fifteen years; general adoption will take roughly twenty to thirty years. The brain chip will probably function as a prosthetic cortical implant. The user's visual cortex will receive stimulation from a computer based either on what a camera sees or based on an artificial window interface.

1.3 DISADVANTAGE/DRAWBACKS OF BRAINCHIPS TECHNOLOGY

1. Cost.
2. Safety (nontoxic materials)
3. Losing Identity.
4. Normal range people seen as subnormal.

5. Risk for surgeons.

1.4 DEFINITION OF TERMS

1. **ACTUATORS**: Something that actuates something else, especially a mechanism that causes a device to be switched on or off
2. **CYBORG:** A person who is part machine, a robot who is part organic. A robot who has organic past
3. **IMPLANTS:** to insert something surgically into the body, to fix firmly or set securely or deeply
4. **CORTEX:** The outer layer of an internal organ or body structure, such as kidney or the brain.
5. **CHIP:** A hybrid device mounted in a substrate, containing electronic circuitry and miniaturized mechanical, chemical and/or biochemical devices.

CHAPTER TWO

LITERATURE REVIEW

2.0 EVOLUTION TOWARDS IMPLANTABLE BRAIN CHIPS

Worldwide there are at least three million people living with artificial implants. In particular, research on the cochlear implant and retinal vision have furthered the development of interfaces between neural tissues and silicon substrate micro probes. There have been many researches in order to enable the technology of implanting chips in the brain to develop. Some of them are mentioned below (Chapin, 2010).

2.1 HISTORY OF BRAIN CHIPS

According to Delgado (1969), "One of the possibilities with brain transmitters is to influence people so that they conform to the political system. Autonomic and somatic functions, individual and social behavior, emotional and mental reactions may be invoked, maintained, modified, or inhibited, both in animals and in man, by stimulation of specific cerebral structures. Physical control of many brain functions is a demonstrated fact. It is even possible to follow intentions, the development of thought and visual experiences. He provoked the animal to charge. Then, with a signal emitted from a tiny hand-held radio transmitter, he made the beast turn aside in mid-lunge and trot docilely away. He has been able to play monkeys and cats like little electronic toys‖ that yawn, hide, fight, play, mate and go to sleep on command. The individual is defenseless against direct manipulation of the brain (Delgado 1969).

Such experiments were done even on human beings. Studies in human subjects with implanted electrodes have demonstrated that electrical stimulation of the depth of the brain can induce pleasurable manifestations, as evidenced by the spontaneous verbal reports of patients, their facial expression and general behavior, and their desire to repeat the experience. With such experiments, he unfolded many of the mysteries of the BRAIN, which contributed to the developments in brain implant technology (Anderson, 2009). He understood how the sensation of suffering pain could be reduced by stimulating the frontal lobes of the brain.

Delgado was born in Rondo, Spain, and interestingly enough he is not a medical doctor or even a vet, but merely a biologist with a degree from Madrid University. He became an expert in neurobehavioral research and when he published a book titled Physical Control of the Mind in

1969, he had more than 200 publishing credits to his name. His research was sponsored by Yale University, Foundations Fund for Research in Psychiatry, United States Public Health Service1, Office of Naval Research2, United States Air Force 657-1st Aero medical Research Laboratory, NeuroResearch Foundation, and the Spanish Council for Scientific Education, among others.

NEURAL NETWORKS

Neural networks are loosely modeled on the networks of neurons in biological systems. They can learn to perform complex tasks. They are especially effective at recognizing patterns, classifying data, and processing noisy signals. They possess a distributed associative memory which gives it the ability to learn and generalize, which is adapted with experience.

The study of artificial neural networks has also added to the data required to create brain chips. They crudely mimic the fundamental properties of the brain. Researchers are working in both the biological and engineering fields to further decipher the key mechanisms of how man learns and reacts to everyday experiences. The physiological evidences from the brain are followed to create these networks. Then the model is analyzed and simulated and compared with that of the brain. If any discrepancy is spotted between the model and the brain, the initial hypothesis is changed and the model is modified. This procedure is repeated until the model behaves in the same way as the brain.

When eventually a network model which resembles the brain in every aspect is created, it will be a major breakthrough in the evolution towards implantable brain chips.

2.2 THE STUDY OF THE BRAIN

The study of the human brain is, obviously, the most complicated area of research. A man known as Jose Delgado of Yale physiologist implanted electrodes in animal brains and attached them to a stimoceiver under the skull. This device transmitted radio signals through the electrodes in a technique called electronic stimulation of the brain, and culminated in a now-legendary photograph in the early 1960s, of Delgado controlling a live bull with an electronic monitor.

Fig.2.1: A picture of Jose Delgado controlling a bull with the "stimoceiver"

2.3 BRAIN CELLS AND SILICON CHIPS LINKED ELECTRONICALLY

One of the toughest problems in neural prosthetics is how to connect chips and real neurons. Today, many researchers are working on tiny electrode arrays that link the two. However, once a device is implanted the body develops so-called glial cells, defenses that surround the foreign object and prevent neurons and electrodes from making contact.

(Graham, 2003) Fromherz is at work on a six-month project to grow three or four neurons on a 180 x 180 transistor array supplied by Infineon, after having successfully grown a single neuron on the device. In a past experiment, the researcher placed a brain slice from the hippocampus of a monkey on a specially coated CMOS device in a Plexiglas container with electrolyte at 37 degrees C. In a few days dead tissue fell away and live nerve endings made contact with the chip.

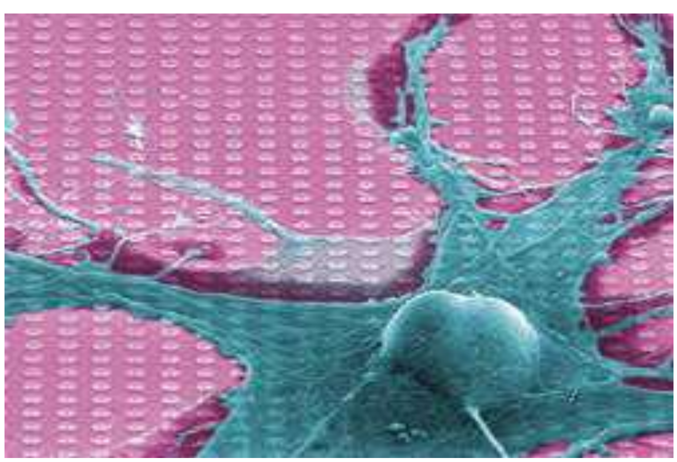

Fig. 2.2 The Max Planck Institute grew this 'snail' neuron atop an Infineon Technologies CMOS device that measures the neuron's electrical activity, linking chips and living cells.

Their plan is to build a system with 15,000 neuron-transistor sites a first step toward an eventual computational model of brain activity

CHAPTER THREE
ARCHITECTURE AND MEHTHODOLOGY

3.0 BRAIN CHIPS ARCHITECTURE

Currently, there are no cures for paralyzed people. However, research concerning the development of brain-computer interfaces (BCIs) presents a potential solution. Successful trials using BCIs (Brain computer interfaces) in subjects, such as Nagle, provide hope that brain chip technology will one day enable paralyzed people to control computers, wheelchairs, and even their own limbs.

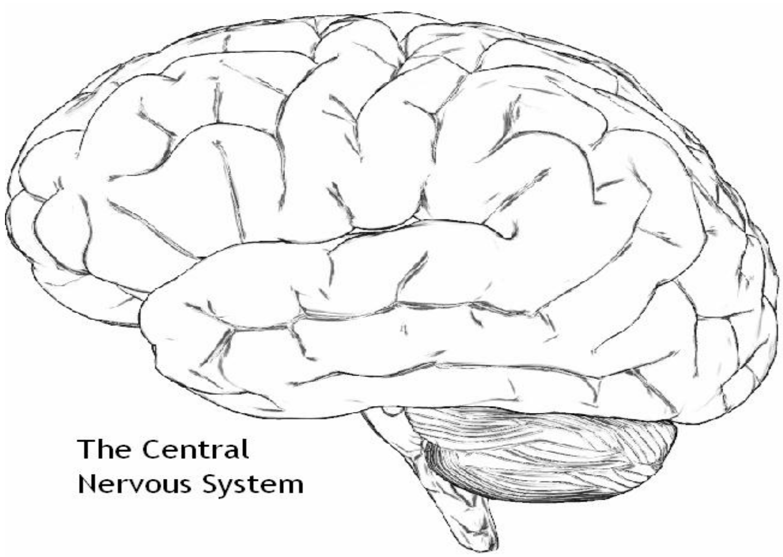

Fig 3.0 The Structure of the Brain

Research in sensory substitution has made significant progress since 1970. Especially in vision, due to the knowledge of the working of the visual system, eye implants (often involving some brain implants or monitoring) have been applied with demonstrated success. For hearing, cochlear implants are used to stimulate the auditory nerve directly. The vestibulocochlear nerve is part of the peripheral nervous system, but the interface is similar to that of true brain implants. Multiple projects have demonstrated success at recording from the brains of animals for long periods of time. As early as 1976, Edward Schmidt made action potential recordings of signals from rhesus monkey motor cortexes using immovable "hatpin" electrodes, including recording from single neurons for over 30 days, and consistent recordings for greater than three years from the best electrodes.

The hatpin electrodes were made of pure iridium and insulated with Parylene-c, materials that are currently used in the Cyberkinetics implementation of the Utah array. These same electrodes, or derivations thereof using the same biocompatible electrode materials, are currently used in visual prosthetics laboratories, laboratories studying the neural basis of learning, and motor prosthetics approaches other than the Cyberkinetics probes. Schematic of the Utah Electrode Array Other laboratory groups produce their own implants to provide unique capabilities not available from the commercial products. Breakthroughs include studies of the process of functional brain re- wiring throughout the learning of a sensory discrimination, control of physical devices by rat brains, monkeys over robotic arms, remote control of mechanical devices by monkeys and humans, remote control over the movements of roaches, electronic-based neuron transistors for leeches, the first reported use of the Utah Array in a human for bidirectional signaling. Currently a number of groups are conducting preliminary motor prosthetic implants in humans.

3.1 RETINOMORPHIC CHIPS

The famed mathematician Alan Turing predicted in 1950 that computers would match wits with humans by the end of the century (Grahams, 2003). In the following decades, researchers in the new field of artificial intelligence worked hard to fulfill his prophecy, mostly following a top-down strategy: If we can just write enough code, they reasoned, we can simulate all the functions of the brain. The results have been dismal. Rapid improvements in computer power have yielded nothing resembling a thinking machine that can write music or run a company, much less unlock the secrets of consciousness.

(Kwabena, 2002), a lead researcher at the University of Pennsylvania's Neuroengineering Research Laboratory, tried a different solution. Rather than imposing pseudo-smart software on a conventional silicon chip, he is studying the way human neurons are interconnected. Then he hopes to build electronic systems that re-create the results. In short, he is attempting to reverse-engineer the brain from the bottom up.

Boahen and his fellow neuromorphic engineers are now discovering that the brain's underlying structure is much simpler than the behaviors, insights, and feelings it incites. That is because our brains, unlike desktop computers, constantly change their own connections to revamp the way they process information. "*We now have microscopes that can see individual connections between neurons*" (Kwabena, 2002). They show that the brain can retract connections and make new ones in minutes. The brain deals with complexity by wiring itself up on the fly, based on the activity going on around it," Boahen (1990) says. This explains how three pounds of neurons, drawing hardly any more power than a night-light, can perform all the operations associated with human thought.

Fig 3.1 Laboratory Experiments

The first product from Boahen's lab is a retinomorphic chip, which he is now putting through a battery of simple vision tests. Containing nearly 6,000 photoreceptors and 4,000 synthetic nerve connections, the chip is about one-eighth the size of a human retina. Just as impressive, the chip consumes only 0.06 watt of power, making it roughly three times as efficient as the real thing. A general-purpose digital computer, in contrast, uses a million times more energy per computation as does the human brain. "Building neural prostheses requires us to match the efficiency, not just the performance, of the brain," says Boahen. A retinal chip could be mounted inside an eyeball in a year or two, he says, after engineers solve the remaining challenges of building an efficient human-chip interface and a compact power supply.

Remarkable as an artificial retina might be, it is just a baby step toward the big objective—reverse-engineering the brain's entire ornate structure down to the last dendrite. A thorough simulation would require a minutely detailed neural blueprint of the brain, from brain stem to frontal lobes.

3.2 THE LAB-RAT AND THE MONKEY

Rats steered by a computer could soon help find buried earthquake victims or dispose of bombs, scientists (Delgado, 2002). The remote-controlled roborats can be made to run, climb, jump or turn left and right through electrical probes, the width of a hair, implanted in their brains. Movement signals are transmitted from a computer to the rat's brain via a radio receiver strapped to its back. One electrode stimulates the feelgood center of the rat's brain, while two other electrodes activate the cerebral regions which process signals from its left and right whiskers. They work for pleasure, says Sanjiv Talwar, the bioengineer at the State University of New York who led the research team. The rat feels nirvana. Asked to speculate on potential military uses for robotic animals, Dr Talwar agreed they could, in theory, be put to some unpleasant uses, such as assassination.

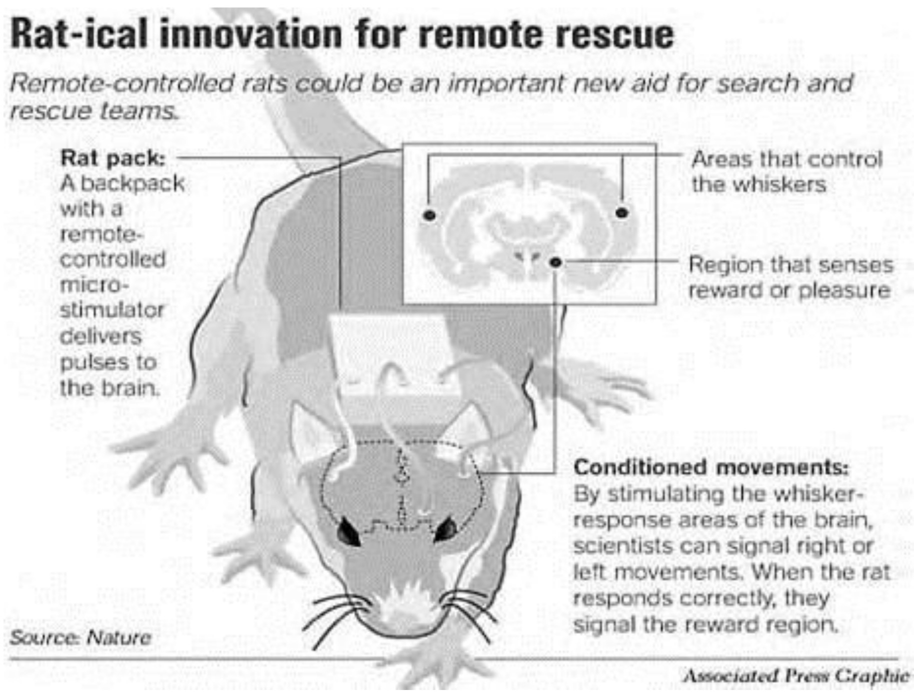

Fig 3.2 Lab and Rat Monkey

Scientists say they have developed a technology that enables a monkey to move a cursor on a computer screen simply by thinking about it. Using high-tech brain scans, the researchers determined that small clump of cells…were active in the formation of the desire to carry out specific body movements. Armed with this knowledge, [researchers at the California Institute of

Technology in Pasadena implanted sensitive electrodes in the posterior parietal cortex of a rhesus monkey trained to play a simple video game.

A computer program, hooked up to the implanted electrodes, then moved a cursor on the computer screen in accordance with the monkey's desires left or right, up or down, wherever the electrical (brain) patterns tells us the monkey is planning to reach, according to researcher Daniella (1969). Director of the neural prosthesis program at the National Institute of Neurological Disorders and Stroke, believes that the path to long-lasting implants in people would involve the recording of data from many electrodes. To get a rich signal that allows you to move a limb in three-dimensional space or move a cursor around on a screen will require the ability to record from at least 30 neurons, he said.

3.3 HOW DOES BRAIN/NUERAL IMPLANTS WORK?

Neural signals usually run from tens to hundreds of micro-volts in amplitude, with frequencies extending to about 10 kHz. There is no way of knowing in advance where to position electrode sites near neurons of interest. Probes with on-chip electronics interface with sites through selectors that let the user choose a subset of sites to monitor or stimulate. Concentrations of eight or so are common. This compensates for any probe movement in tissue over time. Selected channels are fed to amplifiers that are usually coupled. They boost signal levels by 60 dB, operate from 60 to 80 um in <0.1 mm2, and have significantly less noise than the thermal noise from the site itself. In some cases, the lower cutoff frequency is programmable to record of low-frequency waves in addition to recording neural spikes Output multiplexers are sometimes used to time-multiplex the signals from several channels onto a single output lead, reducing the number of leads from dense multi-channel arrays. Lead count is one of the biggest problems in such systems. Output buffers are also important in making signals immune to leakage and noise externally coupled onto the output leads. The use of dozens or hundreds of sites can quickly exhaust the available bandwidth in inductively coupled stimulation/recording systems. This, and the development of totally implantable microsystems, will require in-vivo interpretation of neural events and proper responses. And in-vivo neural processing chips for spike recognition are already here. Wireless microsystems may be getting under our skin but millions of disabled persons aren't complaining. The BrainGate Neural Interface creates a direct link between a person's brain and a computer, translating neural activity into action.

A person without use of his limbs but fitted with a BrainGate, can now play a videogame or change channels on TV using only his mind. This is how they did it:

1. The chip: A 4-millimeter square silicon chip studded with 100 hair- thin microelectrodes is embedded in a person's primary motor cortex which is the region of the brain responsible for controlling movement.

2. The connector: When the person thinks "move cursor up and left" (toward email icon), his cortical neurons fire in a distinctive pattern; the signal is transmitted through the pedestal plug attached to his skull.

3. The **converter**: The signal travels to a shoebox-sized amplifier mounted on the wheelchair, where it's converted to optical data and bounced by fiber-optic cable to a computer.

4. The computer: Brain Gate learns to associate patterns of brain activity with particular imagined movements--up, down, left, right and to connect those movements to a cursor. Electrical signals are responsible for communication in both the brain and computers. Current research is hoping to use this similarity to get nerve cells and silicon chips interacting directly.

3.4 APPLICATIONS OF BRAIN CHIPS TECHNOLOGY

The following are the areas of application of brain chips technology:

3.4.1 HEALTHCARE INDUSTRY APPLICATIONS

The development of electronic brain implants, called neuroprostheses, that can translate the intention to move into the actual movement of a robotic device, or of a cursor on a computer screen. The hope is to give paralyzed patients greater ability to interact with their environments and perhaps, ultimately, to bypass damaged spinal cords and restore movement to lifeless limbs. The concept of using thought to move a robotic device, a wheelchair, a prosthetic, or a computer was once strictly the stuff of science fiction, but no longer. BrainGate[TM] collects and analyzes the brainwaves of individuals with pronounced physical disabilities, turning thoughts into actions. The potential to better communicate, interact, and improve people's way of life is about to explode. Years of advanced research by world-renowned experts at prestigious universities--including Brown, Harvard, Emory, Columbia, and the University of Utah has resulted in the development of BrainGate[TM], a life-changing technology and device that gives renewed hope to paraplegics, quadriplegics and others suffering from spinal cord injuries and strokes. Eventually, it has the potential to revolutionize the way all of our brains work. BrainGate has been featured on broadcasts such as 60 Minutes and in publications including Popular Mechanics, Nature and Wired.

3.4.2 MENTAL MOUSE

1. Hollow glass cone, size of ball point pen tip. Before implanting, cones are coated with chemicals taken from tissue inside the patients' own knees for nerve growth.
2. Implants contain electrode, picks up impulses from the nerve endings.
3. Implants placed in brain's motor cortex (body movement).

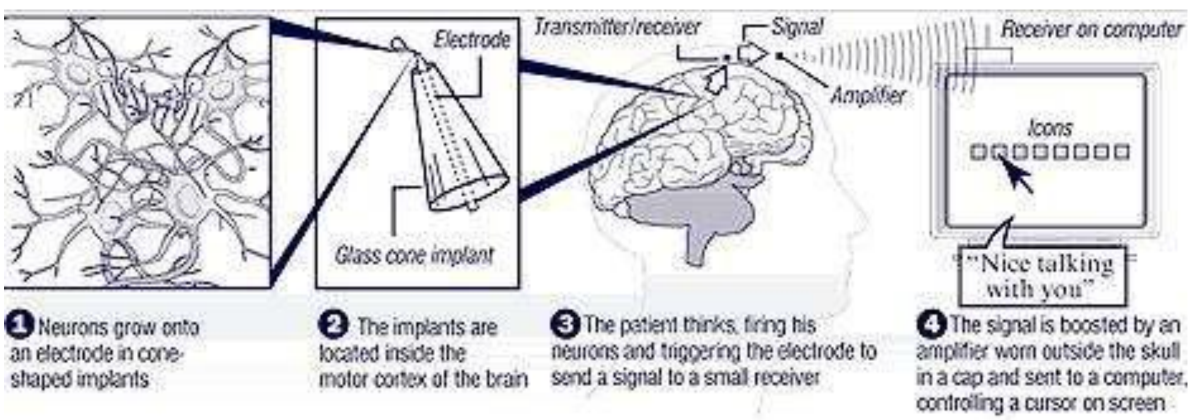

Fig. 3.5

A transmitter inside skull helps the user to pick up signals from the brain and translate them into cursor commands on the computer

3.4.3 REMOTE CONTROLLED RAT

1. Movement signals are transmitted from computer to the brain of rat through a radio receiver strapped to its back.
2. Military purposes and human rescue operations.

Fig. 3.6 Remote Controlled Rat

CHAPTER FOUR

SUMMARY AND CONCLUSION

4.0 SUMMARY

Brain chips are made with a view to enhance the memory of human beings, to help paralyzed patients, and are also intended to serve military purposes. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable "recognition" of previously unmet individuals.
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The future may well involve the reality of science fiction's cyborg, persons who have developed some intimate and occasionally necessary relationship with a machine. It is likely that implantable computer chips acting as sensors, or actuators, may soon assist not only failing memory, but even bestow fluency in a new language, or enable "recognition" of previously unmet individuals Currently, there are no cures for paralyzed people. However, research concerning the development of brain-computer interfaces (BCIs) presents a potential solution. Successful trials using BCIs (Brain computer interfaces) in subjects, such as Nagle, provide hope that brain chip technology will one day enable paralyzed people to control computers, wheelchairs, and even their own limbs.

4.1 CONCLUSION

Brain implants enhance capability of human organs and senses. It has a significant role to play in future genetic engineering fields and neuro science, and the implants may enhance your capabilities, but they will expire when you do.

Brain chips, often referred to as neural implants, are technological devices that connect directly to a biological subject's brain usually placed on the surface of the brain, or attached to the brain's cortex. Some brain implants involve creating interfaces between neural systems and computer chips, which are part of a wider research field called brain-computer interfaces. A typical neural implant consists of an array of electrodes that works with the nervous system, either by recording neuronal activity (recording) or by electrically stimulating them. Electrodes connect the electrochemical functions within the tissue and the electronic system. A circuit chip with site selection, amplifiers, and multiplexers works with some form of signal processing/embedded computing. Finally, a wireless link usually handles bidirectional data and power input. Implanting neural implants in the brain itself generally requires electrode sites every 200 um or so for recording, and perhaps every 400 um for stimulation.

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