ABSTRACT:

Thousands of people around the world suffer from paralysis, rendering them dependent on others toper form even the most basic tasks. But that could change, because of the latest achievements in the Brain-Computer Interface (BCI), which could help them regain a portion of their lost in dependence. Even normal humans may also be able to utilize Brain Chip Technology to enhance their relationship with the digital world-provided they are willing to receive the implant. The term ‘Brain-Computer Interface’ refers to the direct interaction between a healthy brain and a computer. Intense efforts and research in this BCI field over the past decade have recently resulted in a human BCI implantation, which is a great news for all of us, especially for those who have been resigned to spending their lives in wheel chairs. This Brain Chip Technology is a platform for the development of a wide range of other assisting devices.

In this definition of Brain-Computer Interface the word brain mean the brain or nervous system of an organic life form rather than the mind. Computer means any processing or computational device form an integrated circuit to silicon chip. The term ‘Brain-Computer Interface’ refers to the direct interaction between a healthy brain and a computer.

This paper focuses on the Brain Chip Technology which helps quadriplegic people to do things like checking e-mail, turning the TV, lights on or off—with just their thoughts. Also the definition of Brain-Computer Interface, the primary goal of designing Brain gate, the basic elements of Brain Gate, the research work conducted on it at different Universities and some short comings of Brain Gate were also presented.

CONTENTS

Page. No

INTRODUCTION

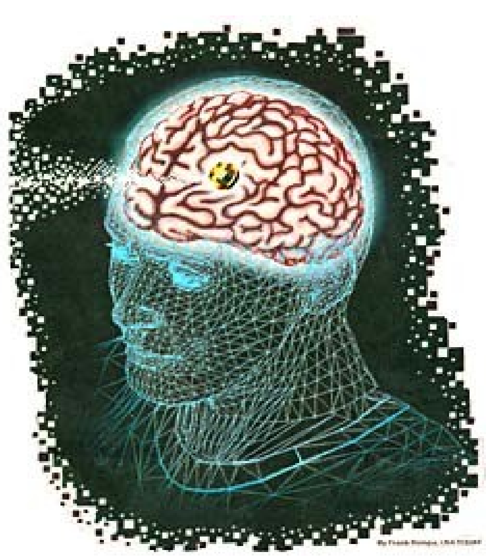
An implantable brain-computer interface the size of an aspirin has been clinically tested on humans by American company Cyber kinetics. The 'Brain Gate' device can provide paralyzed or motor-impaired patients a mode of communication through the translation of thought into direct computer control. The technology driving this breakthrough in the Brain-Machine-Interface field has a myriad of potential applications, including the development of human augmentation for military and commercial purposes.

A Brain-Computer Interface sometimes called a direct neural interface or a brain-machine interface (BMI) accepts commands directly from the human or animal brain without requiring physical movement and can be used to operate a computer or other technologies. This broad term can describe many actual and theoretical interfaces.

In this definition of Brain-Computer Interface the word brain mean the brain or nervous system of an organic life form rather than the mind. Computer means any processing or computational device form an integrated circuit to silicon chip. The term ‘Brain-Computer Interface’ refers to the direct interaction between a healthy brain and a computer.

The goal of the Brain Gate program is to develop a fast, reliable and unobtrusive connection between the brain of a severely disabled person and a personal computer. The aim of designing this chip is to provide paralyzed individuals with a gateway through which they can access the broad capabilities of computers, control devices in the surrounding environment, and even move their own limbs. Researchers at the University of Pittsburgh have already demonstrated that a monkey can feed itself with a robotic arm simply by using signals from its brain, an advance that could enhance prosthetics for people, especially those with spinal cord injuries. Now, using the

Brain Gate system in the current human trials, a 25 year old quadriplegic has successfully been able to switch on lights, adjust the volume on a TV, change channels and read e-mail using only his brain. Crucially the patient was able to do these tasks while carrying on a conversation and moving his head at the same time. John Donoghue, the chairman of the Department of Neuroscience at Brown University, led the original research project and went on to co-found Cyber kinetics, where he is currently chief scientific officer overseeing the clinical trial. It is expected that people using the Brain Gate system will employ a personal computer as the gateway to range of self-directed activities. These activities may extend beyond typical computer functions (e.g., communication) to include the control of objects in the environment such as a telephone, a television and lights. Usually the brain is connected to an external computer system through a chip composed of electrodes. Now it is possible to implant this chip into the brain's motor cortex (the part of the brain that controls the movements of the limbs). This allows us to record the electrical activity of neurons firing and use computers to convert the signals into actions by applying signal-processing algorithms (algorithms used for the processing, amplification and interpretation of signals).



Intense efforts and research in this field over the past decade have recently resulted in a human BCI implantation, which is a great news for all of us especially for those who have been resigned to spending theirs lives in wheel chair.

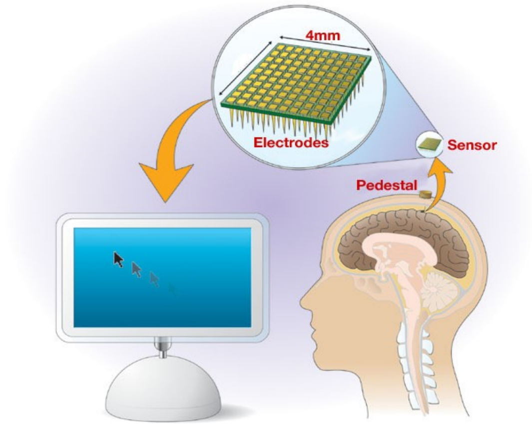
BRAINGATE—EMPOWERING THE HUMAN BRAIN:

The Brain Gate System is used to sense, transmit, analyze and apply the language of neurons. The System consists of a sensor that is implanted on the motor cortex of the brain and a device that analyzes brain signals. This sensor consists of a tiny chip (smaller than a baby aspirin) with hundred electrode sensors-each thinner than a hair- that detect brain cell electrical activity. The principle of operation behind the Brain Gate System is that with intact brain function, brain signals are generated even though they are not sent to the arms, hands and legs. The signals are interpreted and translated into cursor movements, offering the user an alternate "Brain Gate pathway" to control a computer with thought, just as individuals who have the ability to move their hands use a mouse.

The Basic Elements of Brain Gate

1. THE CHIP:

A four-millimeter square silicon chip studded with hundred hair thin microelectrodes is bedded in the primary motor cortex-the region of the brain responsible for controlling movement.



2. THE CONNECTOR:

When somebody thinks “move cursor up and left” his cortical neurons fire in a distinctive pattern; the signal is transmitted through the pedestal plug attached to the skull.

3. THE CONVERTER:

The signal travels to an amplifier where it is converted to optical data and bounced by fibre-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. The Brain Gate technology platform was designed to take advantage of the fact that many patients with motor impairment have an intact brain that can produce movement commands. This allows the Brain Gate System to create an output signal directly from the brain, bypassing the route through the nerves to the Muscles that cannot be used by people suffering from paralysis. The chip is implanted on the Surface of the brain in the motor cortex area that controls movement. In the pilot version of the Device, a cable connects the sensor to an external signal processor in a cart that contains computers. The computers translate brain activity and generate a communication output using custom decoding software.

The Brain Gate System has been specifically designed for clinical use in humans. Currently quadriplegic patients are enrolled in a pilot clinical trial, which has been approved by the US Food and Drug Administration (FDA).

The further development of Brain Gate System is to potentially provide limb movement to people with severe motor disabilities. The goal of this development program would be to allow these individuals to one day use their own arms and hands again. Limb movement developments are currently at the research stage and are not available for use with the existing Brain Gate System.

In the future, the Brain Gate System could be used by those individuals whose injuries are less severe. Next generation products may be able to provide an individual with the ability to control devices that allow breathing, bladder and bowel movements.

BCI versus Neuroprosthetics:

Neuroprosthetics is an area of neuroscience concerned with neural prostheses using artificial devices to replace the function of impaired nervous systems or sensory organs. The most widely used neuroprosthetic device is the cochlear implant, which was implanted in approximately 70,000 people worldwide as of 2005 according to the statistics conducted.

There are also several neuroprosthetic devices that aim to restore vision, including retinal implants, optic nerve cuffs and implants directly into the visual cortex.

The differences between BCIs and Neuroprosthetics are mostly in the ways the terms are used: “Neuroprosthetics” critically refers to clinical devices, where as many BCIs are still in the experimental realm. Practical Neuroprosthetics can be linked to any part of nervous systems, for example peripheral nerves, while the term “BCI” often designates a narrower class of systems which interface with the brain directly.

The terms are sometimes used interchangeably and for good reason. Neuroprosthetics and BCI seek to achieve the same aims, such as restoring sight, hearing, movement and even cognitive function. Both use similar experimental methods and surgical techniques.

Animal BCI Research:

Several laboratories have managed to record signals from monkey and rat cortexes in order to operate BCIs to carry out movement. Monkeys have navigated computer cursors on screen and commanded robotic arms to perform simple tasks simply by thinking about the task and without any motor output. Other research on cats has decoded visual signals.

Studies that developed algorithms to reconstruct movements from motor cortex neurons date back to the 1970s. Work by groups led by Schmidt, Fetz, and Baker in the 1970s established that monkeys could quickly achieve voluntary control over the firing rate of individual neurons in primary motor cortex under closed-loop operant conditioning.

There has been explosive development in BCIs since the mid-1990s. Phillip Kennedy and colleagues built the first wireless, intracortical brain-computer interface by implanting neurotrophic cone electrodes first into monkeys and then into the brains of paralyzed patients. Several groups have explored real-time reconstruction of more complex motor parameters using recordings from neural ensembles, including research groups.

Human BCI Interface:

Non-invasive BCIs*:*

As well as invasive experiments (see below), there have also been experiments in Humans using non-invasive neuroimaging technologies as interfaces.

Electroencephalography (EEG) is the most studied potential human interface, mainly due to its fine temporal resolution, ease of use, portability and low set-up cost. However practical use of EEG as a BCI requires a great deal of user training and is highly susceptible to noise. For example, in experiments beginning in the mid-1990s, Niels Birbaumer of the University of Tübingen in Germany used EEG recordings of slow cortical potential to give paralyzed patients limited control over a computer cursor. (Birbaumer had earlier trained epileptics to prevent impending fits by controlling this low voltage wave.) The experiment saw ten patients trained to move a computer cursor by controlling their brainwaves.

The process was slow, requiring more than an hour for patients to write 100 characters with the cursor, while training often took many months. Another research parameter is the type of waves measured. Birbaumer's later research with Jonathan Wolpaw at New York State University has focused on developing technology that would allow users to choose the brain signals they found easiest to operate a BCI, including *mu* and *beta* waves.

A further parameter is the method of feedback used and this is shown in studies of P300 signals. Patterns of P300 waves are generated involuntarily (stimulus-feedback) when people see something they recognize and may allow BCIs to decode categories of thoughts without training patients first. By contrast, the biofeedback methods described above require learning to control brainwaves so the resulting brain activity can be detected.

INVASIVE BCIS:

Invasive BCI research has targeted repairing damaged or congenitally absent sight and hearing and providing new functionality to paralyzed people. There has been great success in using cochlear implants in humans as a treatment for non congenital deafness, but it's not clear that these can be considered brain-computer interfaces. There is also promising research in vision science where direct brain implants have been used to treat non-congenital blindness. One of the first scientists to come up with a working brain interface to restore sight was private researcher, William Dobelle. Dobelle's first prototype was implanted into Jerry, a man blinded in adulthood, in 1978. A single-array BCI containing 68 electrodes was implanted onto Jerry's visual cortex and succeeded in producing phosphenes. The system included TV cameras mounted on glasses to send signals to the implant. Initially the implant allowed Jerry to see shades of grey in a limited field of vision and at a low frame-rate also requiring him to be hooked up to a two-ton Mainframe. Shrinking electronics and faster computers made his artificial eye more portable And allowed him to perform simple task sun assisted. In 2002, Jens Naumann, also blinded in adulthood, became the first in a series of 16 paying patients to receive Dobelle's second generation implant, marking one of the earliest commercial uses of BCIs. The second generation device used a more sophisticated implant enabling better mapping of phosphenes into coherent vision. Phosphenes are spread out across the visual field in what researchers call the starry-night effect. Immediately after his implant, Jens was able to use his imperfectly Restored vision to drive slowly around the parking area of the research institute.

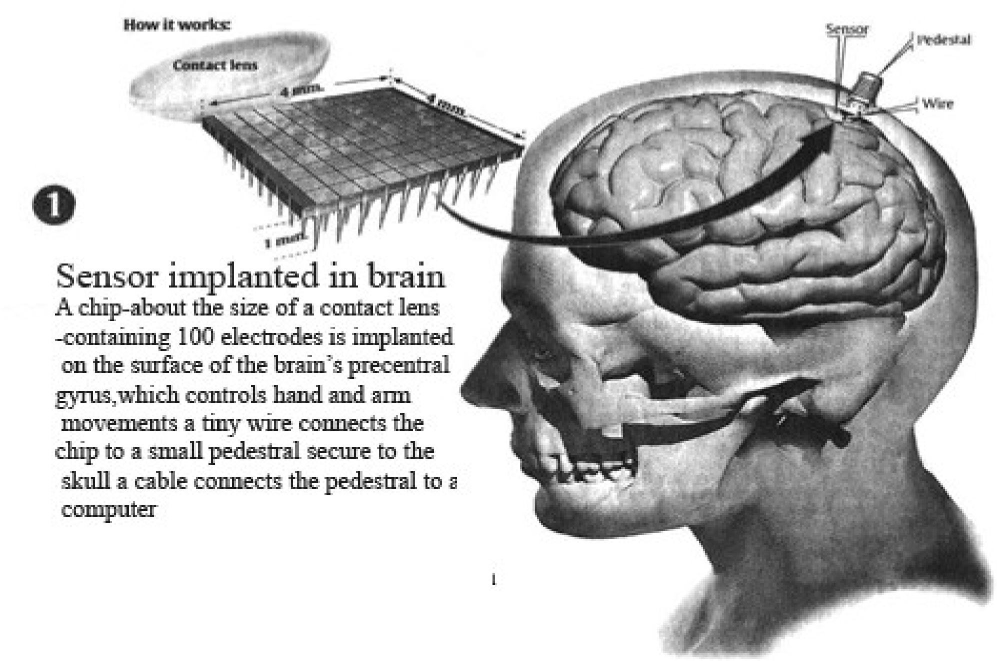
BCIs focusing on motor Neuroprosthetics aim to either restore independent control of the body or provide assistive devices to individuals paralyzed by a variety of causes, including spinal cord injury, amyotrophic lateral sclerosis, muscular dystrophy, multiple sclerosis, spinal muscular atrophy, cerebellar disorders and certain types of stroke. Matt Nagle is one of the first people to use a direct brain-computer interface to restore functionality lost due to paralysis.

THE POWER OF THOUGHT:

Matthew Nagle’s achievement is a historic one, and is in the same league as conquering Mount Everest or putting a human being on the moon. He is the first paralyzed person to have operated a prosthetic arm using just his mind.

On July 4, 2001, Nagle became paralyzed from the neck downwards after being assaulted by a person wielding a knife. He was confined to his wheel chair and was unable to breathe without a respirator. Fortunately there was a scientist and a new device to help him overcome his disabilities. The scientist was Professor John Donoghue and the device was Brain Gate.On June 22, 2004, Donoghue's team implanted a small chip into Nagle's brain. This implanted sensor picked up the electric signals that command the limbs of the body to move. In the case of a healthy man, these signals would have been forwarded to the spinal cord. But as Nagle's spinal cord was damaged, the signals were collected and sent through wires and fiber-optic cable to hardware and software that translated into computer-driven movements.

This implanted device enabled Nagle to do things like check his e-mail, turn the TV on or off, draw a crude circle on the screen, play the game Pong, and control a prosthetic arm-with just his thoughts. Of course, he needed months of training to perform these tasks but his achievement underlines the staggering potential of BCI Technology.

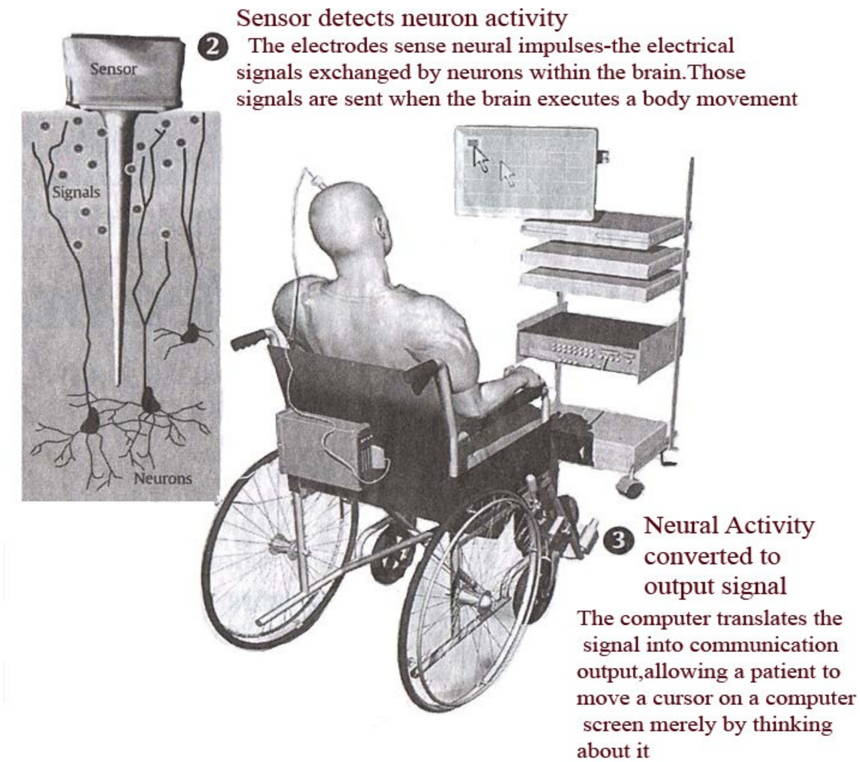


CONNECTING BRAINS TO COMPUTERS: A WAY TO HELP QUADRIPLEGICS:

Cyberkinetics, a company commercializing technology developed at Brown University, just reported the results of its first attempt to implant sensors into the brain of a quadriplegic. Signals from the sensor allow him to control a computer.

JUST LIKE A CELL PHONE:

Many people might wonder how an external device like an artificial arm gets signals from the brain. Well, in a healthy person the message from the brain first moves down to the Spinal cord and from there, to the muscles of the limbs that needs to be moved. But in those with serious spinal cord injuries, the path for the signals is broken. Professor Donoghue explains this state as being similar to cutting a telephone cable-the receivers are fine but the connections Broken. Now, what would most of us do if our land line telephone cables were cut? Well, in all Probability, we would use our cell phones to make calls. Donoghue and his team thought on The same lines. They bypassed the spinal cord altogether and extracting the brains commands, converted them into electrical signals and sent them to a computer.



The brain chip can listen to the electrical impulses produced by the neurons. Placed into the brain itself, the electrode arrays of these chips come into direct contact with live neurons, and so can sense the signal neuron impulses. Current methods of direct neuron sensing being tested in humans use arrays of as many as hundred micro-electrodes, recording the electrical activities of up to 96 different neurons are small groups of neurons at a time.

TEETHING TROUBLES:

For all its potential, Brain Gate is far from perfect. Reading brain signals is not an easy task as even a simple movement, such as raising a hand, requires electrical signals from many regions of the brain. Implanted electrodes pickup just a tiny fraction of the signals from neurons that fire . It is difficult for the computer to convert these signals-resulting in the cursor jiggling and making it difficult to select icons on the screen with accuracy. Donoghue and his team hope to smooth things out using software. Other Brain Gate shortcomings include:

1. **Size:** Brain Gate right now has a bulky look with cables and processors. The device has to less bulky to make the technology main stream. Cyberkinetics is developing a prototype of a device that would fit behind the ear of the patient, much like the cochlear implant, and connect via a magnet to the computer equipment, thus eliminating the need to cross the skin. This will lead to a wireless Brain Gate, giving the patient greater freedom.

2. **Calibration***:* In its current form, it is essential to recalibrate the device before each use by the patient. The team is working on automated calibration to allow greater independence to the user.

3. **Muscle connection:** Today a direct connection from the computer to a muscle is not possible. But researchers believe that they will be able to achieve coordinated muscle movement. In theory electrodes and wires could connect muscles to the functioning brain, thus bypassing the damaged spinal cord. a. The biggest advantage with this Brain Gate implantation was that it eliminated the need for an invasive surgical procedure and the risks associated with it. The problem with this device is its low signal-to-noise ratio, which limits its use to controlling a cursor. It is difficult to perform more complex tasks like controlled muscle movement.

CONCLUSION

Here by, we conclude that neural interfaces have emerged as effective interventions to reduce the burden associated with some neurological diseases, injuries and disabilities. The Brain Gate helps the quadriplegic patients who cannot perform even simple actions without the help of another person are able to do things like checking e-mails, turn the TV on or off, and control a prosthetic arm— with just their thoughts. Brain Chip technology does not Promise miracles-it does not, for instance, say that a paralyzed man will one day walk using an artificial leg by his thoughts alone.

REFERENCES:

[1] http://biomed.brown.edu

[2] http://www.cyberkineticsinc.com

[3] www.itmagz.com

[4] www.gizmag.com