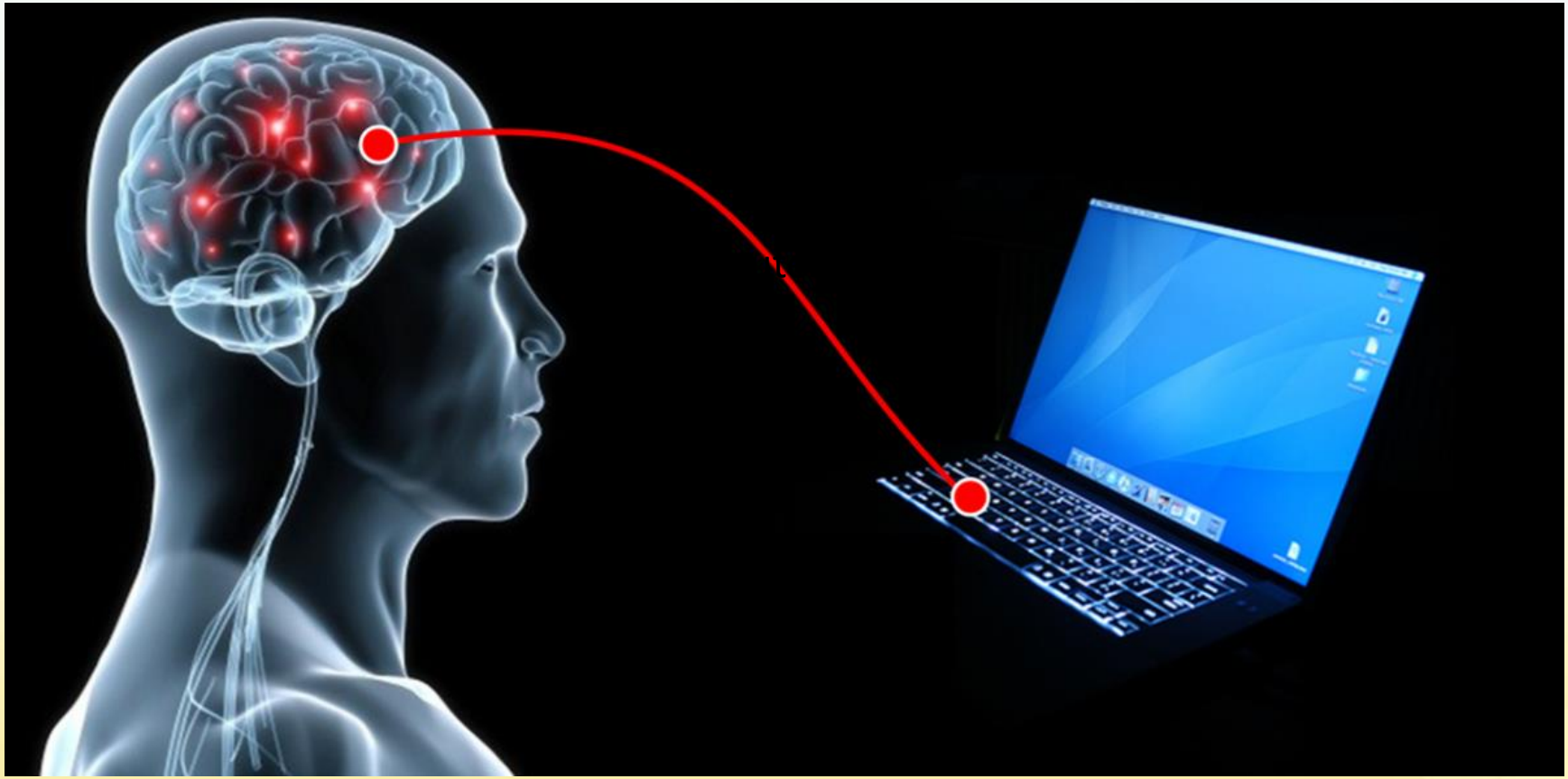
Brain Computer Interface

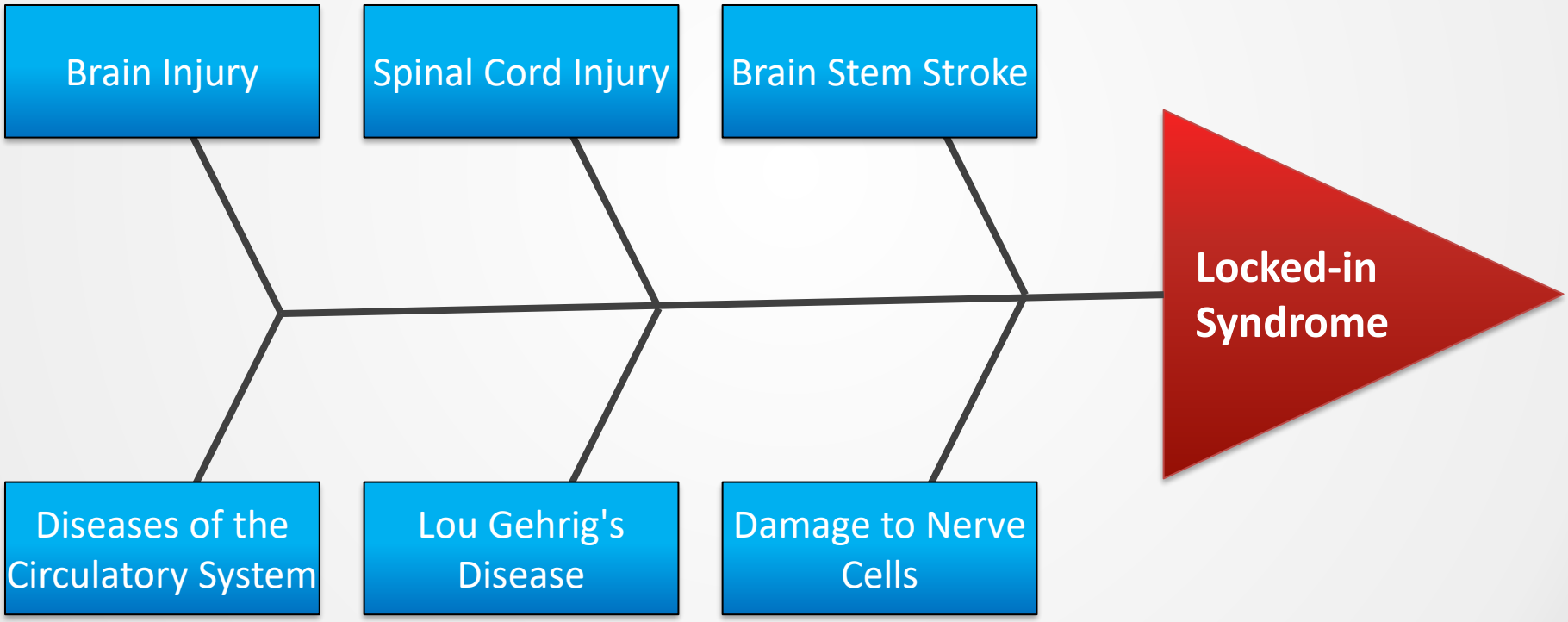
Dr. Faraz Akram

Brain Computer Interface



Motivation

- Locked-in syndrome is a neurological disorder characterized by complete paralysis of voluntary muscles in all parts of the body.



Locked-in Syndrome (LIS)

- Complete paralysis of voluntary muscles in all parts of the body except those that control blinking and eye movements.
- Patients are conscious and can think and reason but can not speak or move anything except their eyes.
- Communication with patients suffering from locked-in syndrome and other forms of paralysis is a challenge.
- The last possibility for those with motor disabilities is to provide the brain with a new, non-muscular communication and control channel, a direct brain computer interface for conveying messages and commands to the external world.

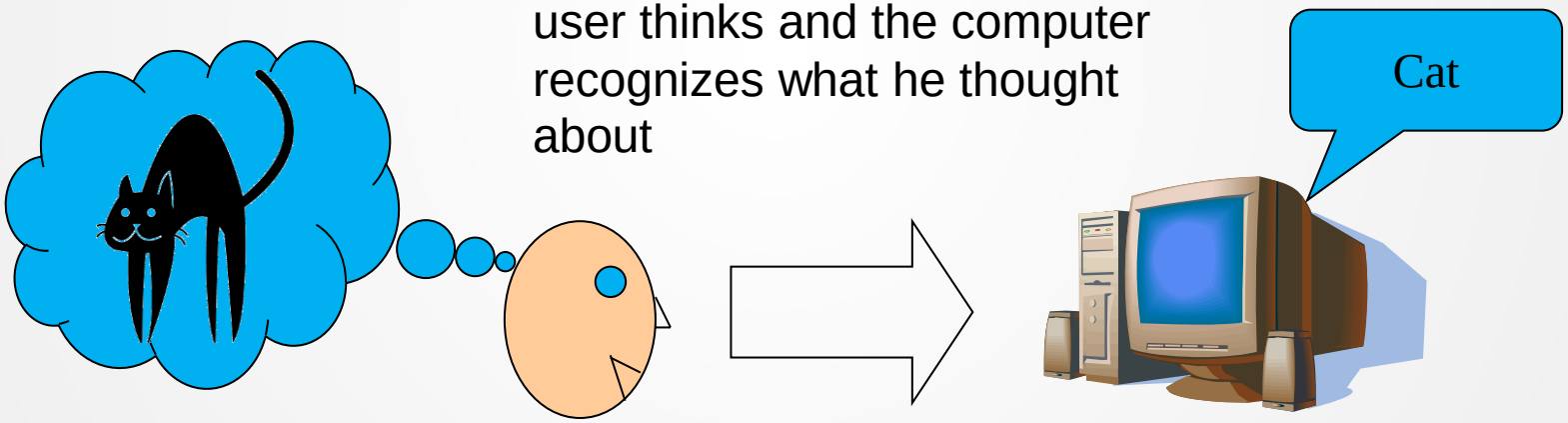
What is Brain Computer Interface?

- Brain Computer Interface (BCI) is a system that can be used for direct communication between a computer and the brain without actual muscular movements.

A brain-computer interface is a technology which allows humans to communicate/control or interact with a computer/electronic device via thought.

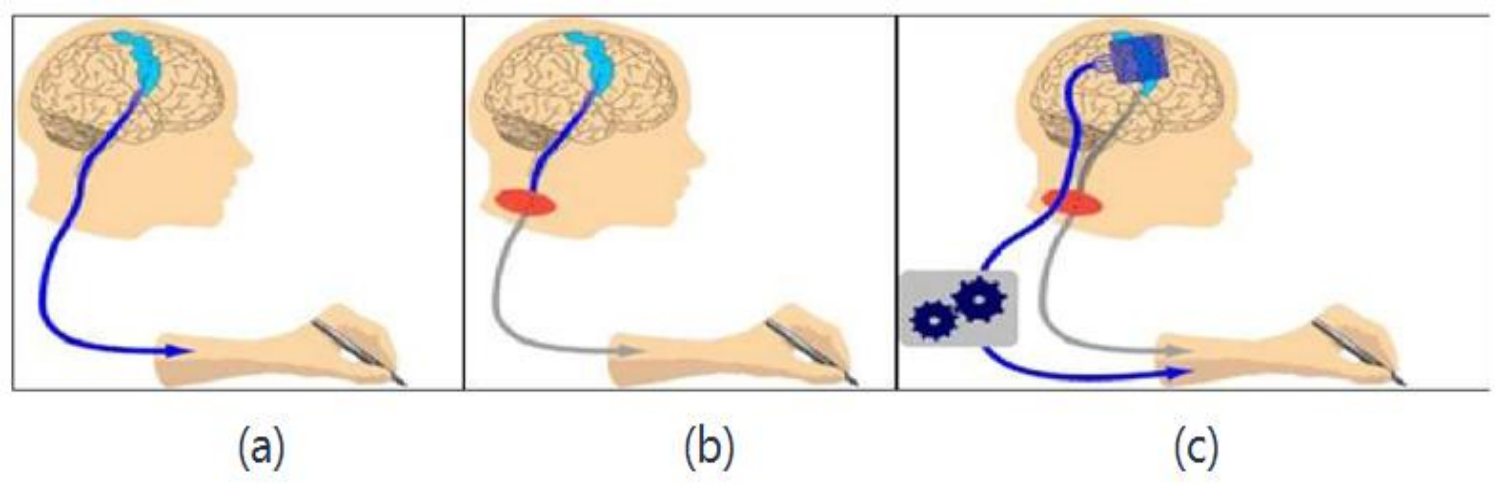
Goal of BCI Research

- The basic goal of BCI systems is to provide communications capabilities to severely disabled people who are totally paralyzed or ‘locked in’ by neurological neuromuscular disorders



➔Brain Computer Interface (BCI)
➔Brain Machine Interface (BMI)
➔Direct Neural Interface
➔Mind–Machine Interface (MMI).

BCI Principle:



(a) In healthy subjects, primary motor area sends movement commands to muscles via spinal cord.

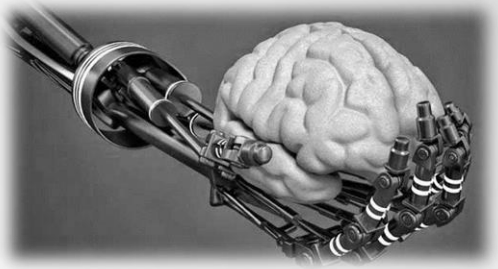
(b) But in paralyzed people this pathway is interrupted.

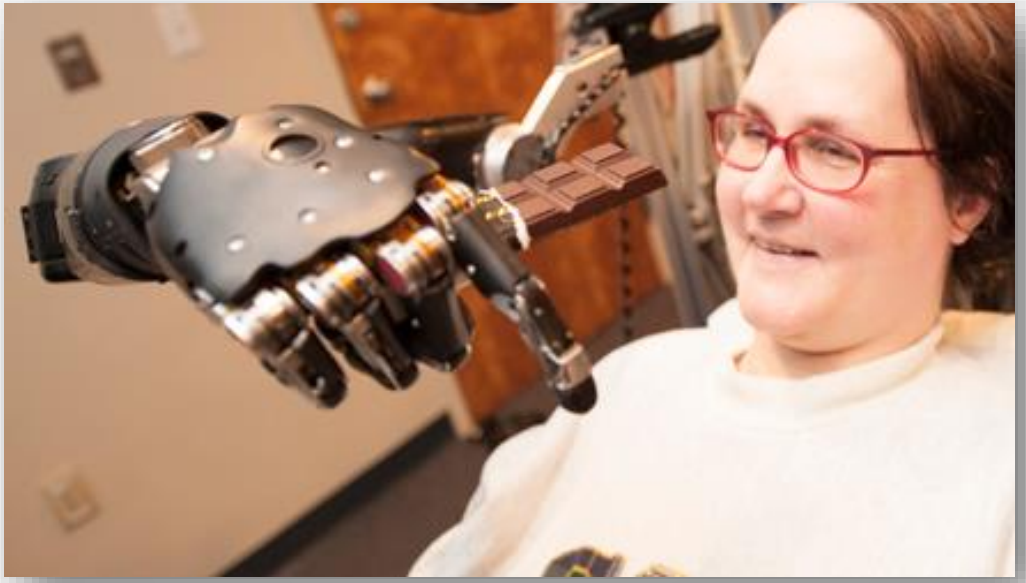
(c) A Computer based decoder is used, which translates this activity into commands for muscle control.

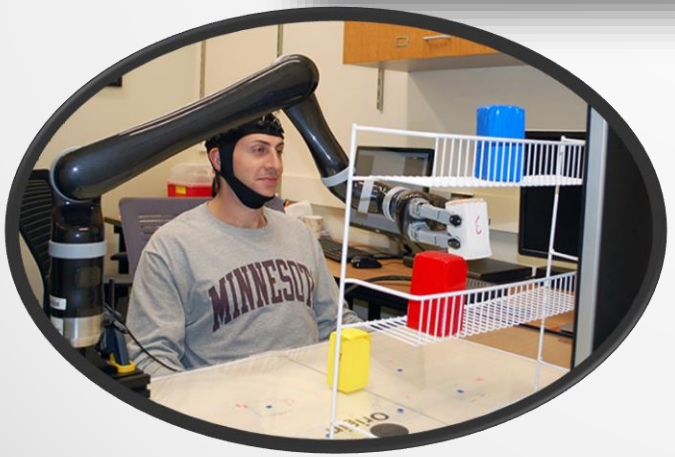
What has been done?
/
can be done

Controlling a Wheelchair

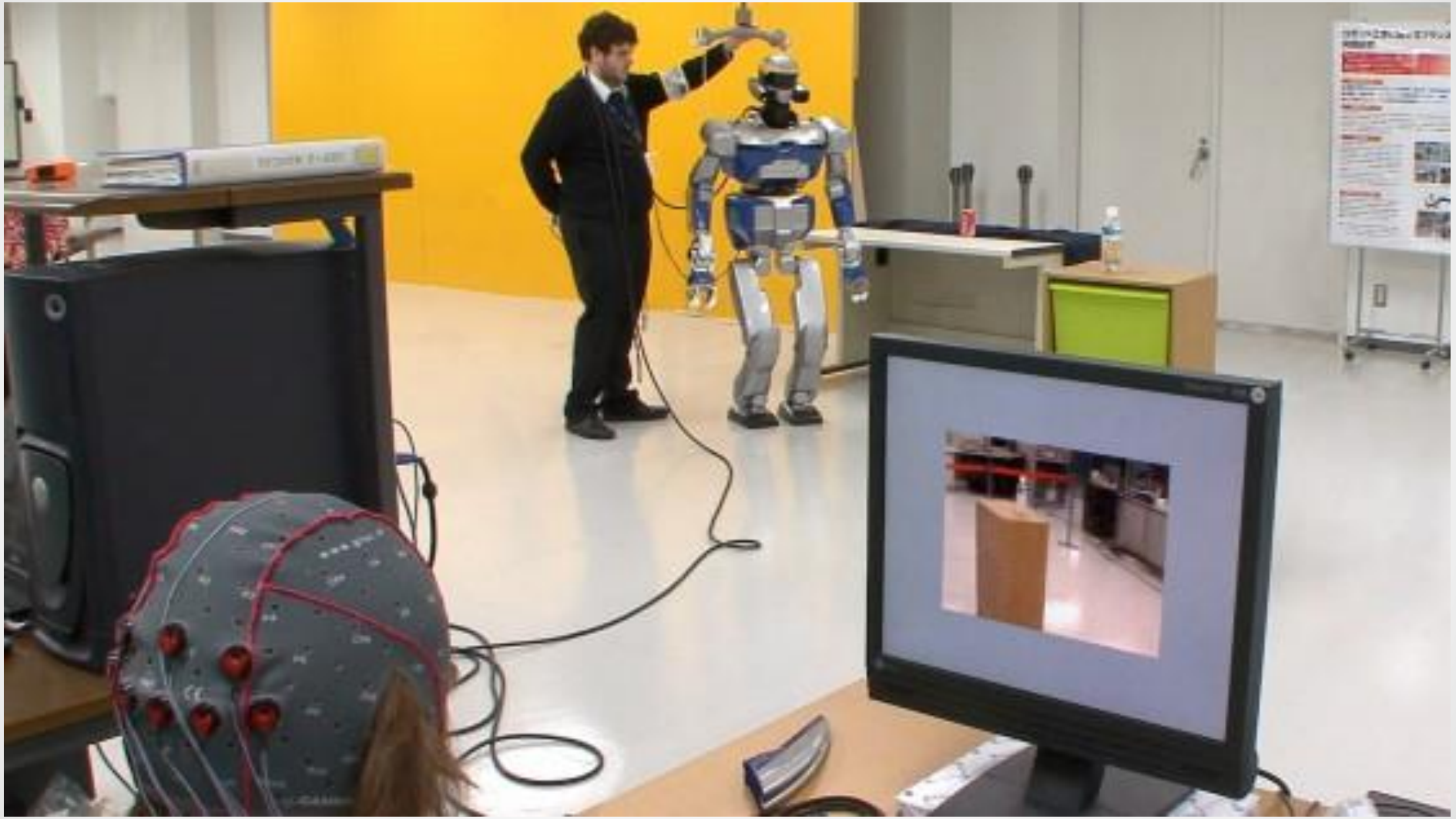
A robotic arm control





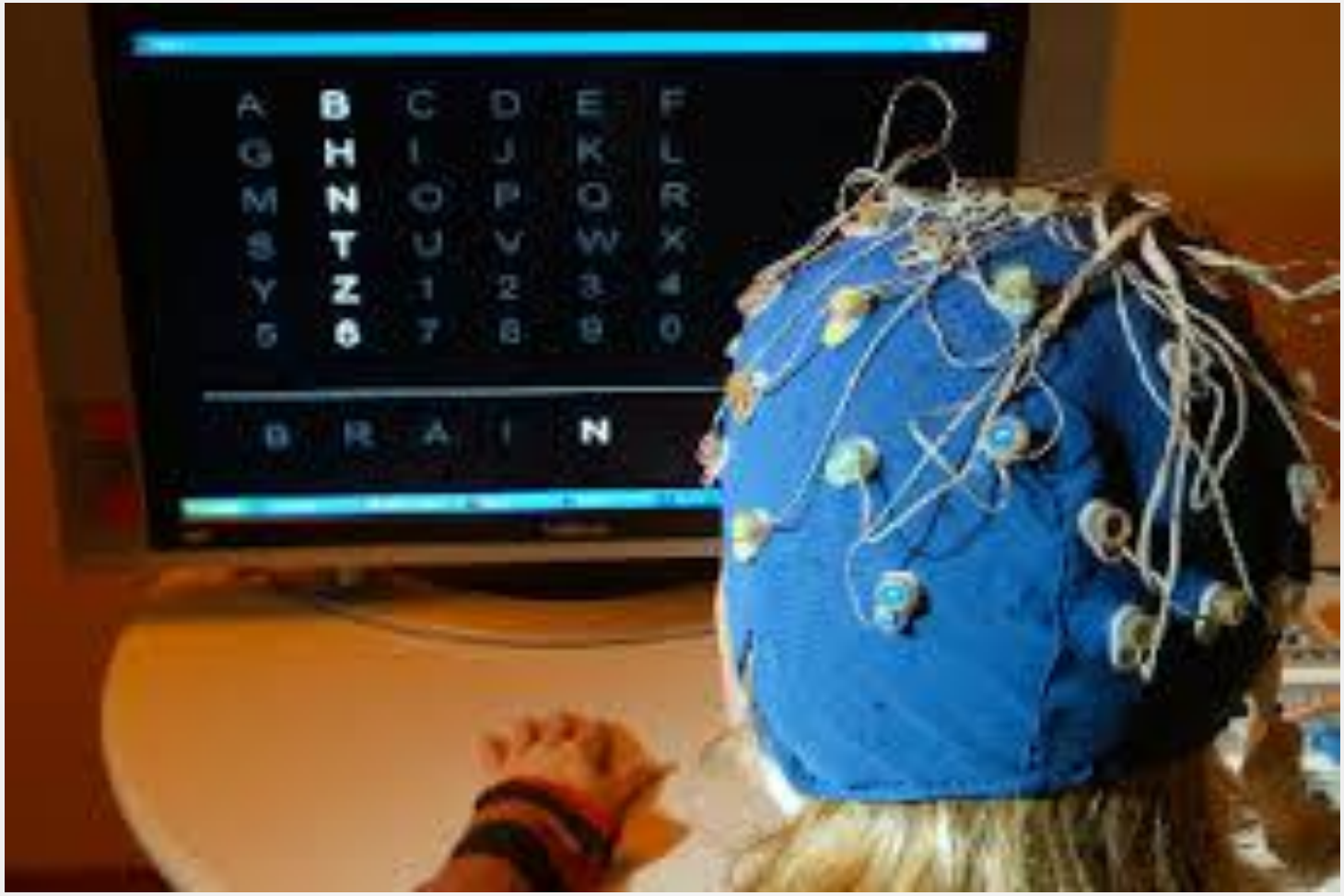


Robot Control



Controlling a cursor on the screen

Type With Your Brain

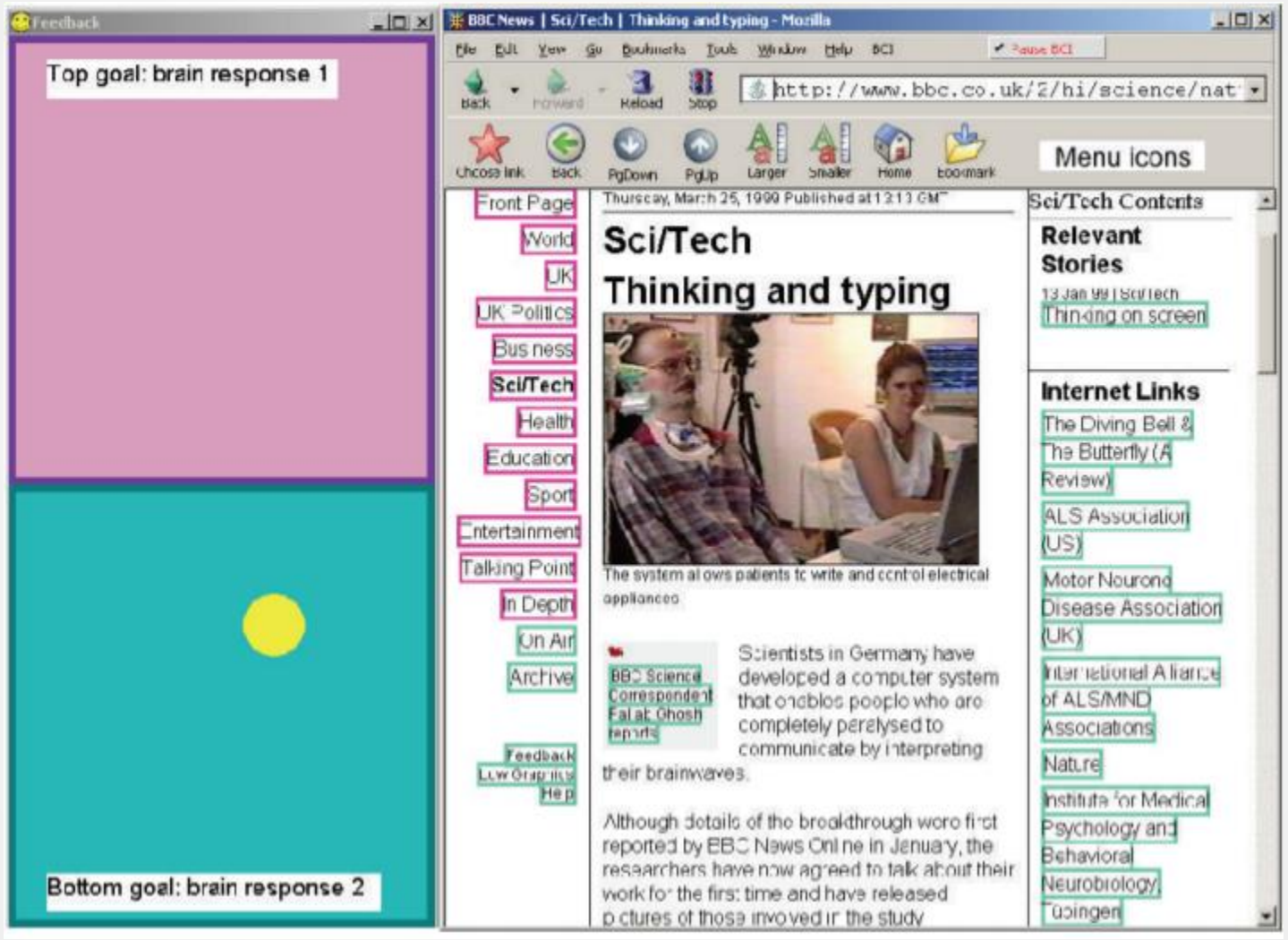


Playing Games

Environmental Control

- Another important challenge for people with severe physical disabilities is controlling devices in the environment, for example, a television, a thermostat, or video recorder.

BCI Controlled web browser



Bensch, Michael, et al. "Nessi: an EEG-controlled web browser for severely paralyzed patients." *Computational intelligence and neuroscience* 2007 (2007).

Emotion Recognition

Mood Recognition

Mood Recognition System Using EEG Signal of Song Induced Activities

Table 13.1 Mental tasks with their description

Sr. no	Mental task	Description
1	Relax	Subject was asked to lie on bed without any activity
2	Happy	Subject listen to the happy mood song such as
		1. Koyal Boli Duniya Doli
		Singer:-Lata Mangeshkar and Rafi
		2. Meri Zindagi Mein Aaye Ho
		Singer:-Sonu Nigam and Sunidi Chavvan
3	Sad	Subject listen to the sad mood song such as
		1. Tanhaai, tanhaai
		Singer:-Sonu Nigam
		2. Khone Dil Se Wo Mehndi Ratachne Lage
		Singer:-Poonam Kumar
4	Romantic	Subject listen to the romantic mood song such as
		1. Rim Jhim Ke Geet Sawan
		Singer:-Lata Mangeshkar and Rafi
		2. Ajnabii Mujhko Itna Bataa
		Singer:-Lata Mangeshkar
5	National	Subject listen to the patriotic mood song such as
		1. Mere Desh Kee Dharatee, Sonaa Ugale
		Singer:-Mehendra Kapoor,
		2. Yahan Yahan Saara Jahan Dekh Liya
		Singer:-A.R. Rehman

Lie Detection

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The Truth Will Out: Interrogative Polygraphy ("Lie Detection") With Event-Related Brain Potentials

LAWRENCE A. FARWELL AND EMANUEL DONCHIN
Cognitive Psychophysiology Laboratory, University of Illinois at Urbana-Champaign

ABSTRACT

The feasibility of using Event Related Brain Potentials (ERPs) in Interrogative Polygraphy ("Lie Detection") was tested by examining the effectiveness of the Guilty Knowledge Test designed by Farwell and Donchin (1986, 1988). The subject is assigned an arbitrary task requiring discrimination between experimenter-designated targets and other, irrelevant stimuli. A group of diagnostic items ("probes"), which to the unwitting are indistinguishable from the irrelevant items, are embedded among the irrelevant. For subjects who possess "guilty knowledge" these probes are distinct from the irrelevants and are likely to elicit a P300, thus revealing their possessing the special knowledge that allows them to differentiate the probes from the irrelevants. We report two experiments in which this paradigm was tested. In Experiment 1, 20 subjects participated in *one* of two mock espionage scenarios and were tested for their knowledge of *both* scenarios. All stimuli consisted of short phrases presented for 300 ms each at an interstimulus interval of 1550 ms. A set of items were designated as "targets" and appeared on 17% of the trials. Probes related to the scenarios also appeared on 17% of the trials. The rest of the items were irrelevants. Subjects responded by pressing one switch following targets, and the other following irrelevants (and, of course, probes). ERPs were recorded from F_Z, C_Z, and P_Z. As predicted, targets elicited large P300s in all subjects. Probes

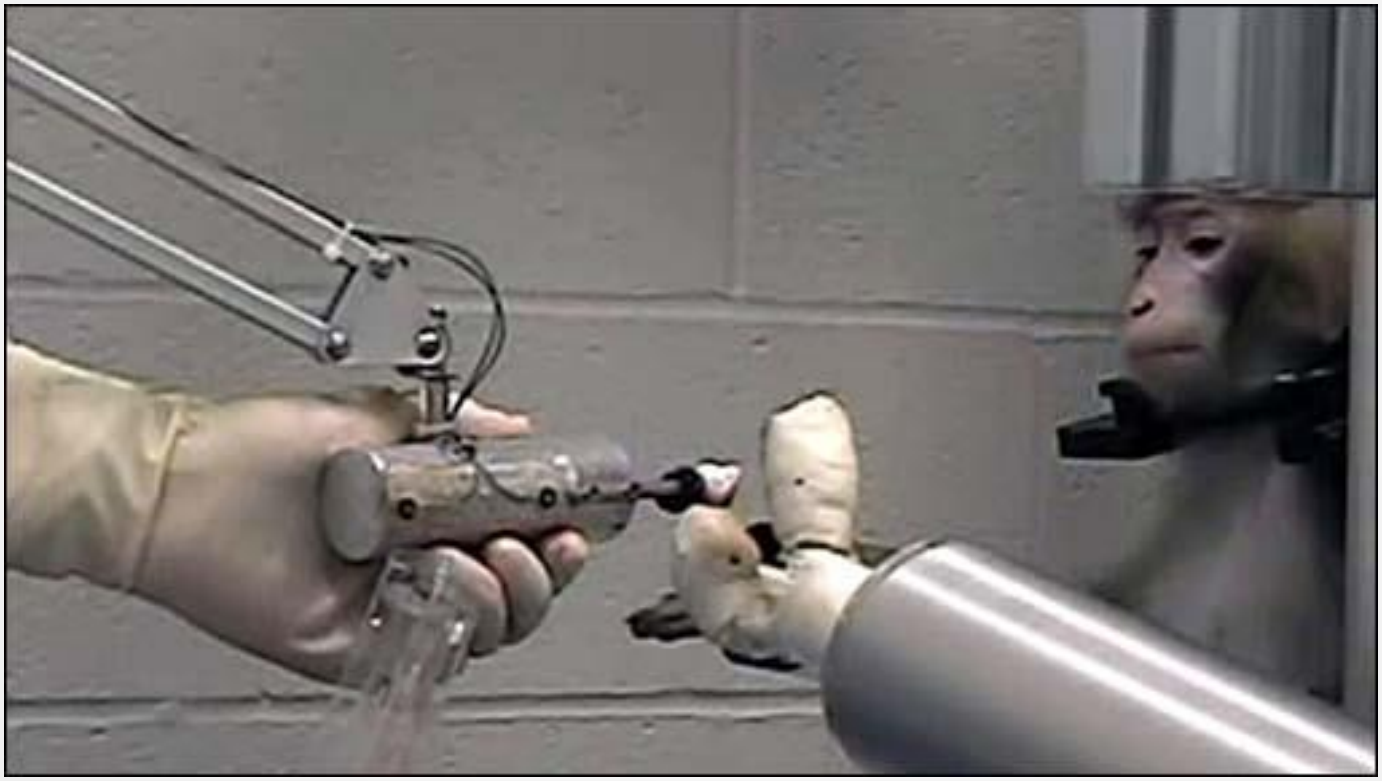
Farwell, Lawrence A., and Emanuel Donchin. "The truth will out: Interrogative polygraphy ("lie detection") with event-related brain potentials." *Psychophysiology* 28.5 (1991): 531-547.

Brain Fingerprinting

- Brain fingerprinting is a technology designed to determine hidden information in individual's brain by measuring electrical brain wave responses to words, phrases, or pictures presented on a computer screen.

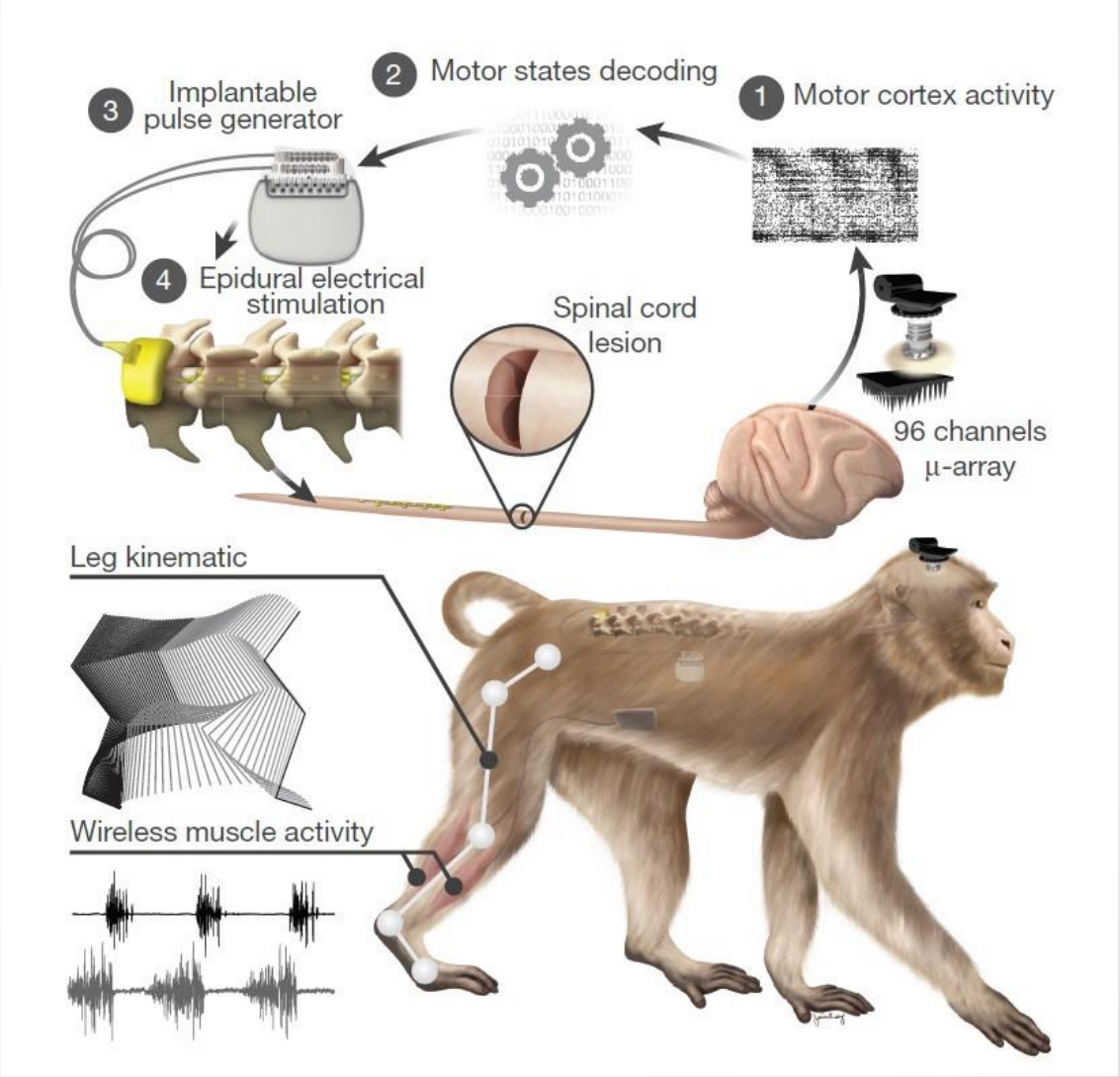
Monkey thinks, Robot does!

- *Experiments with monkey operating a robotic arm with its mind*



Brain-Spine Interface

Wireless communication of decoded motor states recorded by an brain implant to a pulse generator implanted lower spine allows the rhesus monkey to control his limb after spinal cord injury.

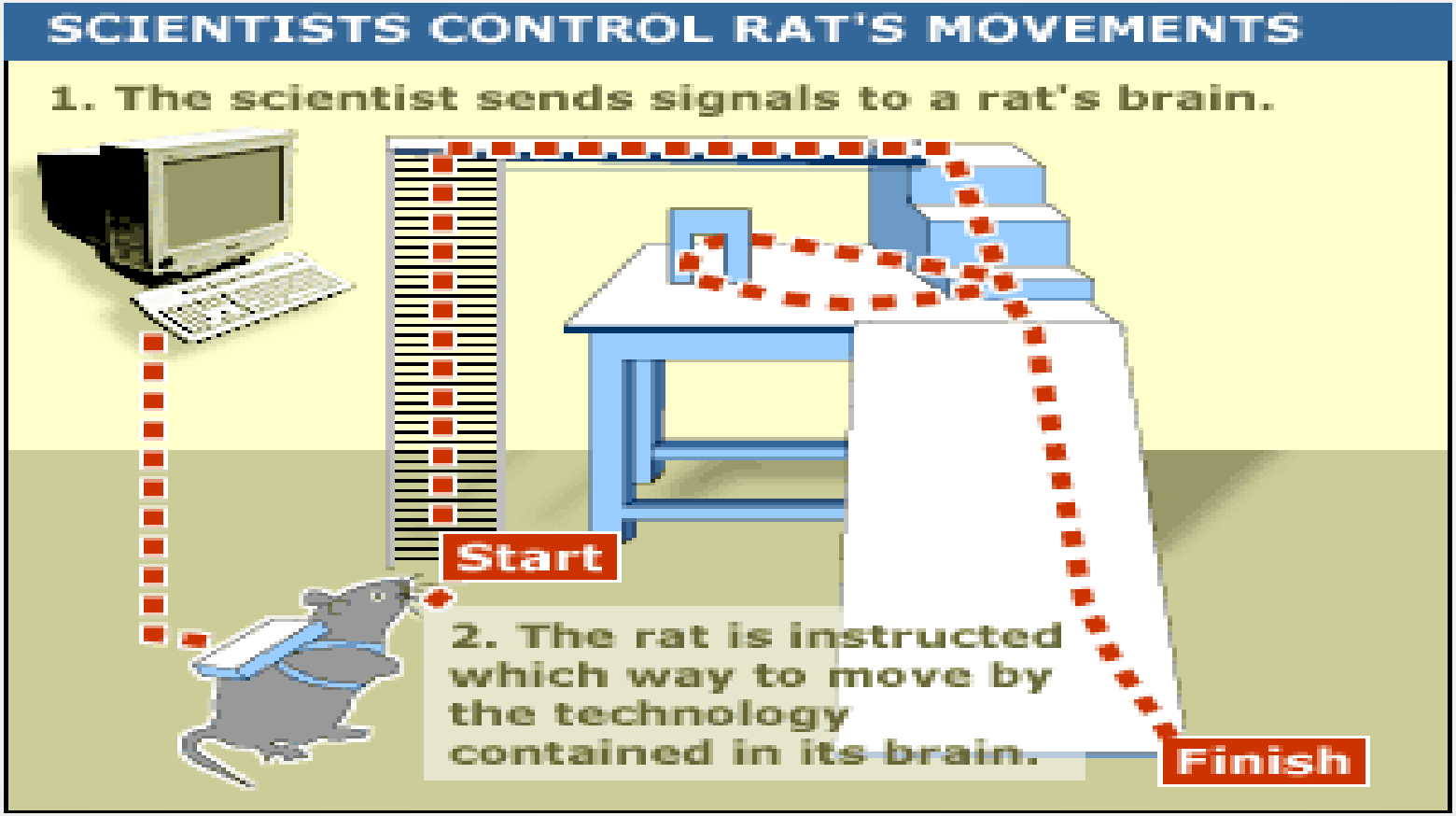


Capogrosso, Marco, et al. "A brain–spine interface alleviating gait deficits after spinal cord injury in primates." *Nature*539.7628 (2016): 284.

Reverse BCI

Ratbot!

- Reverse BCI



REMOTE CONTROL Scientists hack rat brains to control their limbs – making them run, freeze and turn around at the flick of a switch

> Terrifying advance allows scientists to control movement after minor surgery which could go unnoticed

By Margi Murphy

22nd August 2017, 10:53 am | Updated: 22nd August 2017, 2:46 pm

1 COMMENTS

PICTURE walking down a street and suddenly freezing up - with no control of your limbs - because a scientist is remotely controlling your brain.

The nightmarish scenario is now feasible, thanks to a terrifying scientific advance by US scientists.

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Manipulation of Rat Movement via Nigrostriatal Stimulation Controlled by Human Visually Evoked Potentials

Received: 13 July 2016
Accepted: 12 April 2017
Published online: 24 May 2017

Bonkon Koo[1], Chin Su Koh[2], Hae-Yong Park[3], Hwan-Gon Lee[4], Jin Woo Chang[1], Seungjin Choi[5] & Hyung-Cheul Shin[3]

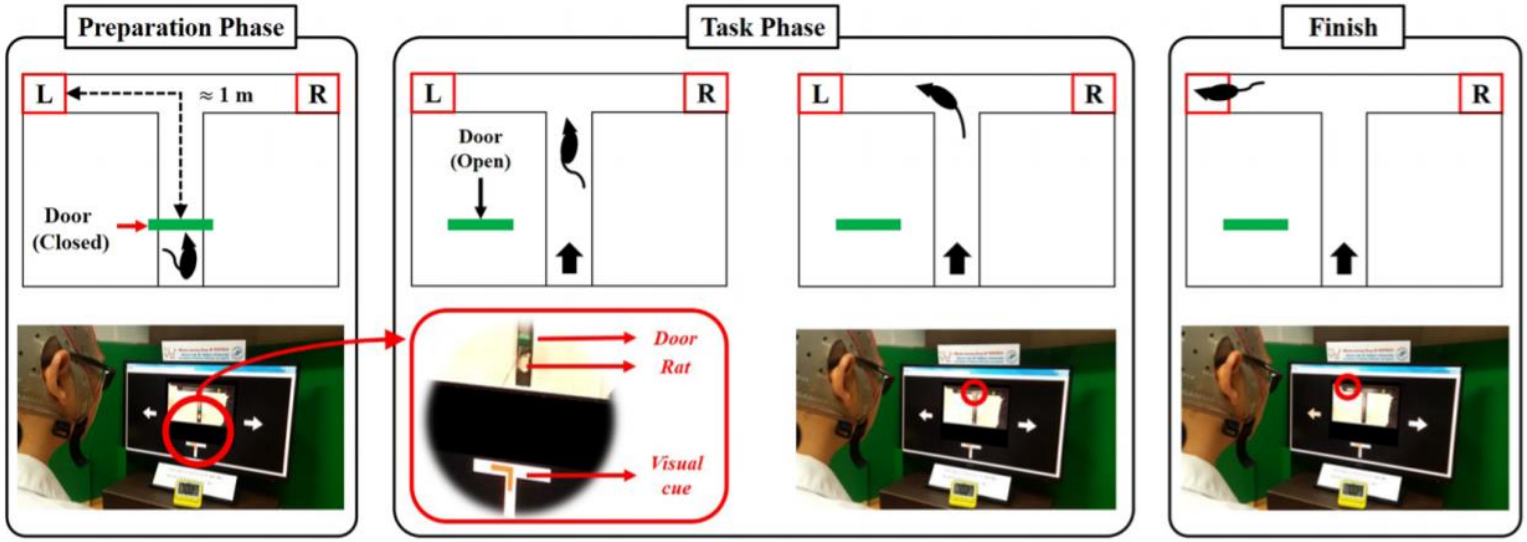
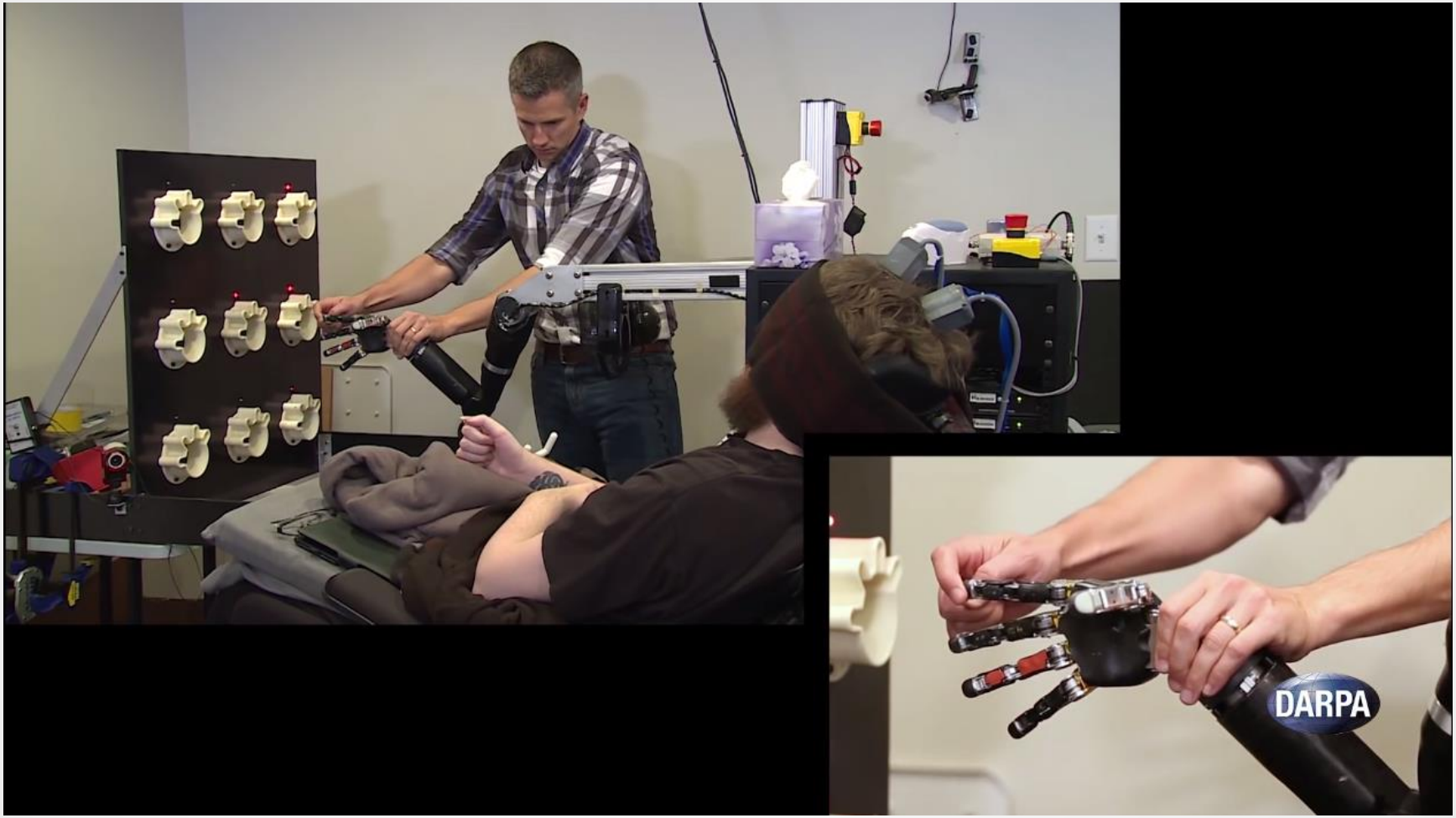


Figure 1. Schematic for the real-time rat-navigation experiment. Each experimental trial comprised a

Providing a Sense of Touch to human



Artificial Vision for the Blind

Artificial Vision for the Blind by Connecting a Television Camera to the Visual Cortex

Dobelle, Wm. H.

ASAIO Journal: January-February 2000 - Volume 46 - Issue 1 - p 3-9
State of the Art

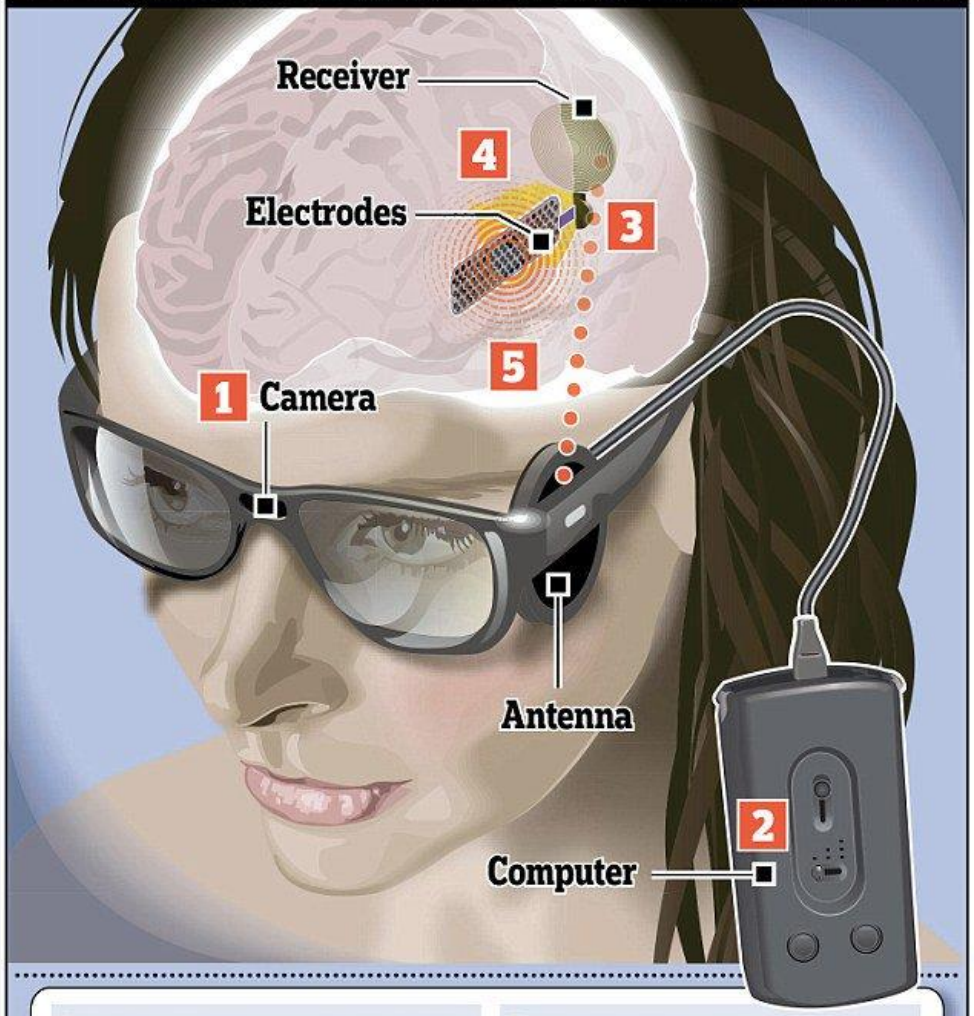
Abstract | Author Information | Article Outline

Blindness is more feared by the public than any ailment with the exception of cancer and AIDS. We report the development of the first visual prosthesis providing useful “artificial vision” to a blind volunteer by connecting a digital video camera, computer, and associated electronics to the visual cortex of his brain. This device has been the objective of a development effort begun by our group in 1968 and represents realization of the prediction of an artificial vision system made by Benjamin Franklin in his report on the “kite and key” experiment, with which he discovered electricity in 1751.*

This new visual prosthesis produces black and white displays of visual cortex “phosphenes” analogous to the images projected on the light bulb arrays of some sports stadium scoreboards. The system was primarily designed to promote

Dobelle, Wm H. "Artificial vision for the blind by connecting a television camera to the visual cortex." *ASAIO journal* 46.1 (2000): 3-9.

TECHNOLOGY TO BEAT BLINDNESS



1 A tiny video camera in the bridge of the glasses captures moving images and sends them via a wire to a computer

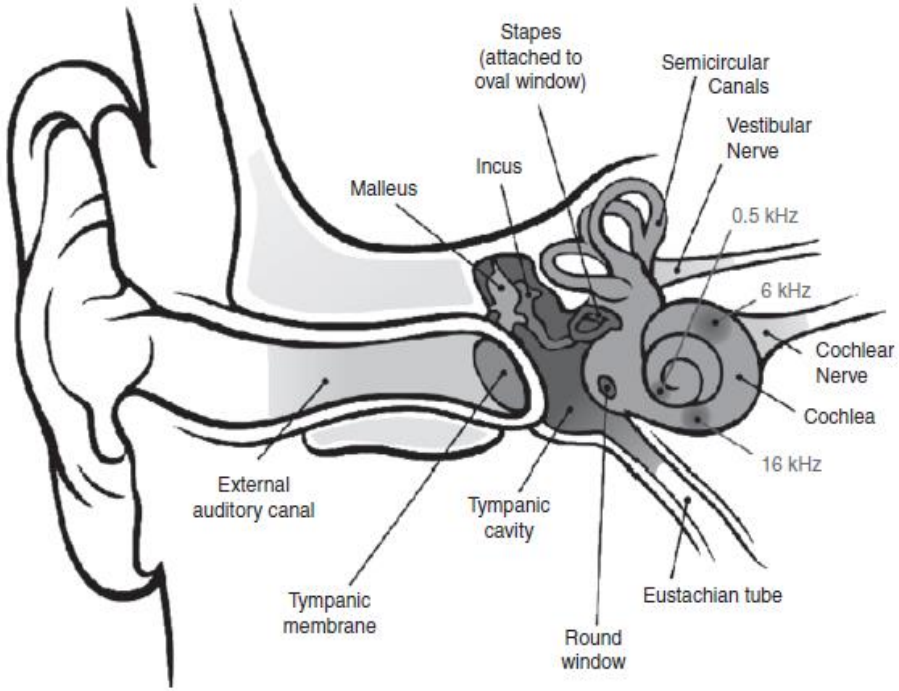
2 The computer unit, carried in a pocket, transforms the images into electrical signals and sends them back to an antenna on the glasses

3 The signals are then transferred wirelessly to a receiver implanted on the back of the skull

4 They are sent on to electrodes placed on the surface of the brain

5 The electrodes stimulate the neural cells in the visual cortex – enabling the wearer to see

Restoring Hearing: Cochlear Implants



Transformation of sound into neural signals in the cochlea. (Image: Creative Commons).

Schematic diagram of a cochlear implant. The external components consist of a microphone, a sound processor, and a transmitter of power and processed signals. The internal components consist of a receiver and stimulator, along with an array of electrodes that can be seen wound up within the cochlea in the figure. (Image: Creative Commons).

1

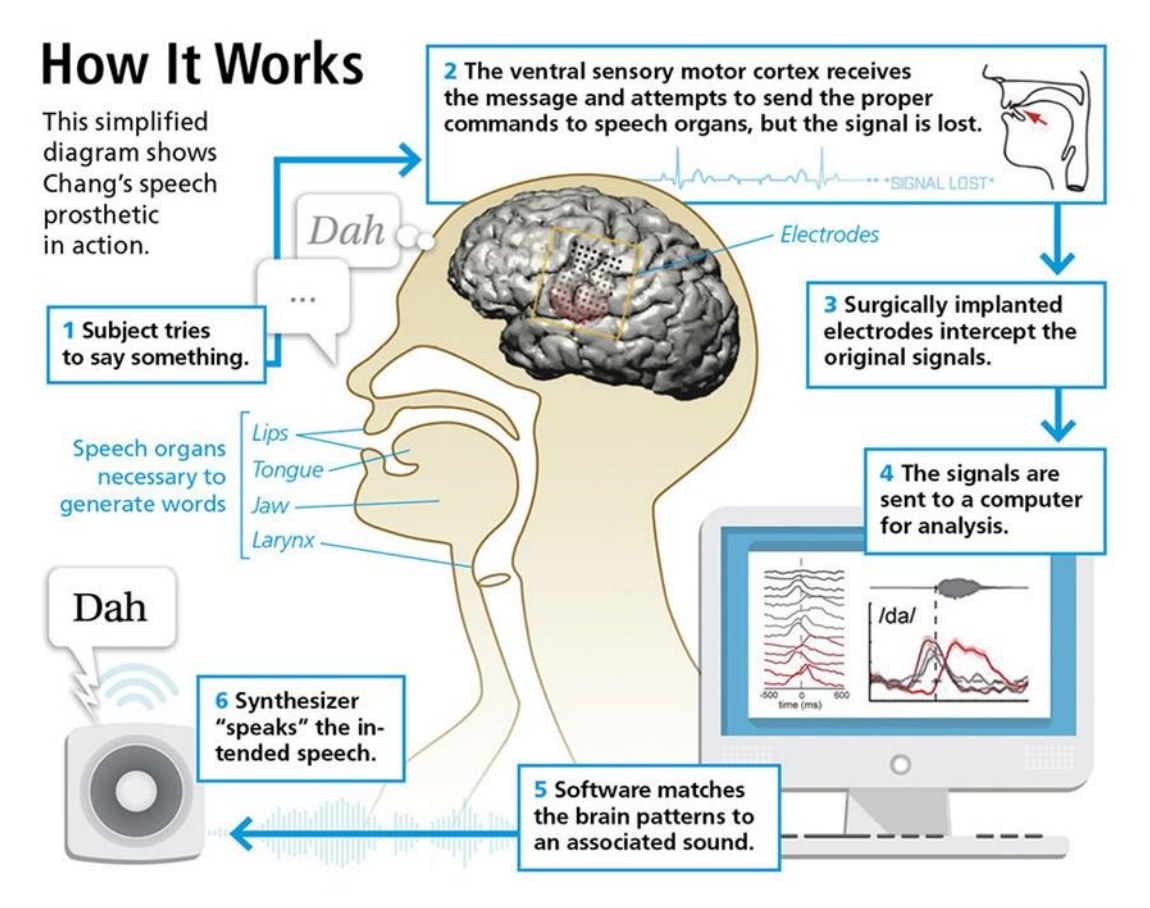
FROM THE APRIL 2014 ISSUE

Brain-Machine Interface Could Give Voice to the Voiceless

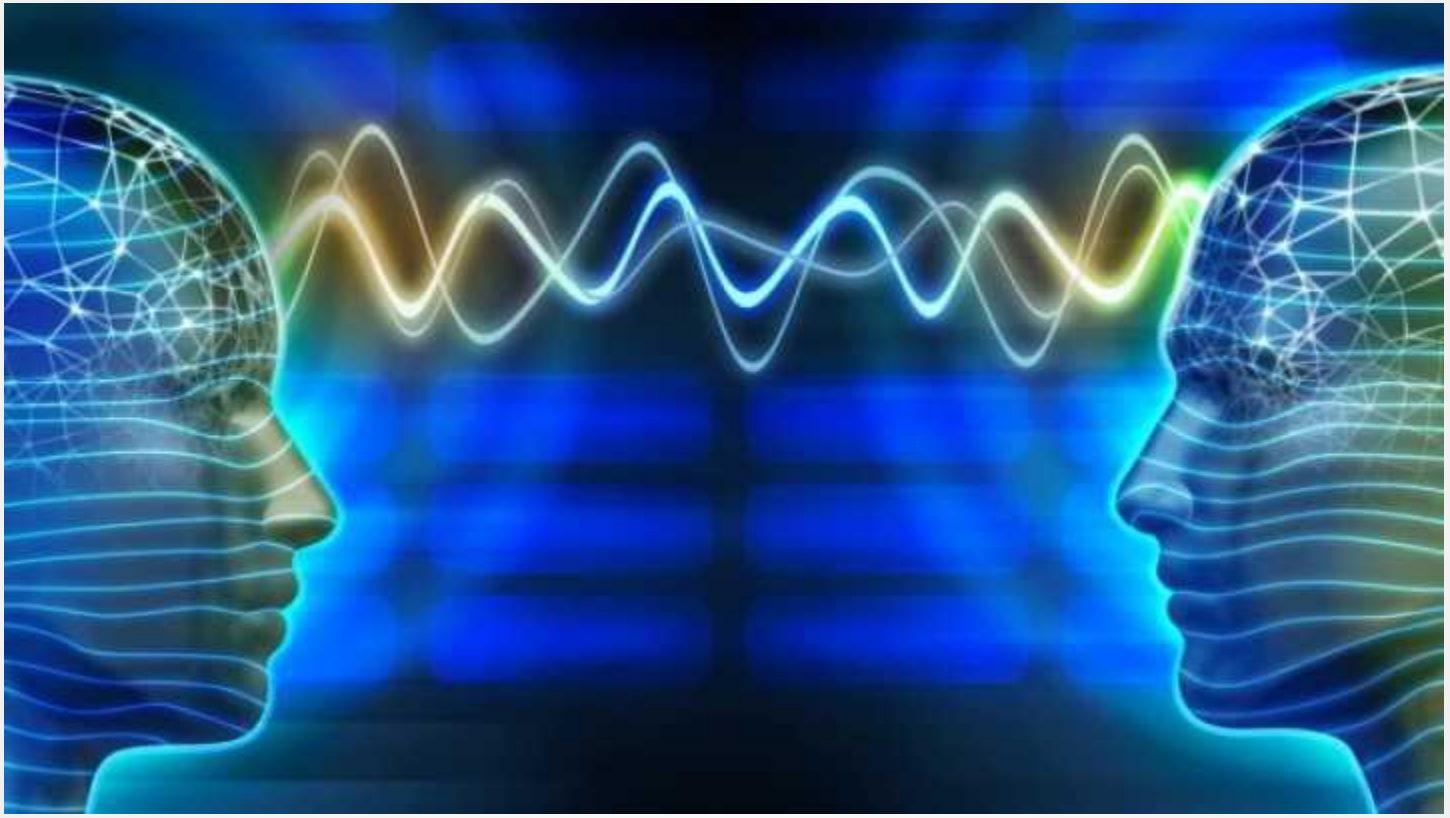
A speech prosthetic could give voice to people who can't speak, by converting their brain activity into words.

By Gordy Slack | Monday, March 17, 2014

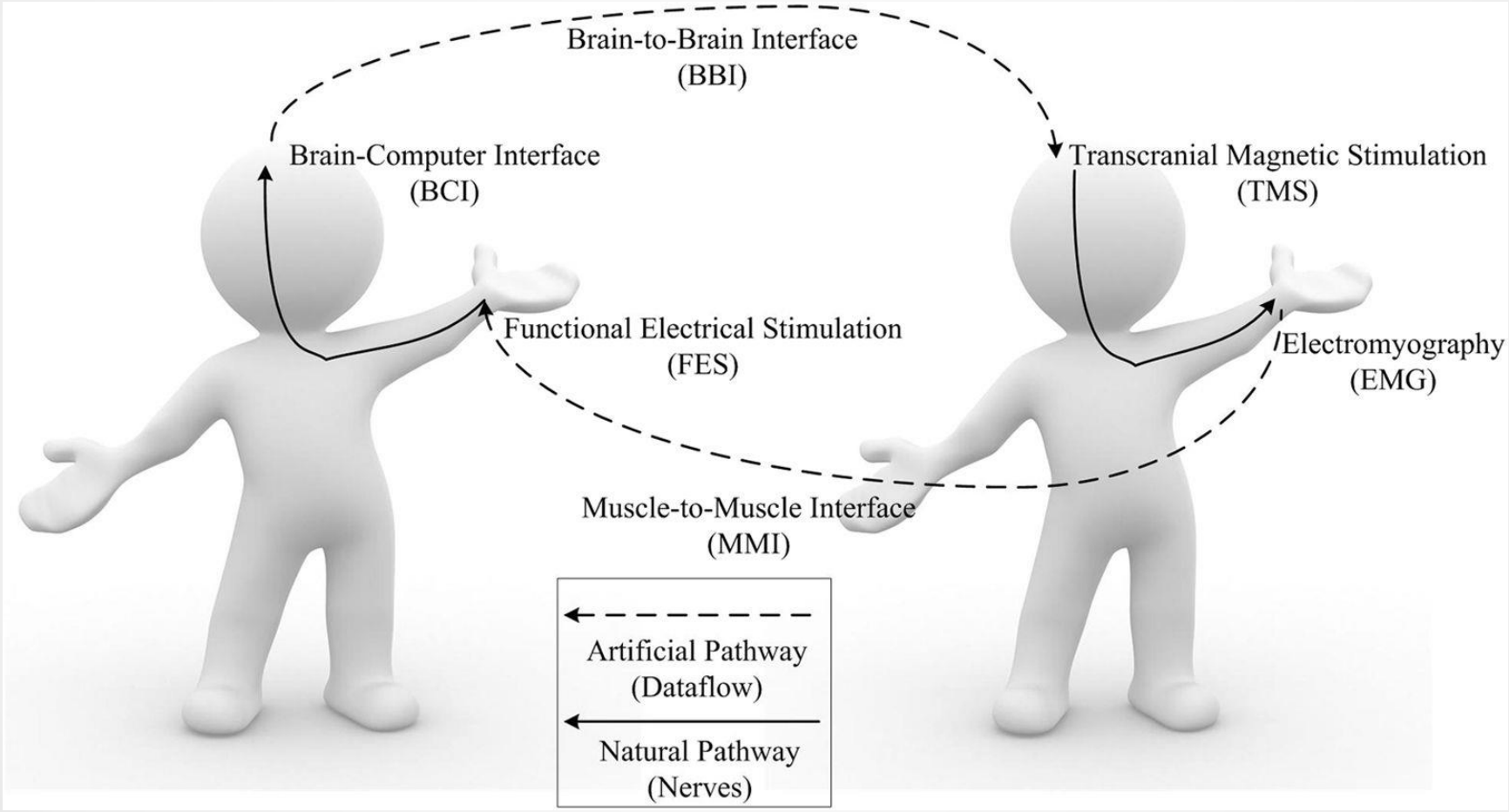
RELATED TAGS: BRAIN STRUCTURE & FUNCTION, MEDICAL TECHNOLOGY

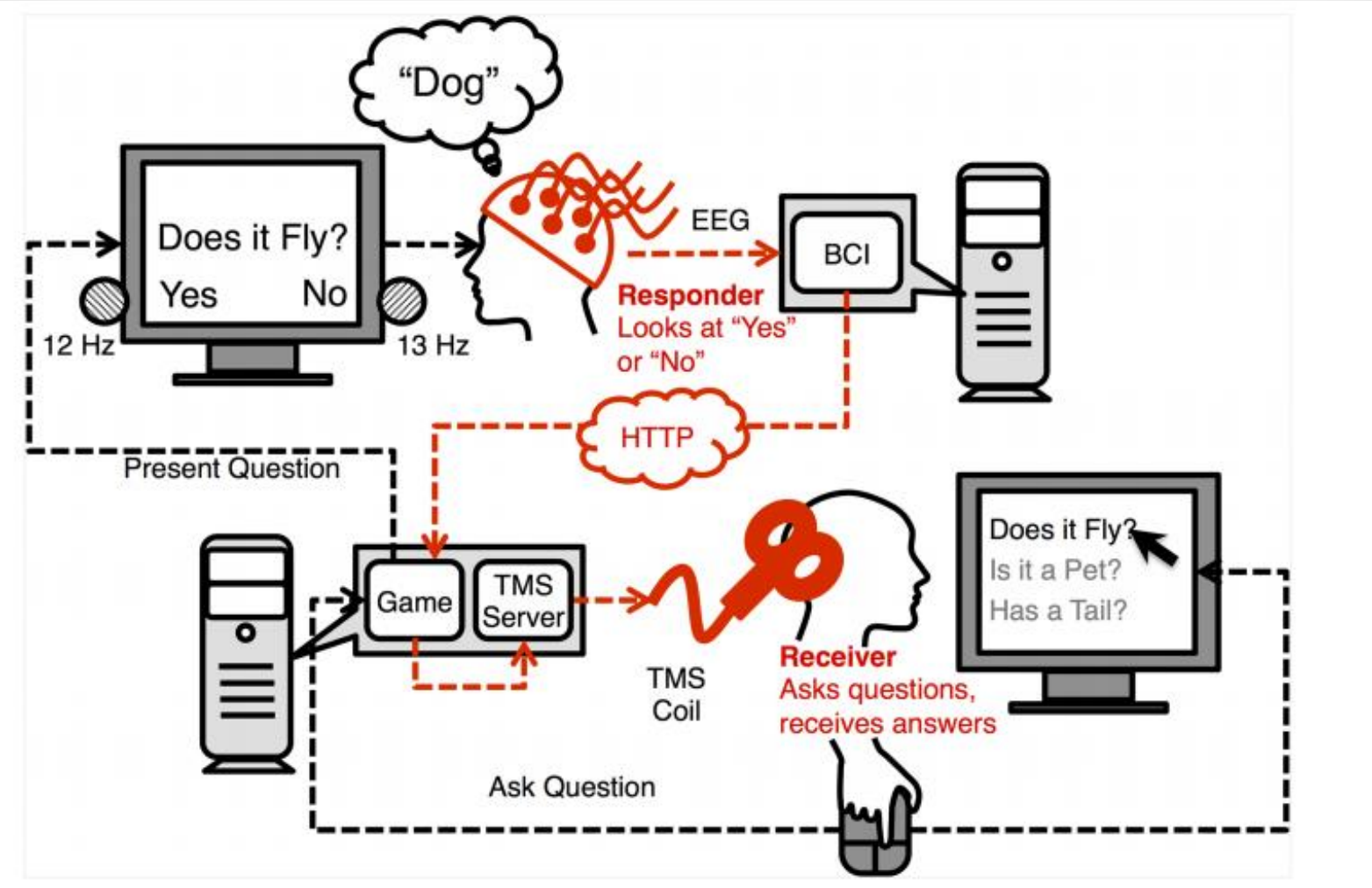


Brain-to-brain interface



Brain-to-brain interface





Scientists at the University of Washington have successfully completed brain-to-brain communication experiment. It allowed two people located a mile apart to play a game of "20 Questions" using only their brainwaves, a nearly imperceptible flash of light, and an internet connection to communicate.

Stocco A, et al. (2015) Playing 20 Questions with the Mind: Collaborative Problem Solving by Humans Using a Brain-to-Brain Interface. PLoS ONE 10(9): e0137303

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