Brain to Brain Interface

Game Changer
HIGH

Early Bird

Technology overview

Brain-brain interface (BBIs)—sometimes referred as *synthetic telepathy* or *silent communication*—technologies enable thought communication.

Neurons

BBIs use neuroscientific principles: The nervous system—brain and spinal cord—comprises neurons, connected by neural synapses, which communicate using electrical signals. Neurons send messages to neurons, or networks of neurons. Neurons' complex firing patterns underpin multiple phenomena, including memory, consciousness, and motor functions.

EEG

While understanding of these complex neural mechanisms is incomplete, by using electroencephalography (EEG)—and magnetic resonance imaging (MRI) and positron emission tomography (PET)—researchers have developed brain-computer interface (BCI) systems that can interpret brain activity. Researchers have also developed *computer-brain interfaces* (CBIs)—in particular *transcranial magnetic stimulation* (TMS) systems—that transmit information to a brain; in some cases precipitating physical reactions. BBI is an extension of BCI and CBI.

Remote control

BBI implementation will in part come through developments in these enabling technologies: DARPA has funded the development of neural implants for 'remote control' of animals. A 2003 Duke University BCI enabled a monkey to control a robot arm. In 2014, a University of Washington noninvasive BBI system captured brain signals from one researcher using an EEG, sent signals via the internet to a TMS attached to a second researcher, in an attempt to initiate finger movement.

Present weaknesses

Only two BBI systems have been demonstrated; their efficacy is controversial. Neuroscientists do not fully understand the brain. BBIs only convey simple "on-off" messages. Equipment is currently slow and complex.

Related fields

Biotechnology; neuroscience; BCIs/BMIs; healthcare; organic computing; wireless/internet communications, data security; interfaces; microelectronics.

Civil uses

healthcare and medicine, in particular, rehabilitation; training, instruction, and machine operation. Long-term, BBIs could enable wholly new, disruptive, communication concepts.

Research trends & Main challenges

Research trends are broad and aspirational. A major research area is the replication
As highlighted above, BBI research programs involve combinations of BCIs/CBIs. Researchers have developed BBI systems that can transmit simple—almost binary in

Replication

Record, Store Brain Activity

nature—pieces of information. For example, researchers at Starlab Barcelona claimed to send a message between Kerala and Strasbourg; the binary message used a TMS to cause the receiver to see light pulses. Understanding brain function is a huge task, and a key challenge for future BBIs. Nevertheless, incredible progress has occurred in the past 20 years; progress that will continue. European and US researchers plan to create technology that can record, store, and play back, brain activity.

General Valuation

Immature

BBI is an immature area and is available only in research laboratories. Nevertheless, related technologies such as BCIs are more mature. Some enabling components such as EEG, functional MRI, and TMS are already commercial. Progress in these enabling technologies will contribute to the success of BBI.

Uncertrain

Some simple BCI technology has crept toward the mainstream. In the mid-1980s, Atari experimented with an EMG headband to detect muscle movements. In the late 2000s, NeuroSky announced EEG/EMG interfaces for entertainment, automotive and health applications. The effectiveness of these systems is uncertain.

Controversial

As the technology progresses, becoming faster and more accurate, BBI is likely to become controversial—for numerous security and privacy reasons. Competing technologies include all existing communications approaches (voice, text, video), and also automation and robotics (effectively, machine-machine interfaces), because automation reduces the need for person-to-person communications.

Defence & Security Valuation

DARPA

The prospect of seamless, wordless information transmission between people and personnel is highly significant—and already of interest to the global defense community. Indeed, a significant amount of BBI, BCI, and neuroscience research is funded by military organizations. For example, DARPA has funded research into BCIs and BBIs (including some work at Duke University).

Communication

Opportunities exist for novel defense-related forms of communication—communication that could render spoken language obsolete in some applications. Training and tutoring is particularly important in defense settings; BBIs could revolutionize training, perhaps enabling instant training of military personnel. Beyond remote control and military-focused medical and rehabilitation applications, long-term opportunities also include connected living systems: Duke University researchers report to have connected the brains of rats, enabling a new form of swarm intelligence.

Privacy

Threats include surreptitious use of BBI, BCI, and CBI approaches. Currently, these technologies are either invasive or at least require wearable interfaces. As this technology becomes more compact, and perhaps more pervasive, new threats could emerge—in particular, hacking. Advanced interfaces could make privacy itself obsolete.

Main actors

University of Washington, Starlab Barcelona (BBIs); DARPA, Duke University, Brown University, Shandong University, State University of New York, Honda, ATI, Toyota (enabling technologies).

Recommendations

Observe & Try

BBI falls into an Observe category. However, enabling BCI/CBI technologies fall between the Observe and Try category—depending on technology complexity). In particular, some BCI technologies fall into the Try category—largely because some simple commercial products exist.

Human augmentation

Key recommendations include tracking and monitoring developments in this technology, and also importantly in related fields—in particular, human augmentation, brain-machine interfaces, and neuroscience in general. In terms of BBIs, one should establish clear signposts that initiate a shift in BBI technology from Observe to Try. (For example: a method emerges for transmitting useful body motions, or perhaps instructions, to another person.)

Disruptive Communication & Training

Although BBI technology is likely to see slow development and adoption, it could render a number of existing communications technologies obsolete. For example, it could replace instant messaging and email in some applications. It could also compete with traditional rehabilitation and—importantly—training methods and procedures.

EDA Taxonomy

A05.01, A05.03, A08.07, A10.01, A10.12, A10.05, A10.08, C01.03, C08.02.