Jonas Calsbeek

Neuro403

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Mind Control in the 21st Century: Humans, Animals & Robotics

Introduction:

What if you could communicate with your best friend using only thought, without saying a word? What if we could communicate directly with one another through brain waves alone? Vast amounts of time and energy go into studying or learning languages, when a simpler answer might be right at the doorstep. Recent developments in neuroscience research have opened the door to a world of possibilities where brains cooperate with computers to allow direct communication between humans, animals and machines without the need for Rosetta Stone® or brain surgery. These breakthroughs include human brains communicating with another across the internet, directly controlling an animal's movement and controlling a bionic limb connected to the central nervous system. Imagine the ability to control a prosthetic limb using only thought, and how this technology could change the future of bionics. These activities are possible by technological advances in recent years that have allowed for the integration of computers into humans and animals. Using a computer to encode and decode neural activity is analogous to how the biological nervous system works, and we might begin to solve serious human problems using

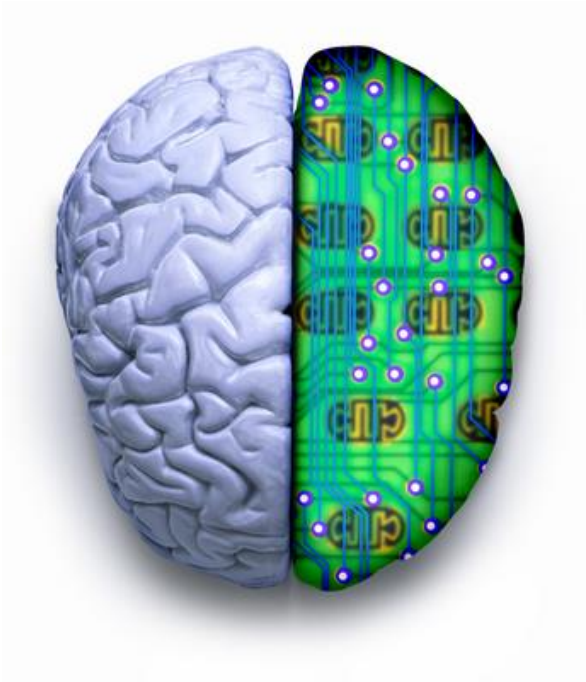

Figure 1. Brain/Computer Concept Art

technology. In humans or animals, this technology is called a brain-to-brain interface, but when a computer is involved it is referred to as a brain-computer interface or BCI. Replacing the need for language in communication with a BCI allows for the unprecedented ability to transfer information between organisms and computers at the speed of the human brain.

Human to Human Interface

University of Washington (UW) scientists achieved a remarkable breakthrough in a recent study that developed a direct human brain–to-brain interface across a network. In the study, two participants cooperatively played a video game that required a virtual rocket fired toward a city to be shot down with a cannon. One subject wore a special "sending helmet" connected wirelessly to his brain and the other subject wore a wireless "receiving helmet" in a different building across the UW campus. The sender was able to see the videogame screen but couldn't control the cannon, while the receiver was unable to see the screen but could operate the cannon with a button. The sender would watch the rocket approach the city and simply *think* about firing the defensive cannon, and the receiver would successfully activate the cannon to stop the incoming rocket up to 83% of the time (Rao, 2014).

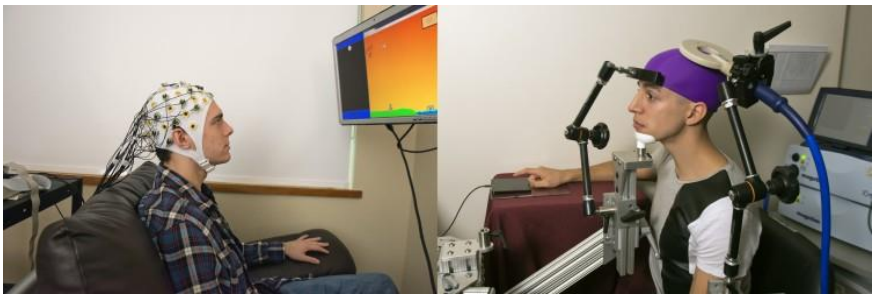

Figure 2. Videogame coordination across campus at UW.

Another example of a human brain-to-brain interface involved the use of the internet to allow human brains to communicate directly without the use of conventional communication. This demonstration was carried out by a team of researchers from Spain, France and the United States led by Dr. Carles Grau from Barcelona, Spain. The study sought to enable brain to brain communication between two subjects located 5000 miles apart via email. One subject used a BCI

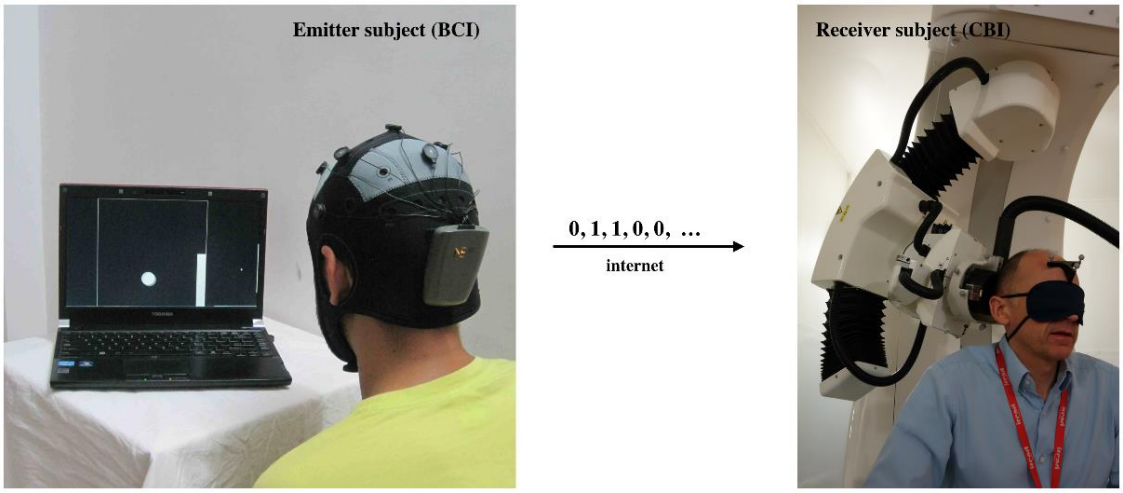

Figure 3. Human Brain Connection over Internet from India to France

that encoded the thought of the words "ciao" and "hola" from his brain and sent them through email from India to a second subject in France. The receiving subject used a computer-brain interface (CBI) that decoded the incoming signals into real thoughts in his brain for accurate pronunciation (Figure 3). The receiver was successful in understanding the thoughts arriving in his brain and repeated back the sent messages without error (Grau, 2014).

Human to Animal Interface

Similar research has been performed between humans and animal brains to study the possibilities that might exist for improved communication between species. Researchers from South Korea and the United States discovered that they could intentionally influence specific brain regions in a rat using a device

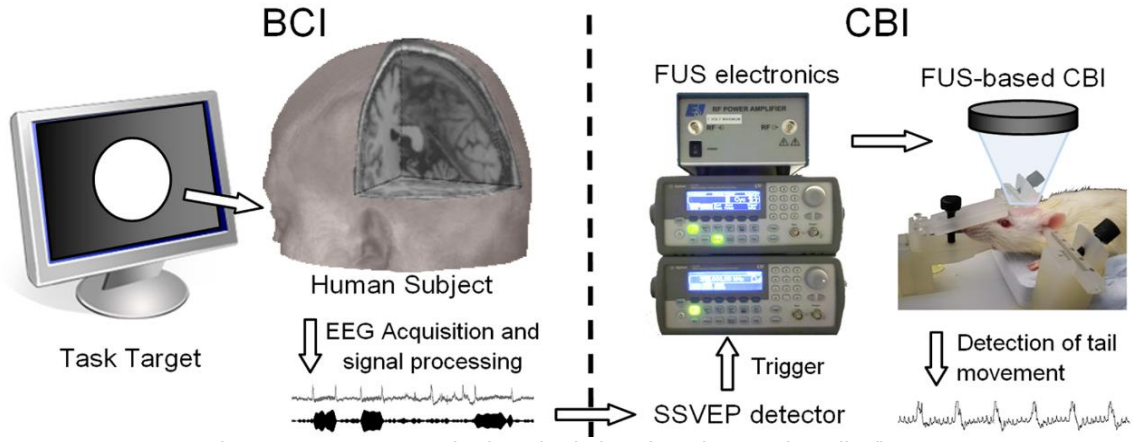

Figure 4. Human to rat brain to brain interface (Harvard Medical)

known as a transcranial focused ultrasound BCI. This device allowed a human subject to control the rat's tail movement by thought alone! The human generated an intent to influence the rat's tail movement that was translated by the BCI to stimulate the motor control part of the rat's brain to produce the intended tail movements in real time (Yoo, 2013).

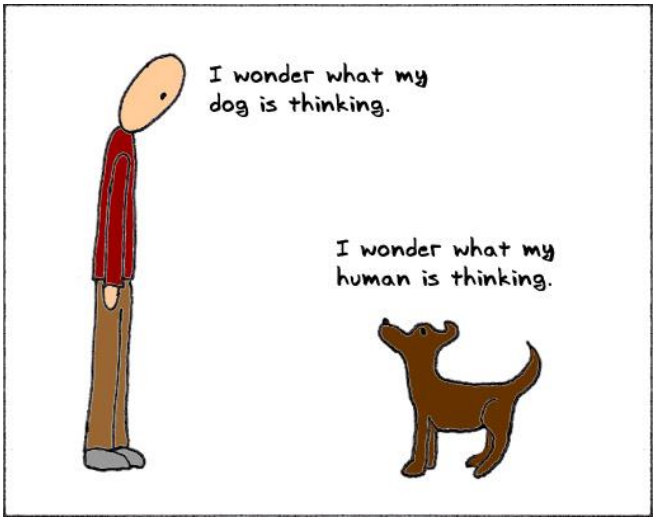

Figure 5. Human-animal thought cartoon

A controversial new product being developed in Scandinavia known as "No More Woof" also demonstrates human-to-animal brain interaction. This product is currently being designed to translate the thoughts of dogs into human language using BCI technology that already exists. The device works theoretically by interpreting and translating common brain states in a dog, and translating those thought patterns into human language through a digital speaker (Figure 6). The product is not yet ready for commercial production but the lab working on the concept is confident that they have stumbled onto future technology. According to their crowd-funding page, they acknowledge the challenges they are facing while hoping for future success: "Yes, we HAVE achieved some results, but we are very far from a mass-producible product. That said, we believe that within a few years the technologies we are working with will revolutionize our relation to pets and animals (Sakr, 2013)."

Figure 6. "No More Woof" concept art from Indiegogo

Human to Computer Interface

With all the developments in brain-to-brain research, the computer should not be left out of the discussion. Promising technology can change the future for biology through the use of bionics. From paralysis to amputees, many humans and animals struggle from debilitating circumstances that prevent them from experiencing life to the fullest. By exploiting the technology of the BCI, new research has discovered how computers can aid in physical therapy, motor control assistance, and movement where none was ever expected again. For example, at the 2014 World Cup a paraplegic was able to make the first kick of the match by using an exoskeleton BCI that bypassed his spinal cord injury, allowing for leg movement directed by his brain to kick the soccer ball (Servick, 2014). This amazing feat was made possible by the research of Duke neuroscientist Miguel Nicolelis and the Walk Again Project, a team of 166 neuroscientists that developed a brain-controlled exoskeleton with hopes to make wheelchairs a thing of the past (DeClerq, 2014).

Figure 7. Paraplegic kicks first kick of 2014 World Cup using exoskeleton

Brains working alongside computers to benefit mobility through BCI communication has been demonstrated in rehabilitation by connecting a BCI directly to the central nervous system. This is accomplished by implanting a small electrode in the outer layers of the human cortex that can detect and

record nerve impulses to send to the BCI. The computer translates these signals and moves a cursor on a computer screen viewed by the patient, allowing him to use the cursor to type and respond to questions using thought alone. A team from Neural Signals Incorporated led by Dr. P. R. Kennedy from Atlanta, Georgia found that the subject was able to move the cursor simply by thinking about driving the movement of the pointer, and he was able to achieve writing rates of 3 letters per minute (Kennedy, 2000). After 192 days, they found a drastic decrease in error counts in a plot of speed versus accuracy as illustrated in panel D of Figure 8, meaning this skill can improve with training. In the future, technological advances could greatly increase the rate of communication and enable these discoveries to be exploited to benefit victims of stroke, paralysis or debilitating diseases.

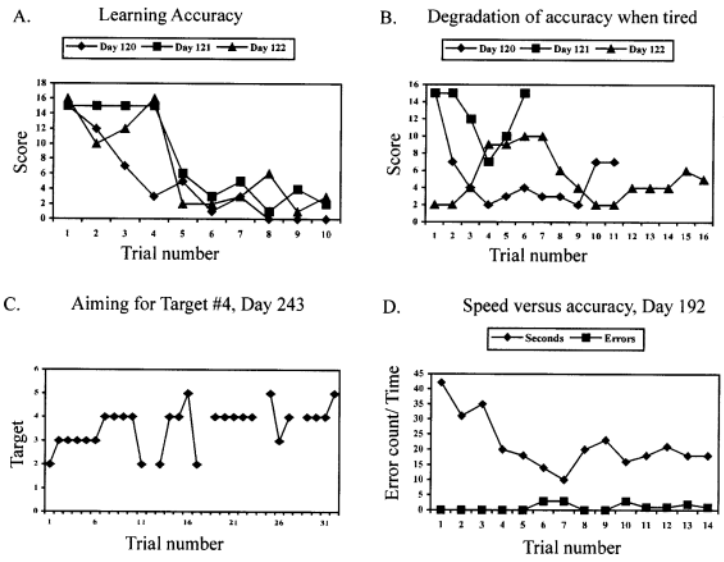

Figure 8. Results adapted from Kennedy et. al, 2000

Conclusion:

Technology is providing the means to augment language in communication with recent advances in brain research as well as computer science. Not only could this research change the way humans and animals communicate, it could also shed light on the other intelligence that surround humans on this planet. There is a constant search for other intelligent life within the universe, but other forms of intelligence exist on Earth already such as whales, dolphins or octopuses to name a few. It may be possible to learn the cognitive capability of these other intelligent beings with the help of BCIs. This could enable humans to communicate and benefit from understanding the cognitive processes of other advanced evolved creatures and change our lives forever!

References:

DeClerq, Katherine. "Cyborg-soccer: How a Paraplegic Took First Kick at the World Cup." *CTVNews*. N.p., 14 June 2014. Web. 27 Feb. 2015.

Grau, C., Ginhoux, R., Riera, A., Nguyen, T. L., Chauvat, H., Berg, M., ... & Ruffini, G. (2014). Conscious brain-to-brain communication in humans using non-invasive technologies. *PloS one*, *9*(8), e105225.

Kennedy, P. R., Bakay, R. A., Moore, M. M., Adams, K., & Goldwaithe, J. (2000). Direct control of a computer from the human central nervous system. *Rehabilitation Engineering, IEEE Transactions on*, *8*(2), 198-202.

Rao, R. P., Stocco, A., Bryan, M., Sarma, D., Youngquist, T. M., Wu, J., & Prat, C. S. (2014). A direct brain-to-brain interface in humans. *PloS one*, *9*(11), e111332.

Sakr, Sharif. "Yes, This Is Dog: No More Woof Aims to Translate Canine Thoughts into Human Speech." *Engadget*. N.p., 18 Dec. 2013. Web. 27 Feb. 2015.

Servick, K. (2014). Kickoff looms for demo of brain-controlled machine.*Science*, *344*(6188), 1069-1070.

Yoo, S. S., Kim, H., Filandrianos, E., Taghados, S. J., & Park, S. (2013). Non-invasive brain-to-brain interface (BBI): establishing functional links between two brains. *PloS one*, *8*(4), e60410.

Figures:

1. https://imaginingtheinternet.files.wordpress.com/2011/04/computer_brain_white.jpg
2. http://www.washington.edu/news/files/2014/11/BrainToBrainSenderReceiver-750x248.jpg
3. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0105225
4. http://journals.plos.org/plosone/article/figure/image?size=medium&id=info:doi/10.1371/journal.pone.0060410.g001
5. http://almostmakessense.com/comics/2009-06-10-dog-thinking.jpg
6. http://www.engadget.com/2013/12/18/no-more-woof-indiegogo-concept-dog-headset/
7. http://iq.intel.com/mind-controlled-robotic-exoskeleton-kicks-off-the-2014-world-cup/
8. http://www.atriumtech.com/muic2008/icsc302/papers/Brain-ControlledComputer.pdf