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Regulating the Brainspray Revolution

By Theodore F. Claypoole

On August 12, 2013, University of Washington computer science professor Rajesh Rao sat in his lab playing a video game. Rao could see the video game, but he didn't hold a game controller. Instead, across campus at the same time, fellow researcher Andrea Stocco had his hand on the game controller, but Stocco couldn't see the game.

Rao, wearing a cap filled with electrodes to read his brain signals, simply thought about specific movements of the game controller, while Stocco, wearing a cap with a transcranial magnetic stimulation coil placed directly over his left motor cortex, involuntarily moved his right index finger to push the game controller, firing a cannon in the video game. Without invading either head, the two researchers were able to share directed thoughts, over a distance connected by the Internet. Rao's cap captured his "brainspray" – brain signals available for capture and interpretation outside his head – and sent the precise signal to Stocco, whose brain accepted the signal and instructed his body to act on it. "The next step," said Rao, "is having a more equitable two-way conversation directly between the two brains."

As demonstrated below, humanity has entered into an era where the deep study of our brains is combining with sophisticated technology to project brain signals, to interpret brain signals, and to transform brain signals into physical action. Once the realm of science fiction, businesses currently exist to allow brainspray control of mechanical objects. For years, scientists have been able to see into our brains, capturing and measuring response to stimuli, but now they can accurately interpret what those signals mean and relay them into actions that can fly a drone or help a person who has lost use of his or her arms to feed him or herself. In addition, technology tends to become cheaper and easier to use over time, so we should expect dynamic growth in the field of capturing and applying brain signals. This technology can provide benefits beyond imagination to the injured and infirm, can make our soldiers and pilots more efficient, and can lead to consumer and business product interfaces controlled through directed thoughts alone.

While we are well on our way toward realizing these benefits to society, we are not adequately prepared as a society for the regulation of this technology. Clearly we have no current laws distinguishing between the legitimate and illegitimate use of technology to capture someone's brain signals without that person's consent, not to mention the technology that can force bodily action through brain stimulation alone. We have no rules about storing and using the brain signals of another person and the intellectual property that might arise from these signals. In the United States, our legal protections for personal privacy are riddled with gaps encompassing the current technology, and larger gaps for the invasive technology that will arise in this area. In short, we are ill-prepared for the brainspray revolution, and we should be examining policy options before it is upon us.

Brainspray: The Current Applications and Research

Brain signal capture and application is not a speculative future advance, but a set of technologies that exists right now. Businesses are using directed thoughts to create consumer toys that play games and move objects in the real world. Doctors are capturing brainspray to help enable people who have lost the use of important body parts and functions. Researchers are peering into brains and interpreting or applying the information they find there. New technologies are developed or expanded to capitalize on each of these advances, but the technology and knowledge we currently possess is already impressive.

In November of 2012, a California company called Puzzlebox published a plan on the business crowdfunding site Kickstarter. Puzzlebox was raising money by promising to deliver a small remote-controlled helicopter globe that used an electroencephalogram headset, plus a mobile phone to fly the drone helicopter only by the user's thoughts. Unsurprisingly, Puzzlebox quickly completed funding through Kickstarter to build and sell the MindWave Mobile compatible brainwave controlled

helicopter. Puzzlebox's partner in this venture, NeuroSky also sells a set of "cat ears" that a person can wear, which express the wearer's mood by capturing brain signals and turning them into movements of the furry appendages. In a less frivolous application of the technology, NeuroSky sells the MindWave headset to monitor attention levels of students as they react with mathematical, memory, and pattern recognition applications. The company also sells its brainwave sensing technology chips to other companies who wish to create completely new applications.

Another company offering an electroencephalographic reading helmet is Emotiv Lifescience, whose CEO Tan Le is a well-known evangelist for controlling machines through a brain interface. Emotiv's brainwave readers are being used by the Grateful Dead's Mickey Hart to make music simply by thinking of the sounds, and by a Chilean company to create three-dimensional objects by picking shapes from a screen with directed brain waves. Emotiv equipment has been used to operate video games, and German engineers in Berlin have built an Emotiv brain interface into a car's controls, although they have not produced a roadworthy product yet.

Emotiv brain helmets have helped create the world's first thought-controlled wheelchair in Japan, and scientists in Switzerland have built on the concept to allow "shared control" between the brain and the sensors in the chair itself. The shared control is easier for the chair's controller, who does not need to give every command to make the chair move or stop.

Clearly an important task for brain-controlled devices is assisting people who have lost limbs or abilities. For example, Ambient Corporation has developed a neckband that reads thought directions for about 150 words, and then wirelessly signals those words to a computer to voice the thoughts out loud. There are clear applications for this technology in silent voice commands for military operations, and the U.S. Army has already invested in transcranial ultrasonic stimulation helmets to transfer orders and affect soldier's brains. CBS news magazine, *60 Minutes*, and ABC News featured University of Pittsburgh researcher Andrew Schwartz, who has been working since 2006 to find ways for a person to control a robotic arm with only brain signals. Working with Dr. Schwartz, surgeons implanted four microchips in a paralyzed patient's brain that translate her brain's signals into movement of a robotic arm. As demonstrated on television, the patient can feed herself through thought instructions alone.

Other instances of "bionic" limbs controlled by directed thoughts include former Army Staff Sergeant Glen Lehman, wounded in Iraq, who can manipulate a prosthetic arm with his mind, including drinking coffee and bouncing a tennis ball. The Defense Advanced Research Projects Agency (DARPA) is funding research in prosthetics controlled by mind signals to address the problems raised by the more than 2,000 U.S. service members that have undergone amputations since the year 2000. The DARPA projects not only focus on signals from brain to arm, but have made strides in the important field of reverse signals from the prosthetic arm back to the brain of a subject. One DARPA funded prosthetic connects the nerves of an amputated limb to enable a sense of touch with neural feedback similar to a natural arm.

An entirely different technology is also spawning applications to read a subject's brainspray and turn those thoughts into physical action. The Functional Magnetic Resonance Imaging (fMRI) machine measures blood oxygenation and flow in the brain and is known for such diverse tasks as brain mapping for clinical use and discovering a "sixth sense" of numerosity in the human brain. The technology allows researchers to identify which areas of the brain activate when certain emptions are evoked, and fMRI has been used commercially for lie detection and advertising evaluations. Honda has applied fMRI brain reading technology to create a helmet that allows its wearer to move a humanoid robot by simply thinking about what appendage to operate. By imaging the movement of his or her right hand, the helmet-wearer can operate the right hand of the robot.

These varied technologies and applications are only a launching pad from which humanity will grow an entire body of science and tech built around a brain-machine interface, allowing people to control an entire range of physical movements and tools – from cars to robots to war machines – with directed thoughts. This science also allows intrusive capture of brainspray, and the tools to interpret the captured signals. In some cases, we have already seen how machines can stimulate a body's involuntary movement by triggering reactions in the brain. And like all useful technology, enormous sums of money will be spent by governments, businesses, and health researchers to make these tools more effective, less expensive, and easier to use.

Legal Issues and Regulation of Brainspray

As this technology develops, legal and ethical questions will increase. Who owns the information generated by a person's brain that is captured by technology created and refined by a company or government? When does the interpretation of brainspray trigger privacy laws? How far can anyone go in reading the thoughts of a person without that person's permission? What kinds of laws can be affected by brain-to-machine interfaces?

The privacy implications of a brain-machine interface are similar to those that exist now on the Internet. Just as a deep knowledge of a person's Internet surfing and searching can provide a distinct picture of that person's thoughts and priorities, the ability to capture someone's brain signals and interpret them would tell an intimate story about that person. Similar to current personal Internet records, we would be concerned about our interior thoughts being exposed to business and government, as well as to predators and even certain neighbors or family members. Any of these people or organizations could use our Internet records or our direct thoughts against us in many uncomfortable ways. And of course, in the United States, we have very little effective regulation about who can see our Internet activities, and the recent National Security Agency scandals have shown us

that even where laws exist to protect our privacy, institutions and individuals are finding ways around them. This is likely to be equally true when the information sought is the direct brain connection of an individual, just as it is true for that person's Internet activity. Without more effective laws protecting personal privacy, it is likely that Americans will be vulnerable to an onslaught of thought capture as the technology improves to harness brain signals.

It seems the most obvious legal problem with the ability to capture and interpret brainspray is the possibility that someone will use the technology to invade another person's thoughts without that person's consent. And like many places in the law where a person's consent is required, the method of attaining and then proving consent may be difficult to prove. In many cases, consent may simply be a matter of acquiring a confirmation signature prior to using a person's private financial or health care information. But many messy aspects of life make proof of consent a dicey topic. For example, after taking pictures at a crowded festival, a photographer is likely to find it impossible to track down specific photographed individuals if he she decides to use the pictures commercially. The medical establishment has not always requested consent for use of tissue samples in research, and often the tissue donors have passed away before the question arises. Two decade's worth of police procedurals have been based on the difficulty of proving consent, or lack of consent, in sexual relations. If the technology advances enough for law enforcement, government, or even an employer to read a person's brainwaves without that person's knowledge, when would consent be needed and what kind of consent would suffice?

The law frequently acknowledges that context is important in regulating behavior. It might make a difference why the brainspray is being accessed in the first place. By analogy, not every release of a person's medical or health information is protected by the medical privacy laws in the United States. A patient who allows collection of DNA for medical treatment is protected under the privacy sections of HIPAA, but a suspect who allows collection of DNA by the police for an identity match may not have that DNA protected as private under the law, and a person who sends his or her DNA to a private lab for a heritage review analysis is not protected under the law, only the lab's voluntary privacy policy. Similarly, under the U.S. business-friendly privacy laws, if a retailer reads the brainspray of customers at the checkout line to check for shoplifting or to analyze each customer's satisfaction at the shopping experience, nothing under current law would be likely to prohibit those actions; especially if the retailer offered a discount on sales to customers who allowed such a passive examination ("VIP card customers get 10 percent off on ice cream in exchange for passive satisfaction reading of brain waves"). Currently, Google is able to look inside all e-mails that pass through its servers and to keep records of all of the searches you perform with its tools, so how much more intrusive is a painless passive quality check of brainspray in passing? If courts and legislatures are not prohibiting these activities, they may remain aloof about limiting further data collection from consumer's brains.

However, it does seem likely that private commercial use of brain signal capture technology will raise the concern of judges, if not legislatures. While new laws may be passed to address this issue, older rules may be stretched to fit this situation as well. We can see this trend in a ruling filed the week this article was written, where a three-judge panel of the Ninth Circuit Court of Appeals upheld a lower court's ruling against Google for invasive intrusion into people's private space. *Joffe v. Google*, D.C. No. 5:10-md-02184-JW (9th Cir., Sep.10, 2013). Google contended that its apparently random "war driving" capture of private information from unprotected Wi-Fi in people's homes and businesses could not, by law, be considered wire-tapping under the definition of the federal and state wire-tapping statutes, because unencrypted Wi-Fi data could be picked up by anyone with the right equipment. The court clearly felt that using sophisticated listening systems to capture information that people considered private may well cross some kind of legal line, and wire-tapping was the closest line available. Judge Bybee wrote, "Even if it is commonplace for members of the general public to connect to a neighbor's unencrypted Wi-Fi network, members of the public do not typically mistakenly intercept, store, and decode data transmitted by other devices on the network." When Google argued that anyone who purchased a certain spy device could read unencrypted Wi-Fi signals, the court refuted this argument by stating, "A device that surreptitiously logs a computer user's keystrokes can be purchased online and easily installed, but that hardly means that every keystroke – whether over a wired or a wireless connection – is "readily accessible to the general public." Similarly, using sophisticated equipment to capture the most intimate and personal of signals for private gain may be too much for a court to tolerate, and it may co-opt an existing set of laws as basis for prohibiting this behavior.

Similarly, if the technology for brain signal capturing became pervasive and inexpensive, how would we regulate a prospective father-in-law testing the intentions of his daughter's suitor? Would we find it problematic that a new generation of spouses would be able to tell if their mates were being honest about that late night of working, or even about whether the spouse really looks fat in those new pants? And when teenagers gain access to the brainspray readers, could we expect mature and sober evaluations of friends, love interests, and parents? Would there be age restrictions on appropriation and application of brain signal analysis? Are these everyday applications too insignificant to become a source of regulation, or is the invasion into a person's thoughts simply too creepy to be allowed at the most personal levels without consent? And then again, how would we measure coercion of that consent? The most quotidian tasks and interactions of our lives will be altered forever when others can know our thoughts and emotions with more precision. Etiquette would likely

instruct us that unauthorized brain reading is rude and inappropriate, but many of our civilized customs are not enforceable in law. As many an attorney has told a pleading client with a tenuous claim, there is no law against being a jerk, so passive personal use of brain signal technology may be tolerated by the law, even if frowned upon socially.

If an employer captured and analyzed brain signals for job purposes, then state employment laws and federal labor laws are likely to provide some limitations, just as the U.S. National Labor Relations Board has been recently aggressive at limiting employer's use of social media complaints in union organizing campaigns, and just as several states have restricted employers from forcing employees to provide passwords to private accounts. See *The NLRB and Social Media*, www.nlrb.gov/node/5078; and *Employer Access to Social Media Usernames and Passwords*, www.ncsl.org/issues-research/telecom/employer-access-to-social-media-passwords.aspx. The asymmetrical power relationship between employer and employee often triggers concerns about fairness that may not exist in other situations. The existence of a separate set of employment regulations would also make it easier to limit intrusive brain studies in employment as part of the nation's industrial policy. The same may be true for education, where many parents would be concerned about the school administration examining a student's moods and thoughts, rather than evaluating him or her on classroom behavior.

Under U.S. laws, access of private data by law enforcement is a special case and may raise Constitutional concerns. The Fourth Amendment promises us security in our persons, houses, papers, and effects against unreasonable searches and seizures. Because the technology is in its infancy, it seems unreasonable that police would investigate or interview us in a manner that allows our own thoughts to be read from outside our head. We would not know how to guard against such intrusion. When the government even passively reads a citizen's brainspray, the government is likely violating the Fifth Amendment as well, forcing a suspect to incriminate him or herself as his or her brain provides the vital information needed to arrest and convict. But once we become used to passive brain reading, it is really no more than reading a person's other involuntary reactions – sweaty palms, stuttering speech, glances cast to the side – that interrogators rely upon all of the time. It may be that rather than prohibiting the collection and analysis of brain signals by the police, our society allows this behavior but sets limitations on the evidentiary value of the information collected in this fashion, and/or that courts require a warrant to use brainspray capturing technology.

Under the *Katz* test of reasonable expectation of privacy, we would currently be reasonable to expect that the thoughts inside our heads would be private. *Katz v. United States*, 389 U.S. 347, 88 S. Ct. 507, 19 L. Ed. 2d 576 (1967). But the *Katz* test allows for changes in social norms. For example, it may soon be unreasonable for U.S. citizens to expect behavioral privacy anywhere but in their own homes, given the expansive systems of cameras, drones, and satellites available to watch their every move. Similarly, it may soon be unreasonable to expect that U.S. citizens can expect geolocation privacy anywhere at all, given that smartphones, cars, tablets, and other items capture and report location data constantly. So it is not outside the realm of belief that one day brain scanning and reading technology will become pervasive enough that it would be unreasonable for a person to believe that he or she were not open to a scan while standing in a public place, or stopped in a car at a traffic signal.

One of the most intriguing questions is whether the invasion of a person's thoughts ever will be considered a criminal act in this country? We have been discussing passive capture and interpretation of brain signals, which could, in itself, be considered an assault on the victim whose brain was mined for data. Assault has traditionally been both a crime and a tort, and it consists of a threat against a person combined with the present ability to act on that threat. Battery, on the other hand, involves a touching of a person and harm resulting from that touch. Battery also supports both civil and criminal penalties. The field of brain signal research and practical applications show us that brain crimes could be possible even given the technology available or under consideration right now. For example, actively forcing signals into a person's brain without that person's permission can be a sort of "brain rape," especially if the victim is made to act involuntarily as a result of the imposing signals. It is easy to imagine the use of a special helmet by the military that is capable of affecting brain health with a transcranial magnetic or ultrasonic stimulation device, so that a hack of that helmet could cause damage to the brain health of the soldier wearing it or could force the soldier to take an action against his or her interest or to forgo an action in that interest. The physical effect would not have to be overwhelming to be significant. If the helmet simply made a soldier stand tall for a moment in a foxhole or hiding position, it could cause the ultimate damage. If it caused a pilot to sleep for a moment at the controls of an aircraft, the worst would occur. Such an act would meet all the elements of a crime, and could be harmful, perhaps even fatal, to the victim.

There are commercial legal issues of this technology as well. For example, a company that develops a prosthetic limb that is connected directly to the nervous system of its wearer would want to own the data generated by the computing aspects of the device. This data will be helpful in servicing the limb and in developing better subsequent prosthetics. But can we allow a company to own the interior directed thought signals of the wearer and to know the thinking process that is encompassed in each action of the limb? Data ownership of brain signals and intellectual property claims on active thoughts will open a new area of consideration for commercial exploitation of personal data. It is one thing to allow the grocery store to keep records of all that you purchase there, and another thing altogether to allow a private company to own the signals sent from your brain to your right hand.

Conclusion

Is reading or manipulating the brain from outside a person's head a legal bright line, or will we have time to grow accustomed to the practice before the law addresses it? Without a doubt, the dawn of brain signal capture and interpretation is upon us, and like other technologies in our lives, it will continue to grow in usefulness and relevance until we are all acclimated to it. We should consider the legal and ethical consequences of such technologies now, so that we are not forced to do so when the technologies and the legal implications affect us all.

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