KOPF CARRIER

October 2014

Kopf Carrier #82

PUBLISHED BY DAVID KOPF INSTRUMENTS ■ TUJUNGA, CALIFORNIA

Neuroethics in Neuroscience Series: Exploring Ethical Implications of the Commercialization of Physiological Computing

Katie L. Strong, PhD Candidate
Emory University
1515 Dickey Drive
Atlanta, GA 30322

Introduction

Although much development has been made in the field of human computer interactions (HCI), we mostly rely on peripheral controls, such as a mouse, to direct changes to a computer's interface. The future of technology will be more autonomous though due to advances in non-deliberate physiological computing (PC). Non-deliberate PC is a unique form of HCI because the user is no longer consciously expressing intentions. Instead, the nervous system is monitored and changes in physiological signals are used to infer a user's mental or emotional state (Fairclough, 2009). With the advent of consumer products that implement this type of technology, it is necessary to discuss the many associated ethical concerns.

Physiological Computing

There is a continuum for physiological computing which ranks technologies in order of intentionality on the part of the user (Allanson and Fairclough, 2004). Users can interact with input devices that are based on muscle movement such as electrooculography (EOG) in a voluntary capacity to direct the movement of a cursor. Typically, brain-computer-interface (BCI) technologies are a bit more involuntary since they are often developed for those with diminished movement abilities due to disabilities, but the general principle is the same in that the interface is translating a neural signal that the user has specifically directed to complete a task (Allison et al. 2007). On the other hand, non-deliberate PC involves a biocybernetic approach where spontaneous changes in the nervous system, such as a heart rate or electroencephalographic (EEG) signal, are monitored, rendering the user's role involuntary. These technologies are able to record a physiological change and then label the motivational, cognitive or emotional state of the user. Once the interface detects the user's emotional state, it can often adapt in an attempt to promote a specific type of positive mentality or negate a potentially hazardous emotional state. For example, if a computer calculates that the user is stressed, it can play soothing music or offer to help to diffuse the negative situation. The long-term recording of physiological data usually for learning purposes is referred to as ambulatory monitoring (Fairclough and Gilleade, 2014).

Technologies that incorporate aspects of PC, such as the recently released Kinect 2 from Microsoft, have become more prevalent in consumer products. Using technology similar to that developed at MIT and referred to as

Eulerian Video Modification (Wu et al., 2012), the camera on the Kinect monitors heart rate optically by detecting small changes in skin color pigmentation. Although pulse rate can be an indicator for an emotional state, at this time the Kinect 2 focuses on monitoring heart rates during physical activity. However, portable, wireless sensors that are able to convert raw EEG signals into meaningful information are currently available. The EEG signal is collected while the user is thinking or emoting, and since certain EEG signals are indicators of a specific emotional state, such as frustration (Kapoor et al., 2007), the interface can label or adapt to a user in real-time. For an interface to actually recognize a user's unspoken conscious intentions, a dictionary must be created where the computer records the EEG data for a series of tasks that the interface will be able to recognize later.

Two companies in particular, Emotiv and NeuroSky, have developed and currently sell wireless headsets that act as EEG sensors. EPOC, made by Emotiv, comes with different detection suites, and using these applications, a user can watch as an avatar mimics his own facial expressions, play a game that is modified based on his emotional or cognitive state, or watch as commands are executed with seemingly only the power of thought. EPOC appears to be marketed to consumers that want to enhance their current experiences when interacting with a computer. MindWave by NeuroSky is also able to enrich the user's computer experience, however one of the core values associated with MindWave is to improve the user's well-being. Two of the algorithms for MindWave are able to convert EEG signals into an attention and meditation meter. Many of the packages that come with MindWave are meant to track attention levels as a user plays a game or completes an educational exercise, although one package contains software that can detect and modify a movie based on a user's emotional changes.

In the past year, there have also been multiple successful crowdsourcing campaigns to develop similar technologies, a reflection of society's interest in having the power to monitor and utilize brain activity. The company OpenBCI, which raised over $200,000 on Kickstarter (Murphy and Russomanno, 2014), is noteworthy because all the algorithms are open source code and users have full access to their own raw data, meaning that anyone with the ability can write additional code and utilize the EEG sensor for novel, unique functionality. OpenBCI is also notable because in mid-2013, the company along with three other neuroengineering groups, received funding from DARPA after the agency solicited proposals to create a portable EEG sensor and mobile application (Jeffries, 2013; Dillow, 2013). With the advent of more sophisticated technology and the backing from federal agencies, the price point on these types of headsets will continue to drop. It is not inconceivable that in the future, EEG sensors will be as prominent as the laptop is today. These types of technologies undoubtedly have the potential to be incredibly powerful, but are entering the marketplace without any regulations before there has been an adequate discussion of the resultant ethical issues.

In terms of validity, the accuracy and quality of the Emotiv EPOC headset has been reviewed and published in peer review journals. The use of the EPOC EEG gaming system for the recording of late auditory event-related potentials (ERPs) for the study of auditory processing has been validated, providing an alternative to the 32-electrode cap that is often used (Badcock et al. 2013). Additionally, the Emotiv EEG system (the EEG hardware removed and placed in a state-of-the-art electrode cap) was studied as users were participating in unconstrained movement, and it was reported that the system yielded robust, quality EEG data (Debener et al. 2012). As laboratories move away from using EEG caps to wireless headsets that allow the subjects more movement and comfort, the accuracy and quality will naturally become validated. However, many companies are releasing this technology before extensive research takes place, meaning that the general public is paying money to be a part of these early experiments.

Pertinent ethical issues include those related to ownership and privacy. Raw EEG or electrocardiogram (ECG) data is powerful information, especially when linked to changes in an emotional state. Emotiv will provide individual raw EEG data to its users for an additional fee, but NeuroSky does not provide this information. OpenBCI strongly believes in providing the EEG data, but there is no rule or regulation that requires any consistency among EEG developers. Today, advertising companies use a wealth of information to determine which products are effective, but they mostly rely on conscious information that we share. Self-reported surveys and market trends based on behaviors are not as personal, and perhaps accurate, as what can be gleaned from the unfiltered subconscious. Already neuromarketing firms such as NeuroFocus and Mindlab employ EEG sensors, eye-tracking technology, and other biometric measures (Singer, 2010). Although more research is necessary to determine if measured brain activity actually correlates to purchasing activity, these researchers conduct studies under the influence of approved and ethical guidelines. These types of regulations may not apply to the commercial applications of these sensors. If EEG sensors became prevalent or Microsoft's Kinect 2 sensor began always monitoring heart rates, this information could be sold to a third party. Advertisers, networks, and politicians may have an interest in obtaining data if it could be correlated to the emotional state of the user. Do we have any claim over our own physiological data once it leaves us? Even if raw EEG signals are worthless without an algorithm to decipher the meaning, the data still originated from only one, original source. As a society, we have become comfortable with posting personal data to the Internet, and many people even participate in "body blogging," the posting of ambulatory monitoring to a public forum (Fairclough and Gilleade, 2014), such as Dr. Kiel Gilleade did in 2012 with his Twitter account. Our desensitization towards sharing personal information through social media may provide the perfect conditions to enable the collection and storage of physiological data.

A precedent for having a dataset of extensive, personal information is the company 23andMe, which provided information based on DNA analysis. The company's complete activities were recently put on hold by the FDA for reasons unrelated to privacy (Wojcicki 2013), but 23andMe collected and analyzed DNA samples for 5 years before they were forced to pause and their policies were reevaluated. Nothing is protecting the users of 23andMe's service from having their personal information sold, but the Genetic Information Nondiscrimination Act (GINA) passed in 2008 protects people from having their genetic information interfere with insurance policies and employment. This type of law does not exist for neurological data. Regulations and discussions should be taking place now before companies like Emotiv or NeuroSky have 5 years' worth of data from their customers whose privacy is not protected in the slightest.

It seems inevitable that one day enough people will participate in the use of these EEG sensors and a massive database of neurological signals will begin to develop. Having a large dataset of neurological data that can potentially be correlated to disease states is already the goal of well established companies such as Lumosity (Sternberg et al. 2013) and BrainResource (McRae et al. 2014). Additionally, the United States government recently launched PCORnet: The National Patient-Centered Clinical Network Project with the intention of building a national health-data system by combining data from 29 different health data networks (Collins et al., 2014). The United Kingdom has recently met ethical conflicts with the introduction of a similar system, care.data (Callaway, 2013), and the United States has already has caused controversy with its National Security Agency policies. In spite of this, government backed organizations are moving forward with the massive collection of medical records and perhaps one day, extensive physiological data. The implications are revolutionary, but also raise a host of ethical concerns. Already specific EEG signals can be used to characterize neurological disorders, and with the collection of more data, we have the potential to be able to recognize specific signals as "brain signatures" for other neurological disorders, or even tendencies toward certain behaviors. This ability, while incredibly powerful, has a high risk for abuse in terms of monitoring individuals. Of course, if a patient has epilepsy, a discrete EEG sensor that has the power to be predictive for seizure activity could greatly increase the health, safety, and quality of life for these patients (Jouny et al. 2011). Would it be appropriate to monitor a person who has been given a neurological diagnosis that has rendered them emotionally unstable if the EEG sensor could detect a very high or low state though? If that EEG sensor means that they are deemed stable enough for certain activities they were once denied, such as driving, does that make the constant monitoring worth what many would consider a violation of privacy?

Conclusion

Deciding when it is appropriate to monitor physiological signals made possible by technology that until recently was restricted to laboratory and hospital settings will require a conversation among ethicists, clinicians, developers, government agencies, researchers, and the users of these sensors. These devices can make life easier and are allowing us unprecedented insight into how our own bodies operate. This is a powerful time for the field of neuroscience with rapid advances in the development of wireless, portable devices that participate in physiological computing, but neuroscience is being brought to the masses without an adequate review of the ownership and privacy of the data collected.

References:

Allanson, J., and Fairclough, S.H. 2004. A research agenda for physiological computing. Interact. Comput. 16: 857–878.

Allison, B.Z., Wolpaw, E.W., and Wolpaw, J.R. 2007. Brain-computer interface systems: progress and prospects. Expert Rev. Med. Devices 4: 463–474.

Badcock, N.A., Mousikou, P., Mahajan, Y., de Lissa, P., Thie, J., and McArthur, G. 2013. Validation of the Emotiv EPOC ® EEG gaming system for measuring research quality auditory ERPs. PeerJ 1: e38.

Callaway, E. 2013. UK push to open up patients' data. Nature 502: 283–283.

Collins, F.S., Hudson, K.L., Briggs, J.P., and Lauer, M.S. 2014. PCORnet: turning a dream into reality. J. Am. Med. Inform. Assoc. 0: 1-2.

Debener, S., Minow, F., Emkes, R., Gandras, K., and de Vos, M. 2012. How about taking a low-cost, small, and wireless EEG for a walk? Psychophysiology 49: 1617–1621.

Dillow, C. 2013. On DARPA's 2013 Wish List: Extreme Diving, Portable Brain Reading, And Gravity Vision. Popular Science, January 4. Available at: www.popsci.com/technology/article/2013-01/darpas-2013-wish-list-robotic-dive-doctor-portable-brain-reading-and-gravity-vision

Fairclough, S.H. 2009. Fundamentals of physiological computing. Interact. Comput. 21: 133–145.

Fairclough, S.H., Gilleade, K. 2014. Meaningful Interaction with Physiological Computing. In Advances in Physiological Computing, ed. S.H. Fairclough and K. Gilleade, 1-16. London: Springer .

Jeffries, A. 2013. Can DARPA spark a DIY brain-scanning movement? The Verge, September 22. Available at: www.theverge.com/2013/9/22/4756816/can-darpa-spark-a-diy-brain-scanning-movement

Jouny, C.C., Franaszczuk, P.J., and Bergey, G.K. 2011. Improving early seizure detection. Epilepsy Behav. 22: S44–48.

Kapoor, A., Burleson, W., and Picard, R.W. 2007. Automatic prediction of frustration. Int. J. Hum.Comput. Stud. 65: 724–736.

McRae, K., Rekshan, W., Williams, L.M., Cooper, N., and Gross, J.J. 2014. Effects of antidepressant medication on emotion regulation in depressed patients: An iSPOT-D report. J. Affect. Disord. 159: 127–132.

Murphy, J., Russomanno, C. 2014. OpenBCI: An Open Source Brain-Computer Interface For Makers. Kickstarter, accessed on 17 May. Available at: https://www.kickstarter.com/projects/openbci/openbci-an-open-source-brain-computer-interface-fo

Singer, N. 2010. Neuromarketing - Ads That Whisper to the Brain. N. Y. Times, November 13. Available at: www.nytimes.com/2010/11/14/business/14stream.html

Sternberg, D.A., Ballard, K., Hardy, J.L., Katz, B., Doraiswamy, P.M., and Scanlon, M. 2013. The largest human cognitive performance dataset reveals insights into the effects of lifestyle factors and aging. Front. Hum. Neurosci. 7.

Wojcicki, A. 2013. 23andMe Provides An Update Regarding FDA's Review. 23andMe Blog, December 5. Available at: blog.23andme.com/news/23andme-provides-an-update-regarding-fdas-review/

Wu, H-Y., Rubinstein, M., Shih, E., Guttag, J., Durand, F., Freeman, W.T. 2012. Eulerian Video Magnification for Revealing Subtle Changes in the World. ACM Transactions on Graphics (Proc. SIGGRAPH 2012) 31.

Biography

Katie L. Strong is a PhD candidate in the chemistry department at Emory University working in Dr. Dennis Liotta's laboratory. Prior to graduate school, she received a BS in chemistry from the University of Mary Washington. In graduate school, her research has focused on the development and synthesis of N-methyl-D -aspartate (NMDA) receptor subunit selective potentiators to be used as therapeutic probes for the study of schizophrenia and cognitive enhancement. Katie is also an Editorial Intern at the American Journal of Bioethics Neuroscience (AJOB Neuroscience), along with a supporting editor and regular contributor to The Neuroethics Blog, the official blog of AJOB Neuroscience. Katie can be contacted at klstron@emory.edu.

Editor's Column

It is almost time for the Society for Neuroscience meeting in Washington, DC. I know that many of you will be coming to the meeting, and we look forward to seeing you there. David Kopf Instruments will be located at booth number 1315. David Kopf Instruments is the manufacturer of the largest and most versatile array of the highest quality stereotaxic instruments in the world. The company founder, David Kopf, developed modern stereotaxic methods in 1958 with the help of preeminent neuroscientists such as Nate Buchwald in Los Angeles. Dr. Buchwald tutored Kopf on the elements of stereotaxis and soon the first of the Kopf stereotaxic instruments was sold to Ross Adey at what soon became the UCLA Brain Research Institute. Practically all present-day stereotaxic instruments are direct descendants of these first Kopf instruments. We would welcome you at the booth to look at these beautiful instruments.

The article in this issue of the *Carrier* was the first place winner is the International Neuroethics Society's recent essay contest. It was written by Katie Strong, a doctoral candidate at Emory University. Ms Strong has put together a very compelling and thought provoking look at an emerging technology called physiological computing. This technology utilizes measures of physiological function, such as heart rate or EEG to impute the emotional or other state of the user. Using this information, the computer controls some function. The emergence of this sort of technology brings with it many ethical and other questions, such as who owns the data taken from the individual with EEG recording? As libraries of EEG recordings are put together for a person, what safeguards are there against misuse of the information? Can this information be used by governmental agencies in monitoring the person? Ms Strong has presented us with a vivid picture of an emerging area that I am sure not many of us have given much thought. I think you will enjoy reading it.

I encourage you to come to the David Kopf Lecture on Neuroethics, on Sunday, Nov 16 at 11:30 am. Mahzarin Banaji, Ph.D. of Harvard University, will deliver it. Her topic is Mind, Brain, and the Ethics of Intergroup Behavior. This lecture has traditionally been one of the highlights of the special lectures at the meeting and I am sure this will be no exception. In addition, you are invited to attend the International Neuroethics Society meeting that takes place on Thursday and Friday prior to SFN. More information on this can be found at www.neuroethicssociety.org.

Here in Florida, we have had a very quiet hurricane season thus far. I noticed an article in the Sun Sentinel this morning that we could be entering a period of relative quiet hurricane seasons. Apparently there are periods lasting from 15-30 years that are either relatively quiet or relatively busy with hurricanes. The past 3 years have been relatively quiet and some forecasters are beginning to think that the water movement patterns in the Atlantic and wind patterns off of Africa are changing enough that it could be the start of a multiyear period of fewer and weaker hurricanes. Well, I suppose that New York and New Jersey might say that Sandy would argue against the weakening hypothesis, but those of us here hope that the forecasters are correct. But as we all know, it just takes one hit to cause a lot of damage.

I look forward to seeing some of you at the SFN meeting. Stop by the Kopf booth and say hi and meet the Kopf team.

If you would like to write an article for the Carrier, please let me know. There is an honorarium for any article published. I can be reached at the phone or email below.

Michael M. Patterson, Ph.D.
Science Editor
David Kopf Instruments
954-288-5518
954-452-6812 (FAX)
drmikep1@me.com