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Papers from the Fifth International Brain–Computer Interface Meeting

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Brain-computer interfaces (BCIs), also known as brain-machine interfaces (BMIs), translate brain activity into new outputs that replace, restore, enhance, supplement, or improve natural brain outputs. BCI research and development has grown rapidly for the past two decades. It is beginning to provide useful communication and control capacities to people with severe neuromuscular disabilities; and it is expanding into new areas such as neurorehabilitation that may greatly increase its clinical impact. At the same time, significant challenges remain, particularly in regard to translating laboratory advances into clinical use.

The papers in this special issue report some of the work presented at the Fifth International BCI Meeting held June 3–7th, 2013 at the Asilomar Conference Center in Pacific Grove, California, USA. Like its predecessors over the past 15 years, this meeting was supported by the National Institutes of Health, the National Science Foundation, and a variety of other governmental and private sponsorsⁱ. This fifth meeting was organized and managed by a Program Committee of BCI researchers from throughout the worldⁱⁱ. It retained the distinctive retreat-style format developed by the Wadsworth Center researchers who organized and managed the first four meetings.

The 301 attendees came from 165 research groups in 29 countries; 37% were students or postdoctoral fellows. Of more than 200 extended abstracts submitted for peer-review, 25 were selected for oral presentationⁱⁱⁱ, and 181 were presented as posters^{iv} and published in the open-access conference proceedings^v. The meeting featured 19 highly interactive workshops^{vi} covering the broad spectrum of BCI research and development, as well as many demonstrations of BCI systems and associated technology.

Like the first four meetings, this one included attendees and embraced topics from across the broad spectrum of disciplines essential to effective BCI research and development, including neuroscience, engineering, applied mathematics, computer science, psychology, and rehabilitation. In addition, this fifth meeting extended the spectrum in two very important ways. For the first time, presentations were given by several people who could potentially benefit from current BCI technology – people with severe disabilities who need assistive

technology for communication. One presented in person and one remotely. A Virtual BCI User's Forum allowed these presenters and other potential BCI users to speak directly to the BCI research community about the advantages and disadvantages of current BCIs and important directions for future study (see ^{vii}). Their personal experiences and desires can help guide BCI research and development. Their active participation, particularly in regard to the selection of goals and the evaluation and optimization of new methods and systems, is essential if BCIs are to become clinically valuable and widely used technology.

The second major innovation in this meeting was the strong emphasis on ethical issues related to BCI development and use. The meeting opened with a keynote presentation entitled "Neuroethics, BCIs & the Cyborg Myth" by Dr. Joseph Fins, a noted authority on neuroethics from the Weill Cornell Medical College and the Rockefeller University. He focused on the ability of BCIs to relieve suffering and restore function, while cautioning against applications that take intentional control away from the user. Ethical issues were also addressed in several of the workshops, and arose on multiple occasions and in multiple contexts over the course of the meeting. Their prominence reflected the growing importance and difficulty of ethical issues as BCI capacities and applications grow and extend to potentially enhancing or supplementing normal nervous system function.

The 16 articles in this special issue reflect the breadth, depth, growing maturity, and future directions of BCI research. The first paper presents a tutorial on best practices in BCI performance measurement ^{viii}. The following eight papers focus on specific BCI applications and on methods for increasing their usefulness for people with severe disabilities. The next two examine how brain activity and BCI use affect each other. The final five studies investigate brain signals and evaluate new signal processing algorithms in order to improve BCI performance and broaden its possible applications in some of the newest areas of BCI research, including the direct interpretation of speech from electrocorticographic (ECoG) activity^{ix}. Together, these papers span many aspects of BCI research, including different recording modalities (i.e., electroencephalogram (EEG), ECoG, functional magnetic resonance imaging (fMRI)) and signal types (e.g., P300 event-related potentials (ERPs), sensorimotor rhythms, steady-state visual evoked potentials (SSVEPs)). Furthermore, additional clinically related studies that were presented at the meeting but were considered to be outside the scope of the *Journal of Neural Engineering* will appear in a special issue of the *Archives of Physical Medicine and Rehabilitation*.

With a theme of "Defining the Future," the Fifth International BCI Meeting tackled the issues of a rapidly growing multidisciplinary research and development enterprise that is now entering clinical use. Important new areas that received attention included the need for active involvement of the people with severe disabilities who are the primary initial users of BCI technology, and the growing importance and difficulty of the multiple ethical questions raised by BCIs and their potential applications. The meeting also marked the launching of the new journal *Brain-Computer Interfaces*, dedicated to BCI research and development, and initiated the establishment of the Brain-Computer Interface Society, which will organize and manage the Sixth International BCI Meeting to be held in 2016.

References

- i . <http://bcimeeting.org/2013/sponsors.html>
- ii . <http://bcimeeting.org/2013/meetinginfo.html>
- iii . <http://bcimeeting.org/2013/researchsessions.html> (indexes individual abstracts)
- iv . <http://bcimeeting.org/2013/posters.html> (indexes individual abstracts)
- v . http://castor.tugraz.at/doku/BCIMeeting2013/BCIMeeting2013_all.pdf
- vi. Huggins JE, Guger C, Allison B, Anderson CW, Batista A, Brouwer A-M, Brunner C, Chavarriaga R, Fried-Oken M, Gunduz A, Gupta D, Kübler A, Leeb R, Lotte F, Miller LE, Müller-Putz G, Rutkowski T, Tangermann M, Thompson DE. Workshops of the Fifth International Brain-Computer Interface Meeting: Defining the Future. *Brain-Computer Interface Journal*. 2014; 1(1): 27–49.
- vii. Peters B, Bieker G, Heckman SM, Huggins JE, Wolf C, Zeitlin D, Fried-Oken M. Brain-Computer Interface Users Speak Up: The Virtual Users' Forum at the 2013 International BCI Meeting. *Archives of Physical Medicine and Rehabilitation*. Accepted.
- viii. Performance measurement for brain–computer or brain–machine interfaces: a tutorial David E Thompson, Lucia R Quitadamo, Luca Mainardi, Khalil ur Rehman Laghari, Shang kai Gao, Pieter-Jan Kindermans, John D Simeral, Reza Fazel-Rezai, Matteo Matteucci, Tiago H Falk, Luigi Bianchi, Cynthia A Chestek and Jane E Huggins (this issue)
- ix. Direct classification of all American English phonemes using signals from functional speech motor cortex Mugler, Emily; Patton, James; Flint, Robert; Wright, Zachary; Schuele, Stephan; Rosenow, Joshua; Shih, Jerry; Krusienski, Dean ; Slutzky, Marc (this issue)