EDITORIAL

Time to address the problems at the neural interface

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Editorial

Time to address the problems at the neural interface

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Neural engineers have made significant, if not remarkable, progress in interfacing with the nervous system in the last ten years. In particular, neuromodulation of the brain has generated significant therapeutic benefits [1–5]. EEG electrodes can be used to communicate with patients with locked-in syndrome [6]. In the central nervous system (CNS), electrode arrays placed directly over or within the cortex can record neural signals related to the intent of the subject or patient [7, 8]. A similar technology has allowed paralyzed patients to control an otherwise normal skeletal system with brain signals [9, 10]. This technology has significant potential to restore function in these and other patients with neural disorders such as stroke [11].

Although there are several multichannel arrays described in the literature, the workhorse for these cortical interfaces has been the Utah array [12]. This 100-channel electrode array has been used in most studies on animals and humans since the 1990s and is commercially available. This array and other similar microelectrode arrays can record neural signals with high quality (high signal-to-noise ratio), but these signals fade and disappear after a few months and therefore the current technology is not reliable for extended periods of time. Therefore, despite these major advances in communicating with the brain, clinical translation cannot be implemented.

The reasons for this failure are not known but clearly involve the interface between the electrode and the neural tissue. The Defense Advanced Research Project Agency (DARPA) as well as other federal funding agencies such as the National Science Foundation (NSF) and the National Institutes of Health have provided significant financial support to investigate this problem without much success. A recent funding program from DARPA was designed to establish the failure modes in order to generate a reliable neural interface technology and again was unsuccessful at producing a robust interface with the CNS.

In 2013, two symposia were held independently to discuss this problem: one was held at the International Neuromodulation Society’s 11th World Congress in Berlin and supported by the International Neuromodulation Society1 and the other at the 6th International Neural Engineering conference in San Diego2 and was supported by the NSF. Clearly, the neuromodulation and the neural engineering communities are keen to solve this problem. Experts from the field were assembled to discuss the problems and potential solutions. Although many important points were raised, few emerged as key issues.

(1) **The ability to access remotely and reliably internal neural signals.** Although some of the technological problems have already been solved, this ability to access neural signals is still a significant problem since reliable and robust transcutaneous telemetry systems with large numbers of signals, each with wide bandwidth, are not readily available to researchers.

(2) **A translation strategy taking basic research to the clinic.** The lack of understanding of the biological response to implanted constructs and the inability to monitor the sites and match the mechanical properties of the probe to the neural tissue properties continue to be an unsolved problem. In addition, the low levels of collaboration among neuroscientists, clinicians, patients and other stakeholders throughout different phases of research and development were considered to be significant impediments to progress.

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1 www.neuromodulation.com/8-june-2013
Fundamental tools development procedures for neural interfacing. There are many laboratories testing various devices with different sets of criteria, but there is no consensus on the failure modes. The reliability, robustness of metrics and testing standards for such devices have not been established, either in academia or in industry. To start addressing this problem, the FDA has established a laboratory to test the reliability of some neural devices.

Although the discussion was mostly centered on interfacing with the CNS, it has recently become clear that the peripheral nervous system (PNS) could be an important target for interfacing, perhaps even more accessible for interfacing than the CNS. A recent initiative called Bioelectronic Medicines3 is a step in that direction. A recent summit held in New York was organized to investigate novel and disruptive neural technologies to interface specifically with the PNS in order to restore health and biological function to organs.

With significant interest in neurotechnology for neural interfacing (see footnotes 1, 2 and 3) and uncovering new ways to treat, prevent and cure brain disorders (President Obama’s brain initiative4), it seems clear that the problems at the interface will not remain unsolved for long. Finding solutions to the problem at the neural interface for interacting with the nervous system (PNS and CNS) is crucial for understanding and restoring brain function. This would in turn have a significant impact on health care and quality of life for patients with neural disorders.

References


3 www.gsk.com/explore-gsk/how-we-do-r-and-d/bioelectronics.html
4 www.whitehouse.gov/share/brain-initiative