Implantable brain-computer interface

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Brain-computer interface (BCI) implants have previously required craniotomy to deliver penetrating or surface electrodes to the brain. Whether a minimally invasive endovascular technique to deliver recording electrodes through the jugular vein to the superior sagittal sinus is safe and feasible is unknown.

Objective: To assess the safety of an endovascular BCI and feasibility of using the system to control a computer by thought.

Design, setting, and participants: The Stentrode With Thought-Controlled Digital Switch (SWITCH) study, a single-center, prospective, first in-human study, evaluated 5 patients with severe bilateral upper-limb paralysis, with a follow-up of 12 months. From a referred sample, 4 patients with amyotrophic lateral sclerosis and 1 with primary lateral sclerosis met inclusion criteria and were enrolled in the study. Surgical procedures and follow-up visits were performed at the Royal Melbourne Hospital, Parkville, Australia. Training sessions were performed at patients' homes and at a university clinic. The study start date was May 27, 2019, and final follow-up was completed January 9, 2022.

Interventions: Recording devices were delivered via catheter and connected to subcutaneous electronic units. Devices communicated wirelessly to an external device for personal computer control.

Main outcomes and measures: The primary safety end point was device-related serious adverse events resulting in death or permanent increased disability. Secondary end points were blood vessel occlusion and device migration. Exploratory end points were signal fidelity and stability over 12 months, number of distinct commands created by neuronal activity, and use of system for digital device control.

Results: Of 4 patients included in analyses, all were male, and the mean (SD) age was 61 (17) years. Patients with preserved motor cortex activity and suitable venous anatomy were implanted. Each completed 12-month follow-up with no serious adverse events and no vessel occlusion or device migration. Mean (SD) signal bandwidth was 233 (16) Hz and was stable throughout study in all 4 patients (SD range across all sessions, 7-32 Hz). At least 5 attempted movement types were decoded offline, and each patient successfully controlled a computer with the BCI.

Conclusions and relevance: Endovascular access to the sensorimotor cortex is an alternative to placing BCI electrodes in or on the dura by open-brain surgery. These final safety and feasibility data from the first in-human SWITCH study indicate that it is possible to record neural signals from a blood vessel. The favorable safety profile could promote wider and more rapid translation of BCI to people with paralysis.

Trial registration: ClinicalTrials.gov Identifier: NCT03834857 [1].

Implantable brain-computer interface (BCI) devices are an effective tool to decipher fundamental brain mechanisms and treat neural diseases. However, traditional neural implants with rigid or bulky cross-sections cause trauma and decrease the quality of the neuronal signal. Here, we propose a MEMS-fabricated flexible interface device for BCI applications. The microdevice with a thin film substrate can be readily reduced to a submicron scale for low-invasive implantation. An elaborate silicon shuttle with an improved structure is designed to reliably implant the flexible device into brain tissue. The flexible substrate is temporarily bonded to the silicon shuttle by polyethylene glycol. On the flexible substrate, eight electrodes with different diameters are distributed evenly for local field potential and neural spike recording, both of which are modified by Pt-black to enhance the charge storage capacity and reduce the impedance. The mechanical and electrochemical characteristics of this interface were investigated in vitro. In vivo, the small cross-section of the device promises reduced trauma, and the neuronal signals can still be recorded one month after implantation, demonstrating the promise of this kind of flexible BCI device as a low-invasive tool for brain-computer communication [2].

The Sixth International Brain-Computer Interface (BCI) Meeting was held 30 May-3 June 2016 at the Asilomar Conference Grounds, Pacific Grove, California, USA. The conference included 28 workshops covering topics in BCI and brain-machine interface research. Topics included BCI for specific populations or applications, advancing BCI research through use of specific signals or technological advances, and translational and commercial issues to bring both implanted and non-invasive BCIs to market. BCI research is growing and expanding in the breadth of its applications, the depth of knowledge it can produce, and the practical benefit it can provide both for those with physical impairments and the general public. Here we provide summaries of each workshop, illustrating the breadth and depth of BCI research and highlighting important issues and calls for action to support future research and development [3].

As Brain-Computer Interface (BCI) systems advance for uses such as robotic arm control it is postulated that the control paradigms could apply to other scenarios, such as control of video games, wheelchair movement or even flight.

The purpose of a pilot study was to determine whether a BCI system, which involves decoding the signals of two 96-microelectrode arrays implanted into the motor cortex of a subject, could also be used to control an aircraft in a flight simulator environment. The study involved six sessions in which various parameters were modified in order to achieve the best flight control, including plane type, view, control paradigm, gains, and limits. Successful flight was determined qualitatively by evaluating the subject's ability to perform requested maneuvers, maintain flight paths, and avoid control losses such as dives, spins and crashes. By the end of the study, it was found that the subject could successfully control an aircraft. The subject could use both the jet and propeller plane with different views, adopting an intuitive control paradigm. From the subject's perspective, this was one of the most exciting and entertaining experiment she had done in two years of research. In conclusion, this study provides a proof-of-concept that traditional motor cortex signals combined with a decoding paradigm can be used to control systems besides a robotic arm for which the decoder was developed. Aside from possible functional benefits, it also shows the potential for a new recreational activity for individuals with disabilities who are able to master BCI control [4].

Branco et al investigated whether four complex hand gestures, taken from the American sign language alphabet, can be decoded exclusively from S1 using both spatial and temporal information. For decoding, we used the signal recorded from a small patch of cortex with subdural high-density (HD) grids in five patients with intractable epilepsy. Notably, we introduce a new method of trial alignment based on the increase of the electrophysiological response, which virtually eliminates the confounding effects of systematic and non-systematic temporal differences within and between gestures execution. Results show that S1 classification scores are high (76%), similar to those obtained from M1 (74%) and sensorimotor cortex as a whole (85%), and significantly above chance level (25%). We conclude that S1 offers characteristic spatiotemporal neuronal activation patterns that are discriminative between gestures, and that it is possible to decode gestures with high accuracy from a very small patch of cortex using subdurally implanted HD grids. The feasibility of decoding hand gestures using HD-ECoG grids encourages further investigation of implantable BCI systems for direct interaction between the brain and external devices with multiple degrees of freedom [5].

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Mitchell P, Lee SCM, Yoo PE, Morokoff A, Sharma RP, Williams DL, MacIsaac C, Howard ME, Irving L, Vrljic I, Williams C, Bush S, Balabanski AH, Drummond KJ, Desmond P, Weber D, Denison T, Mathers S, O'Brien TJ, Mocco J, Grayden DB, Liebeskind DS, Opie NL, Oxley TJ, Campbell BCV. Assessment of Safety of a Fully Implanted Endovascular Brain-Computer Interface for Severe Paralysis in 4 Patients: The Stentrode With Thought-Controlled Digital Switch (SWITCH) Study. JAMA Neurol. 2023 Jan 9. doi: 10.1001/jamaneurol.2022.4847. Epub ahead of print. PMID: 36622685.

2)

Guo Z, Wang F, Wang L, Tu K, Jiang C, Xi Y, Hong W, Xu Q, Wang X, Yang B, Sun B, Lin Z, Liu J. A flexible neural implant with ultrathin substrate for low-invasive brain-computer interface applications. Microsyst Nanoeng. 2022 Dec 25;8:133. doi: 10.1038/s41378-022-00464-1. PMID: 36575664; PMCID: PMC9789992.

3)

Huggins JE, Guger C, Ziat M, Zander TO, Taylor D, Tangermann M, Soria-Frisch A, Simeral J, Scherer R, Rupp R, Ruffini G, Robinson DKR, Ramsey NF, Nijholt A, Müller-Putz G, McFarland DJ, Mattia D, Lance BJ, Kindermans PJ, Iturrate I, Herff C, Gupta D, Do AH, Collinger JL, Chavarriaga R, Chase SM, Bleichner MG, Batista A, Anderson CW, Aarnoutse EJ. Workshops of the Sixth International Brain-Computer Interface Meeting: brain-computer interfaces past, present, and future. Brain Comput Interfaces (Abingdon). 2017;4(1-2):3-36. doi: 10.1080/2326263X.2016.1275488. Epub 2017 Jan 30. PubMed PMID: 29152523; PubMed Central PMCID: PMC5693371.

4)

Kryger M, Wester B, Pohlmeyer EA, Rich M, John B, Beaty J, McLoughlin M, Boninger M, Tyler-Kabara EC. Flight simulation using a Brain-Computer Interface: A pilot, pilot study. Exp Neurol. 2016 May 16.

pii: S0014-4886(16)30124-8. doi: 10.1016/j.expneurol.2016.05.013. [Epub ahead of print] PubMed PMID: 27196543.

[5]

Branco MP, Freudenburg ZV, Aarnoutse EJ, Bleichner MG, Vansteensel MJ, Ramsey NF. Decoding hand gestures from primary somatosensory cortex using high-density ECoG. Neuroimage. 2016 Dec 4. pii: S1053-8119(16)30695-4. doi: 10.1016/j.neuroimage.2016.12.004. [Epub ahead of print] PubMed PMID: 27926827.