 DOI: 10.3217/978-3-99161-050-2-159

A preliminary evaluation of a fully implantable speech BCI

G. Saldanha[1*], M. B. Ben Ticha[1], C. Arvis[1], P. Roussel[1], F. Bocquelet[1], G. Le Godais[1], M. Aubert[1], T. Costecalde[2], L. Struber[2], G. Charvet[2], P. Kahane[3], S. Chabardès[2,4], B. Yvert[1].

[1]Univ. Grenoble Alpes, Inserm, U1216 Grenoble Institut Neurosciences, Grenoble, France; [2]CEA, LETI, Clinatec, Grenoble, France; [3]CHU Grenoble Alpes, Department of Neurology, Grenoble, France; [4]CHU Grenoble Alpes, Department of Neurosurgery, Grenoble, France

*Bio B, 2280 Rue de la Piscine, 38400 Saint Martin d'Hères, France. E-mail: guillaume.saldanha@univ-grenoble-alpes.fr, blaise.yvert@inserm.fr

Introduction: Speech BCIs offer perspectives to restore natural communication in people with Locked-In Syndrome (LIS). Current speech BCI solutions have shown convincing demonstrations for intelligible speech reconstruction with either subdural ECoG [1] or intracortical Utah array [2] recordings over sensorimotor and premotor areas. Yet, these solutions still rely on implants that remain wired to external recording systems, creating risks of infection. Moreover, subdural ECoG and intracortical recordings have been shown to degrade over long periods of time. There is thus a critical need for speech BCI solutions relying on fully implantable wireless technologies offering stable signals over many years. In this context, we propose to use the epidural WIMAGINE implant [3], which has proven to have great recording stability over time [4], to build a chronic speech BCI. Here, we present a complete real-time speech BCI framework based on the fully implantable WIMAGINE technology and its preliminary tests in a patient able to speak and chronically implanted in the context of a clinical trial aiming at evaluating the WIMAGINE technology for the motor control of an exoskeleton [5] (NCT02550522).

Material, Methods and Results: Over the 64 implant electrodes covering the hand motor cortex, the 32 most ventral were used in order to be as close as possible to the dorsal laryngeal motor cortex [6]. In a first step, two open loop sessions were conducted during which the patient was asked to read aloud short French sentences and vowel sequences. The absence of acoustic contamination was verified [7]. This data was used to train a Vison Transformer (ViT) based decoder [8], which was then implemented in a real-time processing software developed in C++. This pipeline was then evaluated in subsequent online closed-loop sessions with the same patient in either a sentence-by-sentence or a frame-by-frame speech decoding paradigm.

Conclusion: A complete real-time closed-loop speech BCI framework has been developed for further evaluation in Locked-In individuals chronically implanted with the epidural WIMAGINE technology.

Acknowledgments and Disclosures: We thank participant CLIN1 for his cooperation. This work was supported by the FRM Foundation with the PhD grant ECO202206015553 of GS, and the French National Research Agency (www.anr.fr) for grants No. ANR-20-CE45-0005 (BrainNet project) and framework of the "Investissements d'avenir" program (ANR-15-IDEX-02).

References:

[1] S. L. Metzger et al., "A high-performance neuroprosthesis for speech decoding and avatar control," Nature, vol. 620, no. 7976, pp. 1037–1046, 2023, doi: 10.1038/s41586-023-06443-4.
[2] N. S. Card et al., "An Accurate and Rapidly Calibrating Speech Neuroprosthesis," N. Engl. J. Med., vol. 391, no. 7, pp. 609–618, Aug. 2024, doi: 10.1056/NEJMoa2314132.
[3] C. Mestais, G. Charvet, F. Sauter-Starace, M. Foerster, D. Ratel, and A. L. Benabid, "WIMAGINE®: Wireless 64-channel ECoG recording implant for long term clinical applications," IEEE Trans. Neural Syst. Rehabil. Eng., vol. 23, no. 1, pp. 10–21, 2015, doi: 10.1109/TNSRE.2014.2333541.
[4] C. Larzabal et al., "Long-term stability of the chronic epidural wireless recorder WIMAGINE in tetraplegic patients," J. Neural Eng., vol. 18, no. 5, p. 56026, 2021, doi: 10.1088/1741-2552/ac2003.
[5] A. L. Benabid et al., "An exoskeleton controlled by an epidural wireless brain–machine interface in a tetraplegic patient: a proof-of-concept demonstration," Lancet Neurol., vol. 18, no. 12, pp. 1112–1122, 2019, doi: 10.1016/S1474-4422(19)30321-7.
[6] B. K. Dichter, J. D. Breshears, M. K. Leonard, and E. F. Chang, "The Control of Vocal Pitch in Human Laryngeal Motor Cortex," Cell, vol. 174, no. 1, pp. 21-31.e9, 2018, doi: 10.1016/j.cell.2018.05.016.
[7] P. Roussel et al., "Observation and assessment of acoustic contamination of electrophysiological brain signals during speech production and sound perception," J. Neural Eng., vol. 17, p. 056028, 2020, doi: 10.1088/1741-2552/abb25e.
[8] M. Benticha et al., "A Vision Transformer Architecture For Overt Speech Decoding From ECoG Data," presented at the 46th Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Orlando, Jul. 2024.

 Published by Verlag der Technischen Universität Graz