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# Toward Home-Use BCIs: Development and Evaluation of ECoG WIMAGINE Neuroprosthesis

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*Introduction:* To restore autonomy and improve the quality of life of individuals with motor disabilities, Brain-Computer Interfaces (BCIs) need to evolve from laboratory-based prototypes to functional systems that are practical for daily, home use. This shift requires addressing three critical challenges: (1) developing integrated, compact, and autonomous hardware suitable for patients' independent use; (2) implementing low-power, fast algorithms that run efficiently on small devices; and (3) integrating effectors, that are easy to setup and capable of producing meaningful functional changes for the user.

*Material, Methods and Results:* The development of the electrocorticographic (ECoG) WIMAGINE BCI neuroprosthesis [1] aims at overcoming these challenges. We integrated all hardware for recording and communication into a small, portable design. We implemented a highly optimized signal-processing pipeline capable of real-time operation on low-power embedded systems. The algorithms demonstrated robust decoding of neural signals with low computational time (<100 ms). Finally, we integrated a wireless surface functional electrical stimulation (sFES) sleeve (FESIA-Grasp®) that translates decoded neural commands into functional movements. The neuroprosthesis setup is user-friendly, requiring minimal training for installation and operation, enhancing user independence. Testing was conducted with individuals with spinal cord injury [2,3] implanted for several years (up to 7) with stable signal quality. Results indicate high system reliability and usability, with users able to achieve functional tasks with minimal supervision.

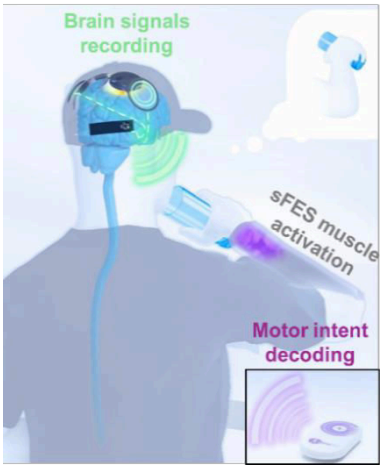


*Figure 1: Principle of the home-use WIMAGINE BCI neuroprosthesis*

*Conclusion:* This work represents a significant step toward enabling home-use BCIs. By integrating compact hardware, efficient algorithms, and functional effectors into the WIMAGINE neuroprosthesis, we have demonstrated the safety and feasibility of autonomous BCI systems for home applications. These advances pave the way for future developments aimed at improving the accessibility and practicality of BCIs outside clinical environments.

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*References:*

[1] Mestais C S, Charvet G, Sauter-Starace F, Foerster M, Ratel D and Benabid A L 2015 WIMAGINE: Wireless 64-Channel ECoG Recording Implant for Long Term Clinical Applications *IEEE Trans. Neural Syst. Rehabil. Eng.* **23** 10–21

[2] Benabid A L, Costecalde T, Eliseyev A, Charvet G, Verney A, Karakas S, Foerster M, Lambert A, Morinière B, Abroug N, Schaeffer M-C, Moly A, Sauter-Starace F, Ratel D, Moro C, Torres-Martinez N, Langar L, Oddoux M, Polosan M, Pezzani S, Auboiroux V, Aksenova T, Mestais C and Chabardes S 2019 An exoskeleton controlled by an epidural wireless brain–machine interface in a tetraplegic patient: a proof-of-concept demonstration *Lancet Neurol.* **18** 1112–22

[3] Lorach H, Galvez A, Spagnolo V, Martel F, Karakas S, Intering N, Vat M, Faivre O, Harte C, Komi S, Ravier J, Collin T, Coquoz L, Sakr I, Baaklini E, Hernandez-Charpak S D, Dumont G, Buschman R, Buse N, Denison T, van Nes I, Asboth L, Watrin A, Struber L, Sauter-Starace F, Langar L, Auboiroux V, Carda S, Chabardes S, Aksenova T, Demesmaeker R, Charvet G, Bloch J and Courtine G 2023 Walking naturally after spinal cord injury using a brain–spine interface *Nature* **618** 126–33



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