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Interfacing artificial and biological neurons: first step towards the development of autonomous implantable neurobiohybrid medical devices.

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ABSTRACT

Energetically autonomous implantable neurobiohybrid devices able to communicate with biological neurons could offer new solutions for durably alleviating symptoms of a variety of neurodegenerative diseases with more flexibility of use for the patient. Designing such devices is however a challenge that several research groups are currently addressing worldwide. Most approaches include voluminous equipments lacking of flexibility (thus preventing their use *in vivo*), require numerical/analogical conversions leading to high-energy consumption, and are subjected to long time constraints thus precluding real time communications between artificial and biological components of the neurobiohybrid. To conceive a device suitable for long-term implantation, we plan to create a fully analogical system, which would therefore be smaller, more energy-efficient and able to communicate in real time with its biological targets. Such autonomous implantable devices have to meet precise specifications ensuring not only their harmlessness for living tissues but also their long-term efficiency. Most importantly, as highlighted above, their ability to communicate in real time with the living tissue is crucial. This presentation will address this key objective.

Based on a biomimetic spiking artificial neuron developed and patented within the SPINE project (<https://spine.univ-lille.fr/research.html>), we aim to create a fully analogical neurobiohybrid system by connecting these biomimetic artificial neurons (AN) to living neurons maintained *in vitro*. In this context, the objective of my thesis project is to establish and characterize the bidirectional communication between AN and biological neurons (BN). To achieve this objective, we developed an interface that allowed us to demonstrate the ability of biomimetic signals (applied with a generator and extracted from artificial neurons) to stimulate living neurons through gold electrodes (thus enabling communication "Emulated AN" -> BN). New interfaces are under development to demonstrate the possibility to detect BN signals. The complete communication loop will be achieved by physically connecting biomimetic AN (excitatory) to living neurons (receiving/responding) themselves linked to other biomimetic AN (listening/recording). In conclusion, this thesis work is a first step towards the creation of a fully autonomous implantable neurobiohybrid for medical applications.

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