BIO

Jeremie Lefebvre is a scientist at the Krembil Research Institute and Assistant professor at the Department of Mathematics and Institute for Biomaterials and Biomedical Engineering of the University of Toronto. He obtained his PhD in physics in 2010 at the Center for Neural Dynamics of the University of Ottawa. As a postdoctoral fellow, he worked first in Geneva and then Lausanne, doing research on probabilistic neural coding and cognitive neuroimaging. His lab combines mathematical and computational techniques to understand the link between microcircuits, emergent neural dynamics and cognitive processes and diseases. Dr Lefebvre uses models and experimental data to collaborate closely with experimentalists and clinicians worldwide in the fields of biomedical engineering, neuroimaging and brain stimulation.

ABSTRACT

Promising experimental findings over the last two decades have sparked a strong interest in using electromagnetic stimulation to treat a variety of neuropysiological disorders, such as depression, Parkinson and epilepsy. One strategy is to use periodic waveforms to engage brain oscillations - rhythms generated by synchronized neurons and involved information processing - to regulate neural communication and interface with neural circuits at a functional level. While relatively well characterized at the scale of individual cells, the effect of fluctuating electromagnetic fields on neural circuits dynamics and computation remains poorly understood. We here interface experimental, computational and mathematical approaches to understand the neurophysiological mechanisms underlying oscillatory activity, as well as develop new biomedical paradigms to entrain brain rhythms. Our findings reveal that modulation of brain oscillations is best achieved in states of low endogenous rhythmic activity and that irregular, state-dependent fluctuations tune the susceptibility of cortical network to exogenous control. We will discuss the influence of stimulation waveforms and how these define the type of interaction with non-linear neural circuits. We will also see how machine learning and patient imaging data can be combined to inform personalized brain-scale simulations to study how endogenous and exogenous inputs interact to engage networks across the white matter. Taken together, these results provide new and exciting perspectives on the development of neuromodulatory paradigms for the treatment of neurological diseases and for cognitive enhancement.

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