Towards data-driven brain stimulation target discovery using single-subject whole brain models

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Disorders of consciousness (DoC) have been shown to be difficult to treat due to our limited knowledge on the neural basis of consciousness and the heterogeneity of their causes. For that reason, individual and novel treatments for these disorders are sought after.
In recent years, brain stimulation has been proposed as a therapeutic approach for treatment of DoC [1], but finding reliable targets for brain stimulation has been shown to be a difficult task. Previous studies, especially using animal models, have shown that stimulation of some areas of the encephalon improve scores associated with consciousness on anesthetized subjects [2]. Using data from an individual anesthetized macaque with a Deep Brain Stimulation (DBS) implant in the thalamus, we were able to create a whole brain model that fits the cortical dynamics of the monkey. The model couples anatomical structure in the form of a DTI tractography with the local dynamics of the different regions described as a critical Stuart-Landau oscillator [3]. By using this model, and the help of a Variational Autoencoder to achieve a low-dimensional embedding of the underlying dynamics, we were able to uncover novel cortical targets for brain stimulation that shift the state from that of anesthesia to that of the macaque under thalamic DBS, as well as novel targets that might indicate other kinds of dynamical behavior. This type of individualized models and search of stimulation targets might move us one step closer to effective treatment of DoC, as well as the study of the heterogeneity of the physio- and psychopathology of these and other brain disorders.

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