Modeling disorders of consciousness at the patient level reveals the network's influence on the diagnosis vs the local node parameters role in prognosis | Lou Zonca

Disorders of Consciousness (DoC) regroup a wide spectrum of conditions ranging from coma to more aware (awake) states of consciousness but for patients which remain largely unable to communicate. Although there are universal clinical procedures, to assess the level of consciousness of a DoC patient, precise diagnosis and prognosis remains a challenge. In this talk, I will discuss my current work regarding the development of DoC mathematical models calibrated at the single-patient level. The ultimate goal is to use these models as digital twins to propose better biomarkers, enhance prognosis, and test potential therapeutic approaches using numerical simulations.

I will present my latest results regarding the construction of a modeling pipeline that takes DoC patients' fMRI resting state data as an input and provides automatically fitted mathematical models for each patient.

The pipeline is decomposed as follows: first, the data is first projected, using Auto-Encoders, into a latent-space of optimal reduced dimension that I will describe. Second, in this latent-space, I implement an automatic parameter fitting procedure that can be applied to different mathematical models. I will present and describe two models: (1) the Hopf model, which can be seen as a network of noisy oscillators, which is known to provide good results for fMRI modeling but whose biological interpretation is limited. (2) A new model that indirectly accounts for the regulatory role of astrocytes (a type of glial cells) on neuronal activity: the main advantage of this model, despite its higher complexity, is its more straightforward biological interpretation. Finally, the fitted parameters of the models provide us with two types of biomarkers: (1) The connectivity matrices, revealing the network interactions at the global brain scale, tend to give us information regarding the diagnosis of the patients, i.e. the severity of their condition. (2) On the other hand, the local node parameters tend to correlate to other relevant clinical information such as age, etiology and prognosis.

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