# Low-dimensional representation of global brain states of reduced consciousness and its transitions

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Brain states are frequently represented using a unidimensional scale measuring the richness of subjective experience (level of consciousness). This description assumes a mapping between the high-dimensional space of whole-brain configurations and the trajectories of brain states associated with changes in consciousness, yet this mapping and its properties remain unknown. We combined whole-brain modelling, data augmentation and deep learning for dimensionality reduction to determine a mapping representing states of consciousness in a lowdimensional space, where distances parallel similarities between states. We assessed how the modelled brain activity can be represented as a trajectory into an embedded low-dimensional space generated with a variational autoencoder (a neural deep network structure). We focused on reduced states of consciousness including pathological states (post-coma state), pharmacological states (anaesthesia) and physiological (sleep stages), but also this framework can be easily extended to different diseases. Finally, we adapted the computational models to include electrical and pharmacological interventions to explore how to induce transitions between different states systematically.

We found an orderly trajectory from wakefulness to brain injured patients is revealed in a latent space whose coordinates represent metrics related to functional modularity and structure-function coupling, both increasing alongside loss of consciousness. Finally, we investigated the effects of model perturbations, providing geometrical interpretation for the stability and reversibility of states. In particular, are able to provide a perturbational landscape in low-dimensional space indicated possible mechanism of how to destabilise pathological states and restate the neuronal dynamics described in healthy subjects. In this sense, we provide insights on how and why these states of consciousness and their transitions are mapped into a low-dimensional space by implementing quantitative and algorithmic methods to find and investigate this space.