Predicting individual traits from models of brain dynamics using the Fisher kernel

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Predicting an individual's cognitive traits or clinical condition using brain signals is a central goal in modern neuroscience. This is commonly done using either structural aspects, such as structural connectivity or cortical thickness, or aggregated measures of brain activity that average over time. But these approaches are missing a central aspect of brain function: the unique ways in which an individual's brain activity unfolds over time. One reason why these dynamic patterns are not usually considered is that they have to be described by complex, high-dimensional models; and it is unclear how best to use these models for prediction. We here propose an approach that describes dynamic functional connectivity and amplitude patterns using a Hidden Markov model (HMM) and combines it with the Fisher kernel, which can be used to predict individual traits. The Fisher kernel is constructed from the HMM in a mathematically principled manner, thereby preserving the structure of the underlying model. We show here, in fMRI data, that the HMM-Fisher kernel approach is accurate and reliable. We compare the Fisher kernel to other prediction methods, both time-varying and time-averaged functional connectivity-based models. Our approach leverages information about an individual's time-varying amplitude and functional connectivity for prediction and has broad applications in cognitive neuroscience and personalised medicine.