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Research interests:
My interest is in the study of mind-brain relationships (i.e., the age-old problem of 'how brains make up their minds'), as they are typically addressed in disciplines such as Cognitive Neuroscience and Human Neuropsychology. In particular, I have explored the neural dynamics underlying human attention and memory using fast functional brain imaging techniques such as magnetoencephalography (MEG) and electroencephalography (EEG/ERPs) in both normal people and neurological and psychiatric patients.
My future research contemplates the use of computational models based on Information Theory and Bayesian statistical inference to describe, explain and predict cognitive control as an emerging property of large-scale neural dynamics. More specifically, I am interested in exploring the "entropy control" hypothesis of prefrontal function that "by linking novel to familiar information at the highest level of neural representation in a context-sensitive way, lateral PFC fulfills a physically and biologically plausible function of reducing stimulus and response entropy in the nervous system" (Barcelo & Knight 2007). From this perspective, cognitive control could be envisaged as the highest cortical exponent of energy minimization and homeostatic regulation in humans (Cannon 1932; Fuster 2002; Friston 2005).

"FAST NEURAL DYNAMICS OF A FRONTOPARIETAL 'MULTIPLE DEMAND' NETWORK INVOLVED IN COGNITIVE CONTROL"

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The fast neural dynamics of task-specific and domain-general mechanisms subserving cognitive flexibility are still ill defined. In this study, event-related potentials (ERPs) were recorded from 36 participants while they were intermittently cued to switch or repeat their perceptual categorization of Gabor gratings varying in color and thickness (Switch task), or else they performed two visually identical control tasks (NoGo and Oddball). Our task cueing paradigm was designed to examine proactive and reactive control modes during both cue-locked rule preparation and target-locked rule implementation stages. Unlike past studies, we addressed trial-by-trial dynamics of sensorimotor, contextual and episodic control operations ensuing task transition points. Both switch-specific (indexed by cue-locked P600 and a sustained target-locked positivity following task transitions) and domain-general mechanisms (indexed by cue- and target-locked P2 and P3 ERP components) revealed fast recurrent modulations of neural activity within a common frontoparietal network. Topographic analyses of normalized brain responses revealed distinct split-second swings of activation across posterior and frontal scalp regions as a function of increasing cognitive demands and proactive vs. reactive control modes. Modulations of domain-general brain potentials paralleled predictions from information

theoretic models (Koechlin & Summerfield, 2007) that envisage cognitive control as a series of temporarily ordered processing stages at various levels within a hierarchy of representations (e.g., sensory, contextual, episodic) in the brain. These results suggest distinct functional roles for the fast and recursive activations observed within a frontoparietal "multiple demand" system (Duncan, 2013) during the preparation and implementation stages of task switching.

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