

Prediction, precision, and context: dynamic causal modelling of MEG and ECoG

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Despite similar behavioral effects, prediction (expectation) and other types of top-down influences on perception (e.g. attention) have differential effects on evoked responses: expectation typically reduces event-related responses, while attention enhances them. This dissociation has been reconciled under predictive coding, where prediction errors are weighted by precision associated with attentional modulation. In this talk I will present results of three studies where we used dynamic causal modelling (DCM) to elucidate the mechanisms of prediction and dissociate them from other top-down influences. In the first study using magnetoencephalography, temporal attention and sensory expectation were orthogonally manipulated in an auditory mismatch paradigm, revealing interactive effects on evoked response amplitude. This interaction effect was modeled in a canonical microcircuit using DCM, comparing models with modulation of extrinsic and intrinsic connectivity at different levels of the auditory hierarchy. We found that while mismatch responses were explained by recursive interplay of sensory predictions and prediction errors, attention was linked to the gain of inhibitory interneurons, consistent with its modulation of sensory precision. In the second study, we analyzed electrocorticographic data recorded from individuals performing a task in which content-based and time-based predictions were orthogonally manipulated. DCM served to disambiguate between models of stimulus expectancy in terms of top-down processing and gain modulation. In the optimized model, object-based predictions increased top-down dependent gain modulation in sensory regions, consistent with their reliance on NMDA-dependent short-term plasticity. Temporal predictions, on the other hand, increased the gain of premotor areas, reflecting classical neuromodulatory mechanisms. In the third study, we aimed at explaining previous findings that predictable tone sequences evoke neural activity (as measured with magnetoencephalography) are characterized by higher amplitude of sustained fields than unpredictable sequences. Specifically, we tested whether (i) pattern regularity and alphabet size of auditory sequences affect the amplitude of induced high-frequency (broadband) gamma oscillations; (ii) these effects can be modelled as slowly fluctuating changes of neural gain in a biophysically realistic network; (iii) modulations of neural gain can explain the observed sustained field dynamics. To model these effects in terms of the underlying neurophysiology, we used DCM for cross-spectral density. We found evidence - in terms of effects of predictability on high-frequency gamma activity and the underlying neurophysiological mechanisms inferred from DCM - that the slow-fluctuating changes in synaptic efficacy combined with sustained input (e.g. tone sequences) can result in large sustained effects on neural activity.