Dynamic causal modelling of retino-cortical connectivity

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Objective
While nearly all visual research in humans has focused on visual cortical regions, surprisingly little is known about the human retinal network. This is important if we want to understand how the retina and the visual cortices are coupled as the LGN, both in terms of their relative spectral behaviors, their timing and the ensuing animal conduction delays.

Visual paradigm
- Full-field bright white light flash in a dark MRI
- Probes projector (Stimulight Technologies, Canada)
- Stimulation duration: 1 ms
- Inter-trial interval: 1000 ms
- 2b0 trials

Methods
We used a combination of non-invasive electro-retinography (ERG) of the retina, using a corneal silver/nylon electrode (DTL Plus Electrode, Diagnosys, USA) and MEG of cerebral cortex (Elema Neuromag Triux) in 11 healthy human adults. Following source analysis of fused magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI) using an Empirical Bayesian beamformer (Blackwood et al, 2012) implemented in SPM12 (2012), the ERG and MEG source space data were analyzed. Using Dynamic causal modelling (DCM), we used DCMs of induced responses (Chen et al, 2006) to evaluate the Bayesian model evidence for frequency-specific coupling, compared to cross-frequency coupling between the human retina and V1. We further used DCMs for cross-spectral densities. (Friston et al, 2012) to estimate the coupling strength, coherence and the underlying conduction delay during visual flash stimulation, treating the LGN as a (hidden) relay. Here, we present the results from a single subject.

Conclusions and future research
Combining recordings from the human retina with electromagnetic recordings, we were able to show that feedforward projections (via the LGN) are likely to operate in both a frequency-specific manner and through cross-frequency coupling. We were able to obtain a realistic estimate of the conduction delay between retina and V1 (Pitcher et al, 1995). Our future research will include a biologically realistic neural mass model of the human retina for DCM of CSD. This will be important in characterizing diseases that affect both early and late connectivity in the visual system, including diabetic retinopathy andoptic neuropathy, as well as blindsight, extinction and neglect syndromes.

References