Title: Modelling decision making in a rodent judgement bias task using a biophysically realistic neural network model.

Claire A. Hales, Emma S. J. Robinson, Conor J. Houghton

Biophysically realistic neural network models have been used to accurately simulate decision making performance in simple, two-choice decision making tasks in humans and non-human primates. These networks comprise competing populations of neurons, each of which is selective for a single choice, and exhibit attractor dynamics which signify evidence accumulation for one or other alternative. A winner-takes-all cortical network model [Wang, 2002, Neuron, 36:955-968] was modified and used to simulate baseline decision making performance in a rodent judgement bias task. The effect of altering the activity of the network through simulated neuromodulatory changes was then investigated.

A biophysically realistic cortical neural network model (based on Wang [2002]) was implemented in the Brian simulator. The parameters and network architecture were identical with the following exceptions: i) an increased external conductance to inhibitory neurons was used to increase decision latency without de-stabilising attractor and decision making dynamics; ii) the decision threshold was increased to 40Hz. Model simulations were compared to baseline decision making performance from the reward rodent judgement bias task [Hales et al., 2016, Plos One, XXX]. The effect of neuromodulation on the network was simulated by following the same procedure as Eckhoff et al. [2009, J Neurosci, 29:4301-4311], by altering cellular or postsynaptic conductances in the model.

Model simulations produced output comparable to behavioural performance on the judgement bias task. For each of the three cues in the task (high reward, midpoint and low reward) behavioural response latencies were 1.99±0.13, 3.20 ±0.24 and 3.76±0.29 seconds respectively, whilst model decision times were 1.86±0.03, 3.18±0.02 and 3.49±0.15 seconds. In the behavioural task, the percentages of high reward responses for each of the three cues were 95.67±0.77%, 53.92±4.75% and 33.27±2.80%, whilst the equivalent measures from model simulations were 96.17±0.60%, 52.65±0.68% and 30.73± 5.04%. Simulation of the effects of neuromodulation by altering conductances of either excitatory, or inhibitory neuron populations only tended to rapidly destabilise the network, however altering AMPA, NMDA or GABA conductances to both populations caused directional modulation-dependent changes in percentages of model decisions reaching the high reward threshold following the midpoint cue.

A biophysically realistic neural network model can be used to simulate decision making performance on a rodent judgement bias task. Although this single-layer model is a simplification of the decision making processes that may be occurring in judgement bias, and must be embedded within much larger networks in the brain, initial results from simulation of the effect of neuromodulation on decision making have provided testable predictions. These predictions could be investigated using the rodent judgement bias task by carrying out pharmacological manipulations that replicate the neuromodulatory simulations.

This study was funded by Wellcome Trust Doctoral Training Programme in Neural Dynamics.