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Dynamic modulation of the superior colliculus by the cortical encoding of predictable intervals: a neural field model of eye-movement decisions

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The superior colliculus (SC) is engaged in the integration of sensory and cognitive information during eye-movement decisions. The involvement of SC in decisions is revealed by ramping activity during predictable intervals of mixed-strategy games, where selectivity for an upcoming choice increases over time. SC neurons that do not encode task relevant information also show ramping activity during pre-choice intervals, but at lower rates (Thevarajah et al, J Neurosci, 2009). This profile of activity suggests that competitive dynamics in SC are modulated by spatially non-selective timing signals (Standage et al, PLoS Comput Biol, 2013).

We hypothesize that the encoding of temporal intervals in the frontal eye fields (FEF) controls spatially non-selective disinhibition of SC via the caudate nucleus and substantia nigra pars reticulata. To address this hypothesis, we simulated a mixed-strategy game with a neural field model of SC, in which excitatory populations encoding spatial location compete through a common inhibitory pool. The model reproduces neural activity recorded from SC and its corresponding behavioural outcomes, providing mechanistic explanations for the differential spatial selectivity of ramping activity in FEF and SC, the time-evolution of choice-selectivity by SC neurons, and microstimulation-induced saccadic deviations.