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*A mathematical model for the role of dopamine-D2 self-regulation in the production of ultradian rhythms*

Ultradian behavioural rhythms are highly-flexible oscillations in goal-directed behaviour with periods shorter than a day. They remain mysterious in both their biochemical mechanisms and their functional significance, but are generally believed to be a reflection of neural dynamics. We propose that D2 autoreceptor-dependent dopamine self-regulation in the midbrain-striatal synapses gives rise to ultradian rhythmicity. We express this hypothesis in an ordinary differential equation based mathematical model in a dual-negative feedback-loop structure. Numerical integration and bifurcation analysis shows that the oscillations have a flexible and parameter-sensitive period in agreement with experimental observation. The model also demonstrates the masking-entraining effects of circadian (approximately 24 hour) regulation on ultradian rhythms and the rapid-resetting effect of transient excitation. This reveals the crucial role of circadian-ultradian interaction in consolidating behavioural activity and coordinating the motivation to engage in recurring, albeit not highly predictable events, such as social interactions.