Title: Why does deep brain stimulation do the same thing in the STN and GPI? A computational study of deep brain stimulation in the basal ganglia.

Introduction: Deep brain stimulation (DBS) is an effective treatment for Parkinson’s disease, even though the biological basis for its efficacy is unclear. Stimulation of the subthalamic nucleus and internal segment of the globus pallidus lead to equivalent symptomatic relief. Here we present a computational model of the basal ganglia to understand why similar stimulation patterns in glutamatergic and GABAergic nuclei produce equivalent effects.

Methods: We simulated the activity of six homogeneous neuronal populations, connected according to the consensus macrocircuitry for the basal ganglia using the fomalism of a Hopfield net. The six neuronal populations represented the (1) cerebral cortex, (2) striatum, (3) internal segment of the globus pallidus and pars reticulata of the substantia nigra, (4) subthalamic nucleus, (5) external segment of the globus pallidus, and (6) thalamus. The simulations accounted for only linear pairwise interactions between nuclei, ignoring plasticity and higher-order correlations.

Results: Short square pulses of current (high-frequency stimulation) produce equivalent effects in the subthalamic nucleus and internal segment of the globus pallidus. Patterns of stimulation in the internal segment of the globus pallidus with long current pulses and brief inter-pulse intervals are more effective at decreasing thalamic activity than those in the subthalamic nucleus.

Conclusions: Our results suggest that the pattern of stimulation could be tailored in different nuclei to target different types of Parkinson’s. Our model can be extended to other brain regions, such as the mesolimbic system, to identify novel target nuclei based on the functional equivalence of those nuclei to known sites. More generally, an exploration of different patterns of stimulation in different parts of the basal ganglia may lead to a deeper understanding of the basis of deep brain stimulation.