Basal Ganglia Contributions to Logical Operations in Humans

Submission ID 3000042

Submission Type Poster

Topic Cognitive Science

Status Submitted

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SUBMISSION DETAILS

Presentation Type Either Poster or Oral Presentation

Presentation Abstract Summary The basal ganglia are thought to selectively gate cortical information flow, thereby enabling action selection (Chevalier & Deniau, 1990), working memory updating (Frank et al., 2001), and decision-making (Lo & Wang, 2006; Ding & Gold, 2012). Here, we provide human fMRI evidence that sequential, deductive reasoning recruits the basal ganglia, and does so in a manner consistent with a system-level implementation of simple logic (AND/OR) gates. Specifically, regions of the midbrain and caudate nucleus show an early increase in BOLD signal for OR (low-threshold) trials, relative to AND (high-threshold) trials, consistent with a bias signal for OR. During reasoning, for AND trials only, increases in caudate activity are offset by a decrease in putative indirect pathway activity (GPe). This GPe decrease may prevent premature inference for AND by transiently reducing its tonic inhibition on the BG output nuclei. Finally, when the subject makes an inference, there is a decrease in the activity of a distinct bilateral midbrain/GPi region. This decrease may release thalamic-cortical pathways from inhibition, thereby reflecting logical gating. Though preliminary, these results are broadly consistent with computational models of perceptual decision-making in BG (Wei et al., 2015), extended to a verbal logical reasoning task over discrete, sequential inputs.

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Keywords

Keywords
logic
fMRI
basal ganglia
decision-making
reasoning