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Model-based lesion mapping of cognitive control using the Wisconsin Card Sorting Test

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ABSTRACT: The role of the frontal lobes in cognition and behavior has long been enigmatic. Over the past decade, computational models have provided a powerful approach to understanding cognition and decision-making. Here, we used a model-based approach to analyze data from a classical task used to assess frontal lobe function, the Wisconsin Card Sorting Test. We applied computational modeling and voxel-based lesion-symptom mapping in 328 patients with focal lesions, to uncover cognitive processes and neural correlates of test scores. Our results reveal that lesions in the right prefrontal cortex are associated with elevated perseverative errors and reductions in the model parameter of sensitivity to punishment. These findings indicate that the capacity to flexibly switch between task sets requires the detection of contingency changes, which are enabled by a sensitivity to punishment that reduces perseverative errors. We demonstrate the power of model-based approaches in understanding patterns of deficits on classical neuropsychological tasks.

STATEMENT: *Our study is the first that combines computational cognitive modelling with lesion data from human subjects in a hitherto unreached sample size of over 300 patients. Cognitive modelling offers the advantage to elucidate cognitive processes rather than just analysing test scores which focus only on behavioural markers (like error scores), but often lack the consistent theoretical framework that a cognitive model provides. In combination this with human lesion data this provides causal evidence for the neural foundations of cognitive functions as opposed to most current neuroimaging techniques, which only provides correlational inference. Our main finding suggests that a diminished sensitivity for negative feedback is responsible for the behavioural inflexibility often observed in patients with frontal lobe damage.*

BACKGROUND: This work was performed at the Institute for Systems Neuroscience in the research group from Dr. Jan Gläscher, who is a Principle Investigator in the Institute since 2010. It was conducted in collaboration with Prof. Ralph Adolphs (California Institute of Technology) Prof. Daniel Tranel (University of Iowa) using data from and exceptionally large database of lesion patients with rich psychological characterization of traits and cognitive functions. This is a continuation of a decade-long, very productive collaboration.