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Prefrontal Cortex Activity During Categorization

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Category learning is necessary for humans to distinguish among objects in the world and to understand their unseen characteristics. It is through categorization that similarities and differences among items are understood. A prominent neurobiological theory of category learning called COVIS (for Competition between Verbal and Implicit Systems) contends that separate systems underlie category learning. Specifically, explicit (verbalizable) learning is mediated by the prefrontal cortex (PFC), while implicit (non-verbalizable) learning is largely mediated by basal ganglia structures. The explicit and implicit systems compete to find an effective classification rule. If the explicit system succeeds in finding an appropriate rule, it comes to dominate (i.e., determine) responding. If it fails to find an effective rule, then the implicit system may gradually learn an effective rule for classification and come to dominate responding (Ashby & Waldron, 2000; Maddox & Ashby, 2004). After a verbalizable rule has been learned, the task requires less effort and thus less activation in the prefrontal cortex (Ashby & Waldron, 2000). Increased task difficulty should lead to greater activation in the PFC.

We are investigating PFC activity during rule learning that is either mediated by the explicit or implicit system. In the current study, participants completed either a rule-based (explicit) or information-integration (implicit) learning task. On each trial, participants were shown a 2-dimensional stimulus: a line that varied in length and orientation from trial to trial. Prefrontal cortex activity was measured using fNIRS (functional near-infrared spectroscopy). Our analysis will include fitting computational models that indicate whether participants were using the correct or incorrect rule type (one that integrates dimensions or one based on selective attention to a single dimension, depending on condition completed). We predict that participants showing slower learning performance in the selective attention (rule-based) condition will exhibit greater PFC activation over blocks compared to those learning the rule more quickly. We predict that participants using a (suboptimal) integration rule during the selective attention condition (in which a selective attention rule is optimal) will show higher PFC activation than those using the correct selective attention rule. And we predict that participants learning the correct rule early on in the selective attention condition will show lower PFC activation than those in the dimensional integration condition.

This study is a pilot study for our initial question into whether compensatory activation in older adults is advantageous and to what extent does it benefit explicit rule learning. Compensatory activation refers to the supplementary blood oxygenation that the brain recruits to make up for the increased difficulty of a task. There are other applications for this study, particularly to different types of training. For example this is useful for classification of cancerous tumors. Since every tumor is unique, it requires an implicit understanding. While on the other hand, explicitly written instructions are verbalizable, therefore easier to grasp.