Effort, Motivation and Reward Learning in Schizophrenia: Relationships to Amotivation and Functional Impairment

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Some of the most debilitating aspects of schizophrenia are an apparent lack of interest in or ability to exert effort for rewards and difficulties learning about future rewards. Such "negative symptoms" may prevent individuals from obtaining potentially beneficial outcomes in educational, occupational or social domains. In animal models, dopamine abnormalities decrease willingness to work for rewards and impair the ability to learn from rewards, implicating dopamine function as a candidate substrate for negative symptoms given that schizophrenia involves dysregulation of the dopamine system. Here we present data from two studies, one examining effort allocation and one examining reinforcement learning. In study 1, we used the Effort-Expenditure for Rewards Task (EEfRT) to assess the degree to which individuals with schizophrenia were wiling to exert increased effort for either larger magnitude rewards or for rewards that were more probable in 59 individuals with schizophrenia and 39 demographically similar controls. In study 2, we used the Probabilistic Selection Task Developed by Frank and colleagues, along with fMRI, to examine the contribution of impairments in striatal prediction error signaling to impaired reinforcement learning in 49 individuals with schizophrenia and 41 demographically similar controls. In study 1, individuals with schizophrenia showed less of an increase in effort allocation as either reward magnitude or probability increased. In controls, the frequency of choosing the hard task in high reward magnitude and probability conditions was negatively correlated with depression severity and anhedonia. In schizophrenia, fewer hard task choices were associated with more severe negative symptoms and worse community and work function as assessed by a caretaker. In study 2, patients showed evidence of impairments in learning from positive, but not negative feedback. However, interestingly, we did not find clear evidence of reduced reinforcement learning related activity in the striatum. In contrast, during early learning, several regions involved in cognitive control demonstrated reduced overall choice-related activation in patients as compared to controls, which was consistent with a reduction in explicit learning during the early learning phase. Further, low probability choices were associated with reduced activation in schizophrenia in error- and conflict-processing regions including dorsal ACC, anterior prefrontal cortex, and thalamus, as well as OFC, medial temporal lobe, and cerebellar regions associated with executive control. Together, the results from the behavioral paradigms are consistent with patterns of disrupted dopamine functioning observed in animal models of schizophrenia. As such, these results suggest that two mechanisms contributing to impaired function and motivational drive in schizophrenia may be a reduced allocation of greater effort for higher value/probability rewards as well as impairments in learning from positive reinforcement. However, the imaging data suggest that such impairments may reflect involvement of cortical learning and control systems as well as striatally mediated subcortical systems.