Developmental Changes in Executive and Reward Networks: Implications for Psychopathology and Risk Taking Behavior

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Background: Decision making in adolescents may be limited by factors such as susceptibility to social influences, poor self-regulation, impulsivity, and risk-taking. Decision making is a complex behavior that almost certainly relies on interactions between a series of wide-spread brain networks. Among these are the fronto-parietal network involved in executive functioning and control, as well as the orbitofrontal-striatal network known to mediate reward sensitivity. Both of these networks continue to mature into early adulthood, which may contribute to the behavior observed in adolescents. In patient populations, individuals with both schizophrenia and bipolar disorder have been shown to have decision making deficits that persist into adulthood. Given the known developmental component of such disorders, it is likely that these deficits emerge across adolescence as the underlying networks change. Despite the known importance of these networks, little is known about the contributions of network connectivity measures to decision making and risk taking either in typically developing populations or in clinical populations.

Methods: This work was done as a part of an ongoing study, the Multimodal Evaluation of Neurodevelopmental Disorders (MEND), which is focused on assessing neurodevelopment in healthy adolescents (age 12-21) and adolescents with schizophrenia and bipolar disorder. We used both laboratory based and real-life decision making measures, as well as neuroimaging assessments that included resting state functional magnetic resonance imaging (rsMRI) and diffusion tensor imaging (DTI). Real life decision making was measured based on self-reported life events through the CDC's Youth Risk Behavior Surveillance System (YRBSS). The YRBSS assesses domains such as safety, violent behavior, risky sexual behavior, suicidality, drug use, and alcohol use. Laboratory based decision making was measured using a version of the Balloon Analogue Risk Task (BART). We performed DTI as well as seed based rsMRI analyses, targeting connectivity between regions within the executive and reward networks and assessed the relationship of the connectivity to measures of risk behavior.

Results: Our previous work has shown that structural connectivity in the fronto-parietal network is highly associated with performance on executive function tasks, and that the fronto-parietal white matter shows a different pattern of change across the lifespan than does white matter connecting the nucleus accumbens and orbitofrontal cortex. Here, in an initial analysis of the MEND sample, we found that adolescent patients and controls do show differences in risk taking measures, and that in the healthy controls, functional connectivity within regions of the executive network were correlated with executive aspects of BART task performance.

Conclusions: These findings support the hypothesis that decision making deficits in adolescents may be related to changes in network connectivity across development. Future directions will extend the rsMRI analyses to further assess within and between network connectivity, as well as comparing connectivity between patients and controls.