Cross-Sectional Differences in Brain Activity Supporting Working Memory

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Cross-sectional developmental studies have shown working memory (WM) to follow monotonic developmental trajectories through childhood into adolescence. In contrast, structural neuroimaging studies have shown that several brain regions, such as the prefrontal cortex (PFC), follow nonlinear developmental trajectories from birth through late adulthood. The present study sought to explore the relationship between functional activation in brain regions supporting WM and age throughout adolescence. Forty-two healthy adolescents (aged 11 to 18) completed a delayed-response WM task while functional magnetic resonance imaging (fMRI) data were collected. Participants studied either one or six letters (3.5 seconds), remembered the items over a delay (5 seconds), and then judged whether a single probe letter was in the studied set (within 2.5 seconds). An fMRI blocked design was used: four blocks per set-size and three trials per block. Additionally, the participants completed the Digit Span subtest from the Wechsler intelligence tests in order to obtain behavioral measures of WM. Hierarchical regression analyses were used to evaluate linear and quadratic relationships between WM task-related signal-change per voxel and age while evaluating the potential mediating effects of WM indices (response time [RT], digit span forward, digit span backward). Linear relationships were found in right medial Brodmann's Area (BA) 6, right cerebellum, and left BA34 when the linear effects of gender, handedness, response time, digit span forward, and digit span backward were controlled for statistically. Thus, activation increased with age within these regions, but the linear trends were being suppressed by the covariates. Activation on the WM task increased with age in right medial BA6 when the effects of WM indices, as measured in the present study, were removed. The separate relationship between WM capacity and right medial BA6 activation suppressed the detection of the relationship between right medial BA6 activation and age. The data support developmental, possibly maturational, changes in the role of medial PFC in WM that are independent of WM ability measures used in the present study. This finding has implications for broad theories about the development of WM and other cognitive abilities that allow for the identification of both normal and deviant developmental trajectories.