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White matter tracts and executive functions: a review of causal and correlation evidence

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Abstract

Executive functions are high-level cognitive processes involving abilities such as working memory/updating, set-shifting and inhibition. These complex cognitive functions are enabled by interactions among widely distributed cognitive networks, supported by white matter tracts. Executive impairment is frequent in neurological conditions affecting white matter; however, whether specific tracts are crucial for normal executive functions is unclear. We review causal and correlation evidence from studies that used direct electrical stimulation during awake surgery for gliomas, voxel-based and tract-based lesion-symptom mapping, and diffusion tensor imaging to explore associations between the integrity of white matter tracts and executive functions in healthy and impaired adults. The corpus callosum was consistently associated with all executive processes, notably its anterior segments. Both causal and correlation evidence showed prominent support of the superior longitudinal fasciculus to executive functions, notably to working memory. More specifically, strong evidence suggested that the second branch of the superior longitudinal fasciculus is crucial for all executive functions, especially for flexibility. Global results showed left lateralization for verbal tasks and right lateralization for executive tasks with visual demands. The frontal aslant tract potentially supports executive functions; however, additional evidence is needed to clarify whether its involvement in executive tasks goes beyond the control of language. Converging evidence indicates that a right-lateralized network of tracts connecting cortical and subcortical grey matter regions supports the performance of tasks assessing response inhibition, some suggesting a role for the right anterior thalamic radiation. Finally, correlation evidence suggests a role for the cingulum bundle in executive functions, especially in inhibition tasks. We discuss these findings in light of current knowledge about the functional role of these tracts, descriptions of the brain networks supporting executive functions and clinical implications for individuals with brain tumors.

Keywords: awake surgery; cognitive control; diffusion tensor imaging; superior longitudinal fasciculus; tract-based lesion-symptom mapping; voxel-based lesion-symptom mapping.