Brain areas associated with basic mathematical operations

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ABSTRACT

Mathematics is a core course in school curricula. Children begin formal mathematical training in preschool and continue training throughout school age years or longer as some adults use complex mathematics professionally. The brain correlates of arithmetic process have received extensive attention from neuroscientists. Parietal cortex contribution to mathematical processes is established and extensively discussed (Dehaene & Cohen, 1997; Dehaene et al., 2003). However, the parietal cortex alone cannot support mathematical cognition, as regions such as the frontal cortex are crucial even for basic numerical judgments. Many studies show that arithmetic processes engage a distributed set of areas that includes various regions in frontal, parietal, cingulate and insular cortices (Arsalidou and Taylor 2011; Sokolowski et al. 2017; Yeo et al. 2017; Arsalidou et al. 2018 for meta-analyses). Prefrontal cortex for instance plays key role in monitoring and manipulating of information (Christoff et al., 2009) and maintains processing relevant information to complete the task (Eslinger & Biddle, 2008). Critically, it remains unclear what common or distinct brain regions support problem solving in different basic mathematical operation such as addition, subtraction and multiplication.

Our main research goal is to investigate brain response to mathematical problem solving in healthy adults using quantitative activation likelihood estimate (ALE) meta-analysis. Specifically, these meta-analyses investigate common and distinct brain regions that underlie processing of three mathematical operations: addition, subtraction, and multiplication. Moreover, we performed region of interest analyses in parietal, frontal, cingulate and insular cortices to compute laterality indices to examine hemispheric asymmetry in processing different types of mathematical operations.

Data from 49 original articles,that tested a total of 896 participants (addition N = 386; subtraction N = 399; Multiplication N = 437) were analyzed Results indicated that parietal (BA 7, BA 40), prefrontal (BA 9) and insular cortices make up common regions, whereas distinct regions include the angular gyrus, basal ganglia and cerebellum. Theoretical and practical implications of these findings will be discussed.

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