Eye gaze reveals a fast, parallel extraction of the syntax of arithmetic formulas.

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Source

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Abstract

Mathematics shares with language an essential reliance on the human capacity for recursion, permitting the generation of an infinite range of embedded expressions from a finite set of symbols. We studied the role of syntax in arithmetic thinking, a neglected component of numerical cognition, by examining eye movement sequences during the calculation of arithmetic expressions. Specifically, we investigated whether, similar to language, an expression has to be scanned sequentially while the nested syntactic structure is being computed or, alternatively, whether this structure can be extracted quickly and in parallel. Our data provide evidence for the latter: fixations sequences were stereotypically organized in clusters that reflected a fast identification of syntactic embeddings. A syntactically relevant pattern of eye movement was observed even when syntax was defined by implicit procedural rules (precedence of multiplication over addition) rather than explicit parentheses. While the total number of fixations was determined by syntax, the duration of each fixation varied with the complexity of the arithmetic operation at each step. These findings provide strong evidence for a syntactic organization for arithmetic thinking, paving the way for further comparative analysis of differences and coincidences in the instantiation of recursion in language and mathematics.