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Non-formal mechanisms in mathematical cognitive development: the case of arithmetic.

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Summary: The idea that cognitive development involves a shift towards abstraction has a long history in psychology. One incarnation of this idea holds that development in the domain of mathematics involves a shift from non-formal mechanisms to formal rules and axioms. Contrary to this view, the present study provides evidence that reliance on non-formal mechanisms may actually increase with age. Participants – Dutch primary school children – evaluated three-term arithmetic expressions in which violation of formally correct order of evaluation led to errors, termed foil errors. Participants solved the problems as part of their regular mathematics practice through an online study platform, and data were collected from over 50,000 children representing approximately 10% of all primary schools in the Netherlands, suggesting that the results have high external validity. Foil errors were more common for problems in which formally lower-priority sub-expressions were spaced close together, and also for problems in which such sub-expressions were relatively easy to calculate. We interpret these effects as resulting from reliance on two non-formal mechanisms, perceptual grouping and opportunistic selection, to determine order of evaluation. Critically, these effects reliably increased with participants' grade level, suggesting that these mechanisms are not phased out but actually become more important over development, even when they cause systematic violations of formal rules. This conclusion presents a challenge for the shift towards abstraction view as a description of cognitive development in arithmetic. Implications of this result for educational practice are discussed.

Classification: F32 F33 C32 C33

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