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**How numbers mean: comparing random walk models of numerical cognition varying both encoding processes and underlying quantity representations.**

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Summary: How do people derive meaning from numbers? Here, we instantiate the primary theories of numerical representation in computational models and compare simulated performance to human data. Specifically, we fit simulated data to the distributions for correct and incorrect responses, as well as the pattern of errors made, in a traditional “relative quantity” task. The results reveal that no current theory of numerical representation can adequately account for the data without additional assumptions. However, when we introduce repeated, error-prone sampling of the stimulus superior fits are achieved when the underlying representation of integers reflects linear spacing with constant variance. These results provide new insights into (i) the detailed nature of mental numerical representation, and, (ii) general perceptual processes implemented by the human visual system.

*Classification:* C30 F20 D20

*Keywords:* numerical cognition; random walk; numerical distance; physical similarity; numerical architecture; simulation

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