The situated meaning of mathematical symbols: ERPs to mathematical equations are modulated by the relation between accompanying speech and gesture

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When children explain their mathematical reasoning, they combine speech and gesture to communicate their problem-solving strategies, often pointing to co-situated equations. Children sometimes convey different strategies in gesture than in speech; these speech-gesture “mismatches” are known to predict when a child is ready-to-learn. Here we used event-related potentials to study whether the relation between speech and gesture affects the processing of associated equations. In Experiment 1, participants viewed naturalistic video-recordings of children explaining their solutions to mathematical equivalence problems, followed by a still image of the correct solution (e.g., “8+2+3=8+5”). The children in the videos either solved the problems correctly or incorrectly, and the strategies expressed in speech and gesture either matched or mismatched, producing a 2 x 2 within-participants design. The correct solution was followed by a list of strategies; participants’ task was to indicate which strategies the child used to solve the problem. ERPs were time-locked to the onset of the still of the correct equation. The relation between speech and gesture affected the semantic processing of the equation: Equations following Mismatch videos elicited a larger N400 component than Match videos. Experiment 2 was identical to Experiment 1 except participants had to indicate whether the child had solved the problem correctly. Unlike Experiment 1, ERPs revealed no effect of gesture-speech Match. Thus, processing of mathematical equations was modulated by the relation between speech and gesture—but only when participants attended to the reasoning process (the child’s strategy) rather than the outcome (whether the child was correct).