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Gesture Comprehension Recruits Sensorimotor Systems

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Ethnographers and psychologists have demonstrated how depictive gestures have been used to communicate a wide range of semantic content, from indicating the direction of a block's rotation to mimicking the operation of a forklift at a loading dock. The human capacity to communicate simply through body orientation and movement suggests that some aspects of our conceptual knowledge are represented in highly schematic form. What neurocognitive systems mediate this ability to understand gestures?

EEG was recorded from neurotypical adults as they passively viewed short video segments of spontaneous depictive gestures preceded by either congruent or incongruent cartoon contexts (e.g., a gesture showing an object being raised overhead paired with a cartoon showing a cat trapping a mouse with a flowerpot). To encourage semantic processing, each cartoon-gesture pair was followed by a probe word (e.g., flowerpot) that participants classified as either related or unrelated to the gesture. After preprocessing, underlying brain and non-brain source activities were decomposed by independent component analysis (ICA), which learns from the statistics of time-series EEG a set of linear spatial filters that return maximally distinct estimations of source signals whose contributions sum to the original scalp-recorded data (Makeig, Bell, Jung, & Sejnowski, 1996). Each non-artifact IC scalp topography was modeled as the projection of a single equivalent dipole representing activity in a nearby cortical patch. Event-related spectral perturbations (ERSPs) visualized spectral modulations (3-122 Hz) of IC activations across 200 equally spaced time points during the 2.5-s intervals when gestures were on screen. Measure projection analysis (Bigdely-Shamlo, Mullen, Kreutz-Delgado, & Makeig, 2013) identified a subspace of brain voxels with reliable levels of local correlation between ERSP measures and IC dipoles. This subspace was further divided into three domains by affinity clustering based on local ERSP similarity.

A domain in and near the right superior parietal lobule and right post-central gyrus exhibited sensitivity to cartoon-gesture congruency. Relative to their incongruent counterparts, congruent gestures elicited greater event-related desynchronization (ERD) in the 7 to 12 Hz (alpha) and 17 to 20 Hz (beta) ranges from approximately 500 ms after video onset to video offset. Congruent gestures were also accompanied by intermittently increased power (ERS) near 70 Hz relative to incongruent items.

This cortical source domain overlaps areas known to respond to the perception of meaningful body movement and so are implicated in the human mirror system (Calvo-Merino, et al., 2005). The left hemisphere homologue to this domain has been implicated in the production of meaningful body movements, such as tool-use pantomimes and signed language (Choi, et al., 2000; Emmorey, Mehta, & Grabowski, 2007; Wolpert, Goodbody, & Husain, 1998). This area has also been proposed to mediate proprioceptive monitoring of the body's position in space (Wolpert, Goodbody, & Husain, 1998). Based on an embodied view of language, our results suggest that brain systems recruited during observation (and likely production) of patterned body movements also play an important role in higher cognitive functions, such as establishing conceptual mappings necessary to interpret the meaning of depictive gestures.