Representation of Real and Imagined Actions in the Early Visual Cortex

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Abstract Recent evidence shows that the role of the early visual cortex (EVC) goes beyond visual processing and into higher cognitive functions (Roelfsema and de Lange in Annu. Rev. Vis. Sci. 2:131–151, 2016). Further, neuroimaging results indicate that action intention can be predicted based on the activity pattern in the EVC (Gallivan et al. in Cereb. Cortex 29:4662–4678, 2019; Gutteling et al. in J. Neurosci. 35:6472–6480, 2015). Could it just be imagery? Further, can we decode action intention in the EVC based on activity patterns elicited by motor imagery, and vice versa? To answer this question, we explored whether areas implicated in hand actions and imagery tasks have a shared representation for planning and imagining hand movements. We used a slow event-related functional magnetic resonance imaging (fMRI) paradigm to measure the BOLD signal while participants ($N = 16$) performed or imagined performing actions with the right dominant hand towards an object, which consisted of a small shape attached on a large shape. The actions included grasping the large or small shape, and reaching to the center of the object while fixating a point above the object. At the beginning of each trial, an auditory cue instructed participants about the task (Imagery, Movement) and the action (Grasp large, Grasp small, Reach) to be performed at the end of the trial. After a 10-s delay, which included a planning phase in Movement trials, a go cue prompted the participants to perform or imagine performing the action (Go phase). We used standard retinotopic mapping procedures to localize the retinotopic location of the object in the EVC. Using multi-voxel pattern analysis, we decoded action type based on activity patterns elicited during the planning phase of real actions (Movement task) as well as in the Go phase of the Imagery task in the anterior intraparietal sulcus (aIPS) and in the EVC. In addition, we decoded imagined actions based on the activity pattern

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of planned actions (and vice-versa) in aIPS, but not in EVC. Our results suggest a shared representation for planning and imagining specific hand movements in aIPS but not in low-level visual areas. Therefore, planning and imagining actions have overlapping but not identical neural substrates.

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