

THE MULTIPLE FUNCTIONS OF SENSORY-MOTOR REPRESENTATIONS: AN INTRODUCTION

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The papers in this issue consider the role of sensory-motor processes and their neural structures in higher cognitive functions such as visual and motor imagery, iconic memory, temporal judgement, mental rotation, and the representation of object and action concepts. The papers draw on a range of methodologies, from computational modelling to behavioural studies of brain-damaged subjects, to fMRI, TMS, and ERP studies with normal subjects, and they present various theoretical perspectives. What unites them is the explicit effort to understand how sensory-motor processes might be integrated into cognitive theory.

Damage to a particular area of the brain can result in complex deficits involving different types of cognitive domains. For example, damage to Broca's area has been variously associated with deficits in syntactic processing, morphological processing, selecting among potential responses, short-term memory, procedural memory, sequencing, spoken and written word production, verb and preposition semantics, and motor imitation among others. It is hard to imagine what common cognitive mechanism might underlie this varied set of processes.

Even more dramatic differences are found in the neuroimaging literature, where it is routinely reported that the same brain area is activated by radically different tasks, which supposedly

implicate distinct cognitive operations and mechanisms. For example, Price and Friston (2005 this issue) note that the left posterior lateral fusiform (PLF) area has been implicated in reading, picture categorisation, repetition priming of words and pictures, colour naming, categorisation of Heider-Simmel stimuli, tactile object recognition, and semantic and phonological decisions on auditory words. This situation seems to undermine the classical view of a one-to-one mapping between cognitive mechanism and brain region and has stimulated anew the old debate between localisationist and non-localisationist theories of the functional organisation of the brain. However, the putative many-cognitive-processes-to-one-brain-region result has also encouraged a different type of theorising from the classical view of cognition, which was based primarily on behavioural studies with normal subjects. New approaches emphasise a different way of carving cognition at its joints. For example, Price and Friston (2005 this issue) argue for the development of new theories of cognitive processing that explicitly incorporate the noted variability in brain-cognition mapping. In the case of the left PLF it could be proposed that its function is some sort of sensory-motor integration and that it participates in a network that gives specificity to this general function. The idea that a network approach is the best way to proceed for

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understanding brain-function relations is also the argument developed from a computational perspective by Treves (2005 this issue) and experimentally by Manjaly, Marshall, Stephan, Gurd, Zilles, and Fink (2005 this issue). Similarly, Alexander, Cowey and Walsh (2005 this issue) suggest a role of the parietal cortex in time perception as part of a larger network including motor and supplementary motor areas, prefrontal cortex, and the cerebellum. And, Keysers, Xiao, Földiák, and Perrett (2005 this issue) present evidence implicating the superior temporal sulcus as part of a network involved in iconic memory.

The observation that an area whose putative function is one type (e.g., motor) is also activated (or implicated) in the processing of a different cognitive function (e.g., visual recognition) has stimulated debate on another long-standing issue: the role of motor processes in perception and cognition. Perhaps the best known case of a motor theory of perception is the one proposed by Liberman and colleagues (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967) for speech perception. In recent years, the general issue of a motor basis for certain cognitive processes has regained prominence in the context of “simulationist” theories of cognition, stimulated in part by the discovery of mirror neurons (for a review of the empirical evidence, see Rizzolatti, Fogassi, & Gallese, 2001). Theories of this type assume that perceptual and conceptual processing is dependent on the reactivation of sensory-motor information.

A number of the papers in this issue articulate “simulationist-type” theories of cognitive processes on the basis of results showing activation of sensory-motor areas in the context of cognitive tasks. For example, Kosslyn (2005 this issue) points to the activation of primary visual cortex during imagery tasks to argue for a direct role of low-level visual processes in imagery. Tomasino, Borroni, Isaja, and Rumiati (2005 this issue) point to the disruptive influence of TMS applied to area M1 on mental rotation of hand stimuli to argue for a role of motor processes in a visual-cognitive task. Analogous arguments are

made for the role of sensory-motor processes in cognitive operations in the papers by van Schie, Wijers, Mars, Benjamins, and Stowe (2005 this issue), Tsakiris and Haggard (2005 this issue), Farnè, Bonifazi, and Làdavvas (2005 this issue), and Bekkering, Brass, Woschina, and Jacobs (2005 this issue), while Sebanz, Knoblich, Stumpf, and Prinz (2005 this issue)—though recognising the important role of sensory-motor processes—do not seem to be committed to a simulationist approach to higher cognitive processing.

Finally, Gallese and Lakoff (2005 this issue) propose the boldest simulationist theory of cognition yet. They argue that all conceptual knowledge is “embodied” and that therefore sensory-motor representations are at the core of all cognitive operations. However, Mahon and Caramazza (2005 this issue) discuss neuropsychological evidence showing that the recognition of actions and understanding of objects do not depend necessarily on the ability to produce object-associated actions. The implication of this analysis is that the precise role of the interaction between motor processes and the understanding of actions and objects is in need of further clarification.

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