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Abstract

Symposium III—Knowledge, perception and action: Making the connection

Timothy T. Rogers

Department of Psychology, University of Wisconsin-Madison, Madison, WI, USA

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Cognitive representations for control of object prehension and use, Laurel J. Buxbaum, Moss Rehabilitation Research Institute, Philadelphia, PA, USA

The control systems guiding skilled functional object use (e.g., typing on a computer keyboard) differ in critical ways from the systems used to control grasping based on volumetric information (e.g., picking up a keyboard). We present data from a series of studies that speak to the distinction between the two types of actions. The first study shows that patients with ideomotor apraxia (IM) after left inferior parietal damage are deficient in producing and recognizing hand postures associated with functional object use, but perform normally in recognizing grasp postures associated with object volume and structure. The second study uses functional magnetic resonance imaging to confirm that recognition of object use versus grasp hand postures engage different neural structures, and that the former is associated with greater activation of the left inferior parietal lobe. The third study demonstrates that functional hand postures are the most deficient aspect of gesture imitation in IM patients with left inferior parietal damage and the least impaired aspect of imitation in non-focal IM patients with corticobasal degeneration. The fourth study shows that damage to the systems mediating skilled object use affects the ability to make accurate predictions about appropriate positioning of the hand to engage objects. These data suggest that deficits in pantomime and imitation of skilled actions, the hallmarks of IM, may be attributable in part to deficits in internal models for planning object-related actions in the face of relatively intact on-line, feedback driven control of action. We propose that functional object-related gesture representations are likely to be closely tied to evolutionarily more primitive systems controlling object grasping, and to emerge from a mapping between object and action information coded by ventral and dorsal streams in the left hemisphere.

Knowing what to do: A computational account of routine sequential action, Matthew Botvinick, Center for Cognitive Neuroscience, University of Pennsylvania, Philadelphia, PA, USA

In everyday tasks, selecting actions in the proper sequence requires a continuously updated representation of the current task context. Many existing models address this problem by positing a hierarchy of "schemas," mirroring the roughly hierarchical structure of naturalistic tasks themselves. Although intuitive, such an approach has led to a number of difficulties, including a reliance on overly rigid sequencing mechanisms and a limited ability to address both learning and context sensitivity in behavior. We have pursued an alternative framework in which the representation of context depends on learned, recurrent connections within a neural network that maps from environmental inputs to actions. Applying this approach to specific everyday tasks, we have demonstrated its ability to account for some fundamental characteristics of normal and impaired human performance. In particular, through computational modeling, we have shown how the approach can explain many basic features of action errors, including both everyday "slips of action" and the more severe errors committed in certain forms of apraxia. Our modeling work has given rise to novel predictions concerning both the role of eye movements in sequential behavior and the impact of momentary distraction, predictions that have been successfully tested in subsequent experimental work.

Representing graspable objects: Investigations of "what" and "how" for real and imagined actions, Sarah H. Creem-Regehr, Department of Psychology, University of Utah, Salt Lake City, UT, USA

Research involving hand-tools provides an important contribution to the study of perception–action interactions, as tools can be characterized by their functional identity ("what" they are) as well as by their graspability ("how" to grasp). Gibson suggested that objects may have multiple *affordances*, properties for action that are defined by an organism's goals. Although it is likely that human-made tools have the potential to serve multiple functions, modern tools are created with one specific function in mind, and thus are associated with an action plan that involves grasping the object in a specific way. Over recent years there has been a burst of research examining action representations in the context of tools. Our recent studies have aimed to investigate the contribution of knowledge about an object's function to representations for actions associated with different graspable objects using fMRI. An initial study presented observers with images of hand-tools or neutral graspable shapes while they viewed or imagined grasping the objects. Differences were found in motor-related regions of cortex (posterior middle temporal gyrus, ventral premotor, posterior parietal) for tools compared to shapes. A subsequent study assessed the influence of training about the functions of artificial novel objects on (1) viewers' cognitive representations for overt grasping and using of the objects and (2) viewers' neural representations associated with viewing, imagining grasping, and imagining using the objects during an fMRI session. Functional identity influenced both the overt action responses and the level and extent of neural "motor" activation in the fMRI motor imagery tasks.

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Looking to see: A simple model of active vision for object recognition,
Timothy T. Rogers, Department of Psychology, University of Wisconsin-Madison, Madison, WI, USA

To derive meaning from a visually complex scene, the observer must be able to direct her gaze to relevant objects of interest, identify the objects and establish their spatial relationships to one another, and integrate this information across successive fixations to form a coherent representation of the scene as a whole. Questions about how components of scenes are selected for attention, or how successive fixations can give rise to a coherent percept, have been fundamental to theories of visual scene perception since Helmholtz's time. The same questions are seldom raised in the context of single-object recognition; yet object recognition also requires the observer to identify the important components of an object, establish their spatial relationships to one another, and integrate this information into a coherent object percept. I will describe a theory of visual perception in which direction of gaze critically supports the ability to bind object parts together into a recognisable whole, and separate objects together into a scene Gestalt. The theory is illustrated with reference to a simple recurrent network model which simultaneously learns to (a) direct its gaze to informative regions of a visual scene and (b) integrate inputs over successive fixations to recognise objects in the scene. The model offers a novel explanation of key phenomena in visual recognition, including generalisation across spatial location, recognition of configural stimuli such as faces, the ability to establish object-based frames of reference, sensitivity of gaze-direction to task context, and visual feature binding.