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26 Interaction between feature binding in perception and action

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Abstract. To explain how coherent representations can be formed of information that is distributed throughout the brain, binding mechanisms have been hypothesized that temporarily hold together or bind such distributed information. Evidence of temporary feature binding has been reported from tasks requiring perceptual integration and action planning, and there is some evidence that action planning affects perception. The present study provides further evidence that binding-related effects cross borders between perceptual and motor domains by demonstrating that perceptual integration affects action planning. Results from 3 psychophysical experiments suggest that if a particular perceptual feature is bound into an object representation, it is less accessible for concurrent action planning. Furthermore, our results support the idea that the formation of object representations goes through two phases: feature activation and feature integration. Feature sharing between perception and action is beneficial during the feature activation, but leads to mutual interferences in feature integration. Wider implications of these findings are discussed, especially with regard to feature binding as a general mechanism of cognitive representation as well as the relationship between perception and action.

Psychologists and neuroscientists have long studied how representations of perceptual and action events are organized and how these representations are related to neuronal activity. It is known that elementary features of perceptual and action representations are represented by specific neuronal populations. For example, features of visual objects have been found to be coded in various feature maps distributed across the brain (DeYoe and Van Essen 1988; Ungerleider and Haxby 1994), and neurons coding specific motor features, such as the direction of reaching movements, have been identified (Georgopoulos 1990). Therefore, it is likely that representations of objects and action plans are based on distributed neuronal populations, each coding different aspects or features of the representation (Singer 1994). One of the unanswered questions associated with this hypothesis about the structure of representations refers to the binding problem: if objects are represented by the activity of distributed sets of neurons, how is the relationship between these neurons coded (von der Malsburg 1981, 1995)? This problem is nicely illustrated by Rosenblatt's (1961) example of a perceptron, a simple neural network consisting of just four neurons (Fig. 26.1(a)). Neuron 1 responds to the presence of a triangle and neuron 2 to the presence of a square. Neuron 3 responds to all objects in the upper visual field and neuron 4 to all objects in the lower visual field. If this system has to detect a square in the upper visual field, an output neuron would have to detect the simultaneous activity in neuron 2 and 3 (Fig. 26.1(a)). But now suppose that there is a triangle in the upper and a square in the lower visual field: The output neuron would falsely respond (Fig. 26.1(b)). In other words, the perceptron can only handle one object at a time. The example shows that representing the presence or absence of features alone is not sufficient to represent multiple objects simultaneously.