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## Tactile Shape Processing

**Neuroimaging techniques may aid in the identification of areas of the human brain that are involved in tactile shape perception. Bodegård et al. (2001) relate differences in the properties of tactile stimuli to differences in areas of cortical activation to infer tactile processing in the somatosensory network.**

Shape perception using touch is a remarkable ability, yet its study can be as daunting as it is intriguing. Objects differ in form and tactile properties in almost innumerable ways, and the relevant dimensions of tactile perception and shape processing are for the most part still unknown. The study by Bodegård and colleagues (2001) in the current issue of *Neuron* addresses a problem at the core of this endeavor—can form processing by touch be shown to differ from the component sensorimotor processes that encode, remember, and discriminate stimuli?

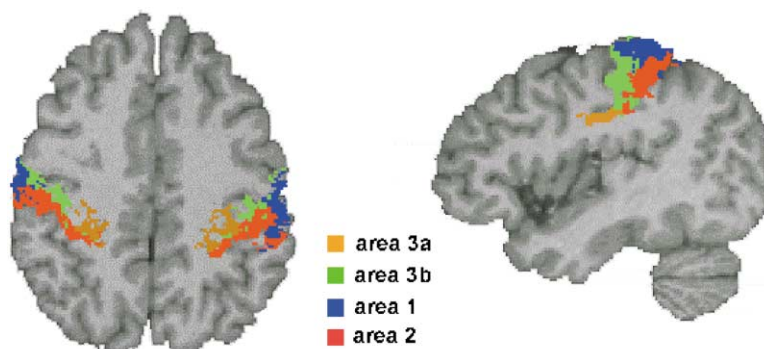
Bodegård et al. report the results of positron emission tomography (PET) studies that are designed to elaborate the sensory processing sequence that subserves tactile shape perception. The experimental manipulation involves a shape discrimination, either in a passive condition in which objects are placed or moved in subjects' hands, or in an active condition in which subjects are asked to manipulate objects. Differences in regional cerebral blood flow (rCBF) are used to infer a hierarchical organization of tactile processing in the somatosensory system.

The basic findings of the present study are consistent

with and extend previous results of electrophysiological and brain imaging studies—activation during cutaneous discrimination is observed in areas 3b, 1, and 2 of the somatosensory cortex (see Figure), motor areas 4, 6, and 44, supplementary motor area, and cerebellum (not shown in Figure). Activation is also observed in anterior parts of intraparietal cortex (IPA) and supramarginal gyrus (ASM) during passive, as well as active, shape processing. This final result extends other work from Roland's laboratory that identifies these areas as somatosensory zones (Bodegård et al., 2000).

The authors reason that in order to take account of object properties that are typically encountered sequentially, shape discrimination must involve several different areas of the brain. They hypothesize that a hierarchy of somatosensory regions specifically associated with shape discrimination may be established by identifying areas that are activated by progressively fewer and more specialized components of tactile form. Thus, cortical areas, such as 3b and 1, that are activated by essentially all types of tactile stimuli and discrimination—curvature, edge length, and roughness in addition to shape—are presumed to be involved in initial low-level shape processing. Areas, such as 2, that are activated by a smaller subset of object features, with preference for differences surface curvature, may be allocated to a subsequent step, and areas such as the IPA and ASM that are activated under few conditions represent a yet higher level related to computation of tactile shape and potentially represent the cortical locus of shape representation.

Several aspects of the data are noteworthy in relation to the idea of a shape processing hierarchy. It is reported that all stimuli activate areas 3b and 1. In conjunction with independent electrophysiological data, there is little reason to doubt the authors' conclusion that these areas are involved in the lowest levels of cortical processing of shape. Area 2 is also activated by all types of stimuli, but activation is less when subjects have to discriminate the velocity of a brush that is applied to the fingers and hand than when a cylindrical object is placed in the same location. This is suggestive of a possible dissociation between tactile shape and motion processing, possibly analogous to that observed in the visual system (DeYoe and Van Essen, 1998; Ungerleider and Mishkin, 1982), and may reveal a preference of area 2 for the processing of object curvature. The authors also attribute activation in IPA and ASM to the encoding of shape information as opposed to transient motion.



Human Somatosensory Areas Activated during Tactile Processing

Primary somatosensory areas 3b and 1 are activated by tactile stimuli discriminated passively and during tactile explorations. Area 2 is preferentially activated by the curvature of surfaces. Areas lining the intraparietal sulcus (IPA) and in the anterior part of the supramarginal gyrus (ASM) are preferentially activated during shape perception (as shown in Figure 6 of Bodegård et al., 2001). This figure was kindly provided by Bodegård and Roland.

A number of considerations may be raised in coming to an understanding of the present findings. The activation patterns are interpreted in the context of object property representations. However, recent electrophysiological studies highlight the diversity of neural functions that occur during cutaneous discriminations (Romo and Salinas, 2001). They report neural activation in areas 3b, 1, and the second somatosensory cortex (and in cortical motor areas as well) in relation to properties of the stimulus, maintenance of stimulus information to enable a subsequent discrimination, activity related to a comparison of stimuli, and, ultimately, to a decision. It is now apparent, at least in monkeys, that classical sensory and motor areas subserve a variety of functions in discrimination tasks. On the basis of rCBF measures, it would seem premature to attribute brain activity to any of these functions or indeed to conclude that object shape coding occurs as opposed to other neural processing.

The results of the present paper are consistent with electrophysiological data showing activation of cortical motor areas during somatosensory processing. The presence of this activity in absence of movement suggests that the function of these areas (4, 6, 44, and SMA) needs to be included in our understanding of somatosensory processing. Consistent with the authors' observation that IPA may be involved in a network that enables the separation of form and motion information, the possible incorporation of premotor areas and prefrontal cortex may provide a fruitful basis for a more elaborate model of the sensorimotor network.

Future studies would do well to include within-subject comparisons of active versus passive tactile discrimination. In the present study, only activation in anterior cerebellum was found to distinguish active from passive touch. Within-subject comparisons between active and passive conditions would permit differences in activation to be revealed in cortical sensory and motor areas, as for example have been observed in studies with primates. This could contribute to a better understanding of the role that movement plays in active tactile discrimination.

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