Scientific Approaches to the Study of Human Hand Function

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The human hand is a critical component of a highly complex system that includes, and is controlled by, a very powerful nervous system. This highly flexible system is used to perform an impressive range of manual functions.

Human hand performance critically depends upon the structure and function of the human hand, the properties of the physical environment, the nature of the hand/environment interactions, and finally, how sensorimotor inputs are processed and represented, both functionally and neurally.

Within this conceptual framework, I will address selected issues relating to the *sensory* side of human hand function that have been investigated by touch scientists. For each, I will outline some of the more successful methodologies that have been employed and illustrate the types of conclusions that may be drawn, using examples from the scientific literature.

1) What is the sensitivity and spatiotemporal resolution capacity of the human hand?

This aspect of psychophysical investigations focuses on the detection and discrimination of threshold-level events. Human hand function is constrained in part by whether the somatosensory system can detect the occurrence of mechanical, thermal and/or electrical events. It is further limited by the precision with which it can discriminate spatial or temporal events. Selective adaptation and masking paradigms have been used to behaviorally determine the relative contribution of different sensory channels.

2) What is the relation between supra-threshold stimulus intensity and perceived magnitude?

This issue involves an aspect of psychophysics that focuses on the nature of the mathematical function that best describes the relation between supra-threshold physical intensity and the perceived magnitude of the corresponding sensation or percept. Psychophysical methods have been used to study human sensation (e.g., warmth, cold, pressure, etc.) and the perception of objects and their properties (e.g., roughness, compliance, weight, shape, size, orientation, etc.).

3) What is the nature and role of manual exploration in human haptic processing of objects and their properties?

Video analysis has shown that manual exploration is highly systematic. Behavioral experiments have revealed the costs and benefits of performing one (or

more) patterns of manual exploration ("exploratory procedures") for haptic object perception. When manual exploration of unfamiliar objects is unconstrained, their material properties are more perceptually salient than their geometric properties. Simultaneous execution of two or more exploratory procedures allows perceivers to integrate valuable redundant property information about the identity of multi-attribute objects.

4) ***What are the contributions of spatial and temporal information to haptic object processing?***

It is possible to assess the contribution of different types of information by manually constraining haptic exploration in space and/or during its time-course, thereby eliminating certain sources of information. The resulting decrement in performance signals the contribution of the missing information.

5) What are the psychological dimensions that underlie complex human tactile/haptic percepts?

Complementary methods involving controlled psychophysical experiments and multidimensional-scaling procedures have been used to determine the perceptual spaces that underlie complex touch-related experiences (e.g., surface texture), and associated physical dimensions.

6) When both vision and touch are used, how is information from both modalities integrated?

Human hand performance is frequently affected by the simultaneous availability of information to more than one sensory modality (e.g., touch, vision, audition). How are multisensory inputs about a common physical event combined? A number of scientific methodologies have been used to address this question, usually by comparing data from unimodal to that of bimodal (or multimodal) conditions.

A number of these topics are also relevant to how cutaneous and kinesthetic cues contribute to human manual kinesthesis and to dextrous grasping and manipulation, as will presumably be noted in other presentations at this workshop.