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Young children's haptic exploratory procedures

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ABSTRACT

Adults vary their haptic exploratory behavior reliably with variation both in the sensory input and in the task goals. Little is known about the development of these connections between perceptual goals and exploratory behaviors. A total of 36 children ages 3, 4, and 5 years and 20 adults completed a haptic intramodal match-to-sample task. Participants were instructed to feel the shape, texture, rigidity, or weight of a sample object and then were asked to find which of three test objects matched the sample on that specific property. Hand movements were examined to determine whether children produced the same exploratory procedures while gathering perceptual information about each property as adults who searched for the same kind of information. Children demonstrated that they had good haptic abilities in two ways: They matched the sample objects on the specified perceptual dimension at near ceiling levels, and they produced the same hand movement patterns to find the same properties as adults.

Introduction

The human hand is a powerful tool. The sensory and motor subsystems that serve the hand allow quick and efficient interactions with the world. The hand's sensory system is designed to learn about the perceptual features of objects and is made up of cutaneous, thermal, and kinesthetic sensors. The hand's motor system is designed to interact with and manipulate objects (Klatzky & Lederman, 2002; Lederman & Klatzky, 2009). The sensory and motor systems are not independent. How the hands are moved determines what sensory information is obtained. The sensory input obtained guides further hand movements and, importantly, constrains what can be perceived.

When adults search for perceptual information, their hand movement patterns (i.e., the haptic exploratory behaviors) are efficient, rapid, and systematic (e.g., Klatzky, Lederman, & Metzger,

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1985). Lederman, Klatzky, and their colleagues have extensively studied the haptic exploratory abilities of adults. Lederman and Klatzky (1987) recorded the hand and finger movements of adults attempting to extract perceptual information about specific object properties—shape, texture, hardness, weight, temperature, volume, part motion, and specific function—using haptics alone. Participants were instructed to find which of three test objects was the best match for a standard object on one of these eight specific dimensions. None of the test objects was identical to the standard, and participants were told to ignore all other properties of the objects. The participants' object matching choices and the hand movements that preceded them were recorded. The researchers identified eight stereotyped hand movement patterns or "exploratory procedures," each associated with a specific task goal. For example, adults who were asked to match objects by texture generally produced "lateral motion"—movements of the fingers lateral to the object's surface. In contrast, adults who were asked to match objects by shape produced "contour following"—tracing the object's contours with their fingertips. Hand movements during haptic exploration varied reliably both with the sensory input and with the kind of information participants had been asked to seek. The consistent relations between particular hand movements and particular goals suggested that observing how participants moved their hands during haptic tasks could reveal the goals behind their exploratory behavior (Lederman & Klatzky, 1987).

Little is known about the development of the connections between particular perceptual goals and particular exploratory manual behaviors observed in adults. In the current study, we asked whether young children perform the same hand movements as adults to achieve the same perceptual goals. There have been very few previous studies on this question. Bushnell and Boudreau (1991, 1993, 1998) developed (but did not test) a set of hypotheses about when in development the exploratory procedures in Lederman and Klatzky's (1987) taxonomy might become available to infants and young children due to age-typical advances in motor behavior and attention. For example, these authors suggested that infants should not be able to produce the contour following exploratory procedure associated with haptic perception of shape until 9 or 10 months of age because it is not until this age that infants acquire the ability to move their two hands independently. Bushnell and Boudreau (1991, 1993, 1998) suggested that children might have the capacity to display mature haptic exploratory movements when they reach the preschool period.

However, there are few data on whether preschool-aged children do employ adult-like exploratory procedures. In fact, there are few data on children's hand movements of any kind during haptic object exploration. Instead, research on the development of haptic perception has focused largely on children's ability to use haptic information for object recognition either in haptics or in vision. A number of studies have concluded that young children have poor haptic perception. However, this conclusion was based on findings of deficits in young children's ability to transfer information between haptics and vision in intermodal object recognition tasks. These studies did not report how children moved their hands during haptic exploration (e.g., Milner & Bryant, 1970; Rose, Blank, & Bridger, 1972).

In contrast, a number of studies have looked at what children do with their hands during visual object exploration. Ruff (1982, 1984, 1986, 1989; see also Ruff & Kohler, 1978) carried out a number of studies documenting how infants handle objects during visual exploration, but there is no evidence that the set of hand movements produced by infants in the service of visual exploration overlaps with the set of hand movements that serve haptic perception. Klatzky, Lederman, and Mankinen (2005) asked preschool-aged children to make decisions about the appropriateness of a tool to perform a certain task, for example, whether a spoon could be used to carry a piece of candy. Children were visually presented with the tools and also allowed to handle them. Children were more likely to haptically explore objects when the important object property was rigidity than when it was shape. Moreover, when children chose to explore haptically, they tested the objects for rigidity using the same exploratory procedure as adults for assessing rigidity (i.e., pressure) (Lederman & Klatzky, 1987).

Only three previous studies have documented what children do with their hands during haptic exploration. Schwarzer, Kufer, and Wilkening (1999) reported that 3- to 9-year-olds produced adult-like exploratory procedures. Following haptic exploration, children in this study haptically grouped novel objects that simultaneously varied in shape, texture, weight, and size. Nearly all participants categorized the objects analytically—that is, on a single perceptual dimension—as opposed to holistically. In at least 60% of their trials, 3- to 5-year-olds produced enclosure, lateral motion, and