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## Cognitive Development



# Haptic exploration of tools: Insight into the processes that drive haptic exploration in preschool-aged children



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### ABSTRACT

Adults' haptic exploratory abilities are efficient and systematic. Associations exist between specific patterns of movement and a person's desired perceptual information (i.e., perceptual goals). These specific movements are called Exploratory Procedures. The development of Exploratory Procedures remains unclear. Young children execute Exploratory Procedures following explicitly given goals, but not implicitly given goals. The present study furthers our knowledge of how implicitly given goals in the context of tool use affect children's exploratory behavior. During haptic only exploration, 3-, 4-, and 5-year-olds and adults verbally indicated if spoons with varied bowl sizes could transport a piece of candy, and sticks of varied rigidity could mix a substance. Five-year-olds and adults varied their exploration patterns as a function of task (transporting or mixing), but younger children did not. Specifically, the older participants executed the anticipated Exploratory Procedures in each task, suggesting that implicit tool knowledge organized exploration.

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## 1. Introduction

Haptics is a perceptual system wherein an active observer employs his or her sense of touch to obtain material and structural characteristics of objects and surfaces (Lederman & Klatzky, 2009).

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Adults show sophisticated haptic exploratory abilities: their movement patterns are efficient, rapid, and systematic (e.g., [Klatzky, Lederman, & Metzger, 1985](#)). In particular, several studies reported associations between haptic exploration patterns of movement and what kind of perceptual information is being sought (i.e., the perceptual goal) ([Lederman & Klatzky, 1987, 1990, 1996](#)). Specifically, [Lederman and Klatzky \(1987\)](#) coined the term, Exploratory Procedures, to refer to six stereotyped movements that adults reliably produce when searching for certain haptic perceptual information. 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, thereby showing a link between movement pattern and perceptual goal. In contrast, adults who were asked to match objects by shape produced “contour following” – tracing the object’s contours with their fingertips. The unconscious coupling of particular hand movements and specific perceptual goals suggests that observing how participants move their hands during haptic exploration could reveal the goals behind their exploratory behavior; thereby, providing insight into the cognitive processes that drive haptic exploratory behavior.

The development of these specific Exploratory Procedures is unclear. How and when do children learn the connections between specific patterns of hand movements, and the ultimate perception of specific perceptual information? This question is different from asking about the status of children’s haptic perception. It is entirely possible that, despite not performing Exploratory Procedures, children could still obtain information haptically. Indeed, it has been established that newborn infants can obtain information haptically ([Streri, 2003](#); [Streri & Feron, 2005](#); [Streri, Lhote, & Dutilleul, 2000](#)). However, the motor movements available to the newborn are quite limited, and largely reflexive in nature. Although it is impressive that newborns can perceive information haptically, it does not inform our understanding of the development of Exploratory Procedures. Execution of Exploratory Procedures requires, not only for the stereotyped movement patterns to be present, but also for the same links between specific exploration pattern and specific perceptual goal to be present.

Participants are provided with perceptual goals within the demands of the experiment. In the case of [Lederman and Klatzky’s \(1987\)](#) classic study, adult participants completed a match-to-sample task in which they were instructed to haptically match the objects on a particular perceptual dimension (e.g., rigidity). In their sample, the precise movement patterns executed by the participants were related to the dimension on which to match. For example, when told to match based on rigidity, participants consistently executed the “pressure” Exploratory Procedure. Because participants were explicitly told the dimension on which to match, the perceptual goal was very clearly provided to them (i.e., the goal of obtaining rigidity information). It is possible to say that the perceptual goals organized exploration such that adult participants reliably varied their execution of Exploratory Procedures as a function of the dimension on which to match.

If it is true that perceptual goals play a crucial role in organizing exploration, then examining the task demands of past research with children will inform our understanding of the development of Exploratory Procedures and provide insight into the cognitive processes that drive exploration. A review of the limited literature on children’s haptic exploration suggests that perceptual goals have been provided to children through one of three means: (1) previous perceptual experience with the objects (prior to haptic exploration), (2) explicit instruction, and (3) implicit instruction. Each category of influence will be discussed in turn.

### *1.1. Previous perceptual experience*

It has been hypothesized that visual experiences drive haptic exploration in adults (e.g., [Sathian, 2005](#)). [Kalagher \(2013\)](#) tested the extent to which having brief perceptual experience with unfamiliar objects would organize haptic exploration during a haptic-to-visual matching task. Prior to the task, 4-year-old children participated in a priming phase in which they explored eight unfamiliar objects visually, haptically, or visually and haptically together. Subsequently, children haptically explored the objects that were presented in the priming phase and then visually identified a match from among three test objects. It was found that children executed adult-like movement patterns, but those movement patterns were not associated with the same perceptual goals as would be expected based on [Lederman and Klatzky’s \(1987\)](#) study. The fact that these perceptual priming periods resulted in adult-like exploration, suggests that visual and haptic perceptual experiences can influence the selection

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