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Infant manual exploration of composite substrates

Sarah A. Fontenelle, Björn Alexander Kahrs, S. Ashley Neal, A. Taylor Newton, Jeffrey J. Lockman *

Department of Psychology, Tulane University, New Orleans, LA 70118, USA

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Abstract

Everyday environments, even small regions within reach, vary dramatically in terms of material composition. Adapting one's manual behavior to such transitions can be considered to be an important element of skilled action. To investigate the origins of this ability, we presented 8-month-olds ($n = 24$) and 10-month-olds ($n = 24$) hard or soft objects on a composite tabletop substrate that was half rigid and half flexible. Results indicated infants explored the objects selectively and geared their manual behaviors, with or without an object in hand, to the particular substrate they contacted. More broadly, the study suggests that infant manual exploration is flexible even in the face of abrupt transitions in material structure. Such flexibility may support early attempts at problem solving and tool use.

Keywords: Motor development; Perception–action development; Object exploration

Introduction

Selectivity is a hallmark of adaptive action. Although individuals are capable of performing a multitude of actions at any one moment, they typically select motor behaviors that trade on the relation between their own physical characteristics and those of their immediate surroundings (Gibson, 1979; Gibson & Pick, 2000). By choosing actions predicated on this relation, individuals are more apt to exploit the properties of nearby objects

* Corresponding author.
E-mail address: lockman@tulane.edu (J.J. Lockman).

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and substrates to accomplish goals, solve problems, and create new opportunities for learning. Furthermore, by doing so, individuals are more likely to act effectively and efficiently, thereby optimizing the fit between themselves and the physical world.

Even human infants show evidence of selectivity in how they relate their motor behaviors to their immediate surroundings. Well before their first birthday, infants use their hands to explore and act on the physical environment in a discriminating manner. They tailor their manual behaviors to the physical properties of objects and the properties of substrates directly before them. With reference to objects, infants in the second half year squeeze flexible objects more than nonflexible ones, shake sounding objects more than ones without this potential, and scratch and finger textured objects more than nontextured ones (Bourgeois, Khawar, Neal, & Lockman, 2005; Bushnell & Boudreau, 1993, 1998; Lockman & McHale, 1989; Palmer, 1989; Ruff, 1984). With reference to surface layout, infants in this age range similarly explore substrates in a targeted manner, for instance, pressing flexible substrates more than rigid substrates (Bourgeois et al., 2005; Palmer, 1989). And soon after the onset of locomotion, infants show comparable manual behaviors as they use their hands to determine whether a substrate is suitable for traversal (Adolph, Eppler, & Gibson, 1993; Eppler, Adolph, & Weiner, 1996; Gibson et al., 1987; Gibson & Schmuckler, 1989; Joh & Adolph, 2006).

Do infants also exhibit selectivity in how they manually combine objects and substrates? This class of relational behaviors has been hypothesized by both cognitive and perception–action theorists to be more psychologically complex than exploring an object or a substrate alone. According to cognitive theorists, such relational behaviors require more advanced symbolic functioning as well as understanding that the physical environment is differentiated from the self (Belsky & Most, 1981; Fenson, Kagan, Kearsley, & Zelazo, 1976; Piaget, 1952). In contrast, according to perception–action theory, such behaviors may depend on perceptual learning in that infants need to explore how the properties of the arm–hand system have changed by virtue of the particular object they are holding (Bourgeois et al., 2005; Lockman, 2000; Palmer, 1989; Smitsman, 1997). Either way, adaptive action calls for individuals to select behaviors based on the relation between the properties of the hand and a single environmental element as well as between the properties of two environmental elements: the object and the substrate.

Yet even during the second half year, infants also begin to evidence selectivity in how they relate objects to substrates. Critically, infants in this age period alter the way in which they manually explore a substrate depending on whether or not an object is in hand. For instance, 6- to 10-month-olds show frequent slapping of a liquid substrate with their bare hands but little slapping of the same liquid substrate when they hold an object in hand (Bourgeois et al., 2005). Moreover, when holding an object, infants do not relate all objects to substrates similarly but rather make objects and substrates interact in ways that capitalize on the physical properties of each. More broadly, the ability to select appropriate manual actions to exploit the material properties of objects, substrates, and their interactions may have important developmental implications for the emergence of many basic adaptive skills involving the hand, including tool use and problem solving (Lockman, 2000).

The problem of selectivity extends beyond just choosing an appropriate action to perform on substrates that are uniform in overall physical composition. In real-world environments, individuals often encounter substrates that vary in terms of their material properties. Moreover, transitions in physical structure can be abrupt. Outdoor surfaces