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*Brief report*

# Infants' perception of object–surface interplays

James D. Morgante[1]* and Scott P. Johnson[2]

[1]University of Massachusetts, Amherst, USA
[2]University of California, Los Angeles, California, USA

Twelve- and 18-month-old infants participated in a study designed to investigate the quality of their manual action when relating an object to the surface on which it is explored. Specifically, infants' perception-action routines were observed when they were presented with multiple objects (wooden scoop, Velcro block, and crayon) on surfaces of varying properties (paper, sand, and Velcro) to determine if sensory feedback or perceptual awareness steered their exploration of the available materials. Infants were observed to selectively tailor their manual actions across conditions, apparently guided by a perceived awareness of the fit between their manual dexterity and the environmental arrangement.

Sensorimotor development investigations have typically focused on infants' interaction with objects (see Bushnell & Boudreau 1991, 1993). Two additional actions, interaction with surfaces and exploration of objects relative to surface, which we refer to as *object–surface interplays*, are equally relevant to a complete account of motor development in infancy, but have been largely neglected (Bourgeois, Khawar, Neal, & Lockman, 2005).

During the second half of the first year, infants are often observed to selectively tailor their manual actions in response to the material properties of available environmental elements. When exploring hardness, for example, 6- to 12-month-old infants discriminate between pliable and rigid objects through pressing and banging, respectively (Bushnell & Boudreau, 1993; Lockman & Wright, 1988; Palmer, 1989), and do so irrespective of the availability of information from vision (Gibson & Walker, 1984). Moreover, recent investigations suggest that both the object's material properties and the surface on which the object rests will guide exploratory activities: 6- to 10-month-olds will bang hard objects more often on hard and taut surfaces than on those that are liquid or soft (Bourgeois *et al.*, 2005; Morgante & Keen, 2008). Exploratory activities, thus, discriminate between a range of conditions, but the mechanism that underlies this discrimination is unclear. When infants bang hard objects on rigid surfaces, for example, they may be responding to sensory feedback (e.g., hearing a 'bang') or perceiving a fit between their manual dexterity and environmental supports.

*James Morgante is now based at the University of California, Los Angeles.*
**Correspondence should be addressed to James D. Morgante, Department of Psychology, University of California, 3291 Franz Hall, Box 951563, Los Angeles, CA 90095, USA (e-mail: jmorgante@ucla.edu)*

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We investigated the specificity of infants' object–surface actions through the presentation of multiple objects on various surfaces, a design requiring self-selection of objects; each of the objects complemented a surface (e.g., crayon and paper) and the pair allowed for a conventional interplay (e.g., colouring). Contrary to prior investigations that have only observed infants' object–surface interplays under conditions with one-object to one-surface (see Bourgeois *et al.*, 2005; Palmer, 1989), the self-selection manipulation allowed for the determination of whether interplays are guided by the stimulating properties of available materials or a perceived fit between them. If infants are responding to sensory feedback, then their actions should get successively closer to the conventional interplays across trials; keen actions from the onset would suggest perceptual awareness of object–surface affordances.

## Method

### *Participants*

Twenty-four full-term 12-month-olds (9 females; $M = 369$ days, $SD = 9.3$ days) and 24 full-term 18-month-olds (10 females; $M = 553$ days, $SD = 8.0$ days) participated in the same experimental condition. Fourteen infants were excluded, 12 either cried or fussed and 2 were excluded because of family interference.

### *Materials*

Three objects were presented to the infant on one of three surfaces, which were designed to fit in the highchair's tray (see Figure 1). Object–surface interplays were expected to

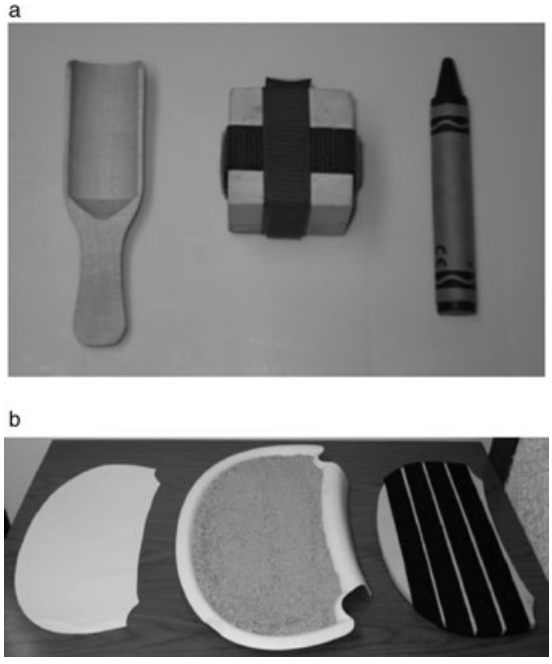


**Figure 1.** Pictures of the (A) objects (wooden scoop, Velcro block, and crayon) and (B) surfaces (Manila paper, 5 cups of play sand in a highchair tray insert, and Velcro). Four 1.5″ strips of Velcro were affixed to a piece of plywood covered in a neutral fabric for this trial type.

vary in difficulty, so materials were chosen with infants' motor skills in mind. Infants as young as 3 months will manipulate Velcro (Needham, Barrett, & Peterman, 2002) and the onset of spoon use and scribbling is at 9 and 18 months, respectively (Connolly & Dalgleish, 1989; Thomas & Silk, 1990), thus presenting feasible and challenging exploratory arrangements for these infants.

### *Procedure*

Infants' actions were recorded on videotape as they explored the three objects, surfaces, and their interrelations. The study used a three-factor design in which object exploration was compared across the three surfaces, succession (i.e., repeated exposure of the surface), and age. Initially, during the familiarization period, infants were given the opportunity to explore each object individually, for 30 s, on the highchair's empty tray;[1] objects were labelled verbally before they were first handed to the infant. After familiarization, infants were presented with one of the three surfaces in the highchair's tray. Once the surface had been secured in the tray, the three objects were again labelled verbally[2] and arranged in a line along the centre of the surface, parallel to the infant, by the experimenter. The duration of each test trial was 1 min. During the trial, the experimenter and infant's parent(s) refrained from using encouraging verbal prompts/gestures that could influence the infant's exploration.

Each surface was presented to the infant and was repeated in the same order (e.g., paper, Velcro, sand) three times, for a total of nine test trials. Surface presentation sequence was counterbalanced across participants and trial orders distributed equally often. Object placement in the linear array varied with the onset of each surface repetition to control for effects of laterality.

### *Scoring*

The movement of the infants' hand(s) in relation to the surface and/or interplay was scored in accordance with pre-established, manual action categories (described subsequently) every 5 s of the 1-min test trial, for a total of 12 observation intervals per trial. Categories were based on affordances of the objects and surfaces for manual behaviours typical of infants' action repertoires. Behavioural observation was purposefully limited to the manual actions that coincided with the conventional use of the available materials; these actions included scrumbling, colouring, gripping, and scooping.

*Scrumbling* on a surface was defined as the repetitive extension and contraction of one or more digits (adopted from Bushnell, Boudreau, Weinberger, & Roder, 1992). *Colouring* was defined as applying the crayon's colour to a surface through a handwriting motion; although colour cannot be transferred to sand, the same motion can be used to 'draw' in it. *Gripping* was defined as exerting a thrusting or tugging force on a surface with the Velcro block. *Scooping* was defined as taking up, digging, or dipping into the surface with the scoop. The same initial observer scored all four manual behaviours for the entire sample and a second observer conducted reliability on 50% of the trials. Percent agreement was 99% or better for each observed behaviour.

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[1] *Infants' object familiarity was established through casual, post-session conversations with parents; none reported having the exact objects at home.*

[2] *Object labels were mainly used to ensure infant comfort, since the experimenter rarely spoke during the session.*

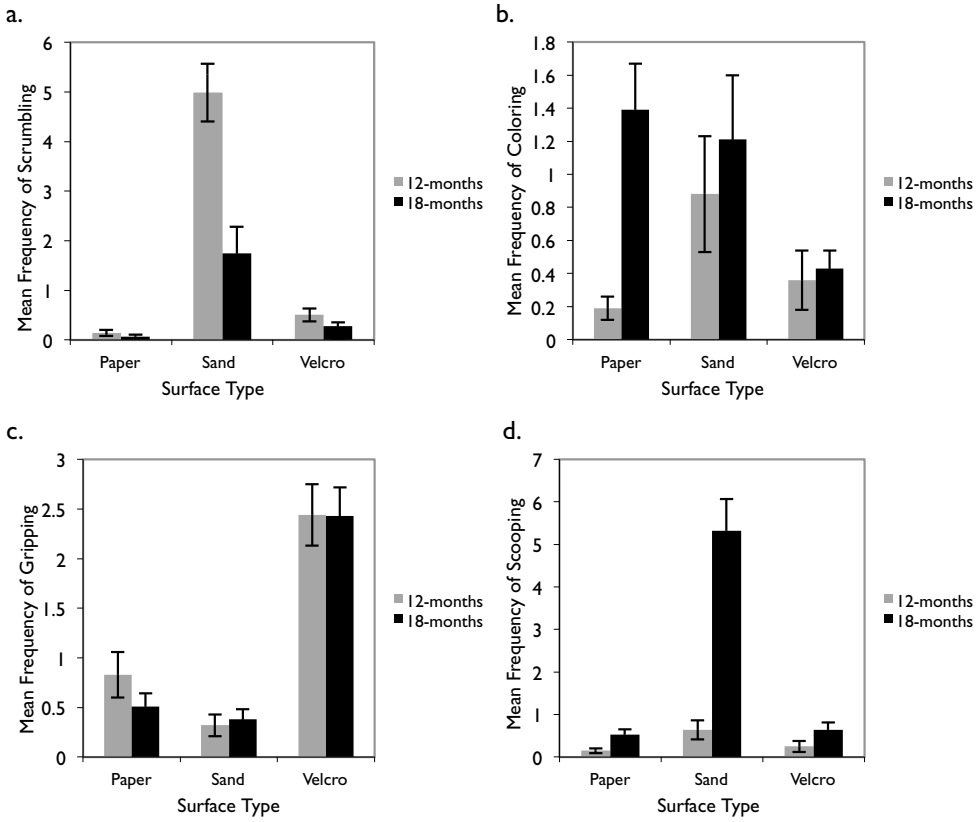


**Figure 2.** Exploration of surface and the object–surface interplays: frequency of (A) scrumbling, (B) colouring, (C) gripping, and (D) scooping on/in the different surfaces as a function of age.

## Results

Each manual action was analysed with a 3 (surface) × 3 (succession: 1st/2nd/3rd exposure) × 2 (age) repeated measures ANOVA. Frequency means[3] for each manual action are reported in Figure 2.

### *Scrumbling*

Analysis of scrumbling revealed a main effect of surface, $F$ (2, 92) = 65.72, $p < .001$; pairwise *post hoc* comparisons using Bonferroni adjustment[4] indicated that scrumbling occurred more frequently in the sand than on the other two surfaces. Although rare for both age groups, scrumbling was also greater on Velcro than paper (see Figure 2A). Analyses also revealed a significant Surface × Age interaction, $F$ (2, 92) = 15.75, $p < .001$. A test of simple main effects of age at each level of surface indicated that 12-month-olds scrumbled more than 18-month-olds in the sand.

[3] *Infants' action frequency was reported because their first selected object was not always used for an interplay (e.g., mouthing an object or holding it on the surface).*

[4] *Bonferroni adjustment was used for all pairwise post-hoc comparisons and tests of simple main effects.*

*Colouring*

Analysis of colouring revealed a main effect of surface, $F\ (2, 92) = 4.23, p < .05$; pairwise *post hoc* comparisons indicated that colouring occurred more frequently on the sand and paper than Velcro. Analyses also revealed a significant Surface × Age interaction, $F\ (2, 92) = 3.45, p < .05$. A test of simple main effects of age at each level of surface indicated that 18-month-olds coloured more than 12-month-olds on the paper.

*Gripping*

Analysis of gripping revealed a main effect of surface, $F\ (2, 92) = 64.92, p < .001$; pairwise *post hoc* comparisons indicated that gripping occurred more frequently on the Velcro than on the other two surfaces.

*Scooping*

Analysis of scooping revealed a main effect of surface, $F\ (2, 92) = 46.50, p < .001$; pairwise *post hoc* comparisons indicated that scooping occurred more frequently in the sand than on the paper and Velcro. Analyses also revealed a significant Surface × Age interaction, $F\ (2, 92) = 32.06, p < .001$. A test of simple main effects of age at each level of surface indicated that 18-month-olds scooped more than 12-month-olds when presented with the sand and paper; however, there is a considerable difference in the mean frequencies for scooping on these two surfaces. Specifically, 18-month-olds' scooping in the sand exceeded five occurrences per trial, whereas scooping on paper was rare for both age groups (see Figure 2D). Infants were likely exploring rigidity when attempting to scoop on paper and Velcro, for they are observed to relate hard objects to hard surfaces (Bourgeois *et al.*, 2005; Morgante & Keen, 2008).

*Succession*

There were no significant main effects (all $F's < 1.14, p's > .05$) or interactions (all $F's < 2.99, p's > .05$) for succession. Repeated surface exposure did not affect the frequency of any manual action. Actions were observed to be even across trials.

## Discussion

Together, these findings suggest that perceptual awareness guides infants' object–surface interplays. Infants in both age groups tailored their scrumbling and gripping to the environmental arrangement(s) that afforded these behaviours. The sand and Velcro consisted of loose granules and dense nylon pile, respectively, whereas the paper was a smooth, flat surface. Infants adapted their scrumbling in response to these differences in surface texture, scrumbling more often on the highly textured surfaces than on the paper surface. Perception of fit was similarly observed for gripping. Although it was possible to pull the Velcro block along the paper and shove it through the sand, infants more often gripped the Velcro block on the Velcro surface.

Perception of some fits however, seems to develop with age. While overall frequency of sand engagement was comparable, 12-month-olds' manual activity is perhaps best described as being surface directed whereas 18-month-olds more often exploited the interplay. Twelve-month-olds are capable of using a spoon effectively (see McCarty & Keen, 2005), so lack of engagement in this manual action likely reflects their ecological awareness and is not ascribable to manual dexterity. Indeed, half of the 12-month-olds

never scooped. The actions of those who rarely scooped were possibly guided by a scrumbling preference, even though they might have perceived a fit; infants' interaction with surfaces, especially exploratory preferences, certainly requires additional empirical attention. Although scrumbling is a suitable action for sand, because unlike paper and Velcro, it is a discontinuous surface that permits movement through handling, it is not the most sophisticated manual action given the arrangement. Scooping is the conventional interplay and 18-month-olds demonstrated awareness of the object–surface affordance.

The colouring interplay also appears to develop with age. Scribbling generally starts at 18 months (Thomas & Silk, 1990) and the 18-month-olds in this investigation were observed to colour more than the 12-month-olds on paper, however, the frequency of this action averaged to roughly one interval per exposure for the older infants and was comparable to sand. These findings suggest that 18-month-olds begin to detect the interplay around the same time they are able to engage in this manual action.

The present study was designed to investigate infants' manual behaviour in the context of an interplay task that required object selection. Infants' observed action specificity suggests that their manual behaviours are guided by an awareness of the fit between ability and environmental supports; some fits are detected as early as 12 months (e.g., gripping), some develop with age (e.g., scooping) and are likely attributed to increased sensitivity to the environmental arrangement, while the perception of others depends on ability (e.g., colouring). Collectively, infants' manual actions are best characterized as discriminating in nature and not simply a response to sensory feedback; our findings suggest that perception of affordances guides infants' manual behaviour. Further investigation is necessary to determine how this perception develops throughout infancy.

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