

## Do Infants Reach for Perceived Objects? A Reply to Stiles-Davis

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Stiles-Davis proposes that the infants in our experiments (Hofsten & Spelke, 1985) did not reach for perceived objects in order to manipulate them, but rather touched perceived surfaces in order to explore their boundaries. Her commentary raises questions about infants' perception of the boundaries, the unity, and the manipulability of objects. More deeply, it raises the question of what an object is for an infant. We consider each of these questions in turn, in light of our own findings and those of other studies of object-directed reaching, object perception, and the object concept. We suggest that young infants organize the visual world into entities that are bounded, unitary, and manipulable and that infants endow those entities with the core properties of physical objects.

In her thoughtful critique of our article (Hofsten & Spelke, 1985), Stiles-Davis (1986) proposes an alternative interpretation of our studies of object-directed reaching. The infants in our experiments, she suggests, did not reach for entities they perceived as objects; rather, they touched regions of the visual field they perceived as surfaces. More generally, Stiles-Davis's comments raise four questions: (1) When infants touched a display, did they touch objects at their *boundaries*? (2) Given that infants perceived boundaries of some kind, did they endow each bounded region with *unity*? (3) Given that infants perceived regions with both external boundaries and internal unity, did they truly reach for those regions, anticipating that the regions would be *manipulable*? (4) Given that infants perceived entities that are bounded, unitary, and manipulable, what justifies the claim that these entities are *objects*, and that infants, like adults, perceive and conceive of the world in terms of objects? We will consider each question in turn.

### Perception of Boundaries

When an adult grasps an object to pick it up, the grasp will be centered around opposing edges. This is necessary in order to overcome forces and torques that will arise during the task (Iberall, Bingham, & Arbib, 1985). Infants do this as well (Halverson, 1931). We agree with Stiles-Davis, therefore, that it would be desirable to measure only those contacts with an object that fall on one of its boundaries, rather than or in addition to the measure we used: all contacts with the object. We both have the strong impression, however, that nearly every contact with an object centered on its edges, and thus that the two measures would have yielded the same findings.

We are not able to substantiate this impression by recoding the data from the original experiments because the raw data are no longer available. Nevertheless, we have recently completed a new series of experiments using the same method, the same ap-

paratus, and subjects of the same age (Spelke, Hofsten, & Kestenbaum, 1985). Only the object displays differed: the two objects were arranged vertically rather than in depth. In these studies, 97% of all contacts with the objects were contacts with an object's edge. It appears that infants do not just touch the front surfaces of objects but their edges.

### Perception of Unity

The finding that infants touched objects at their edges, and thus perceived certain boundaries in the array, does not imply that infants perceived the unity of the regions delimited by those boundaries. Our final experiment nevertheless provided some evidence that infants perceived the unity of surfaces that moved together relative to the background. In that study, a pattern of common motion appeared to unite two objects whose spatial arrangement was such that the objects would be perceived as distinct if the whole display were stationary.

Stronger evidence that young infants perceive object unity is provided by two additional lines of research discussed in our article. First, studies of perception of partly occluded objects provide evidence that two surfaces that are partly hidden behind the same occluder are perceived as spatially connected when they move together (Kellman, Gleitman, & Spelke, 1985; Kellman & Spelke, 1983; Kellman, Spelke, & Short, in press). Second, studies of sensitivity to number provide evidence that two stationary objects are perceived as one countable unit when they are adjacent and as two countable units when they are separated in depth (Prather & Spelke, 1982). It appears, therefore, that infants endow a collection of spatially adjacent or commonly moving surfaces with unity in three senses: They reach for the collection of surfaces as a whole, they perceive the surfaces as spatially connected (even if no such connection is visible), and they take the surfaces to be one countable unit.

### Perception of Manipulability

The evidence that infants perceive object unity and boundaries and touch objects at their edges is not sufficient, in itself, to demonstrate that the infants are reaching for those objects in order to manipulate them. Perhaps, as Stiles-Davis suggests, in-

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fants simply tend to touch visual displays at the locus of a perceptual boundary. If infants just tend to touch boundary points, however, then one might expect to observe a high proportion of contacts with the background, especially in conditions in which the background moves relative to the stationary objects. In fact, only a small number of infants contacted the background frequently. Characteristics of the reaching of these infants suggested that their encounters with the background resulted from failed attempts to reach for the objects, not from successful attempts to touch a boundary.

During the fifth month, infants systematically begin grasping and manipulating objects in the visual field (see e.g., Hofsten & Lindhagen, 1979). When they face an object that is graspable and manipulable, they engage in preparatory adjustments of the hands and arms to the object's position (Hofsten, 1980), its motion (Hofsten, 1980), its size (Bruner & Koslowski, 1972), and its orientation (Hofsten & Fazel-Zandy, 1984). These adjustments enable the infant to grasp the object in an efficient way. If the object presented is intangible, as in the study of Gordon and Yonas (1976), the infant will continuously pat, pinch, and close his or her hands at the end of the reach as if attempting to grasp the virtual object. An object that is grasped will then be handled in various ways and will usually be brought to the mouth (Hatwell, in press; Rochat, 1985). These observations suggest that a 5-month-old infant who is presented with objects within reaching distance, as in our studies, will perceive the objects as manipulable.

### Perception of Objects

Granting that infants organize the world into entities that are bounded, unitary, and manipulable, one may still ask whether these entities are perceived as objects. Do infants, like adults, perceive and understand the world in terms of objects?

It is clear that infants do not know everything about objects that we know as adults. Experiments suggest, for example, that young infants fail to appreciate that objects are subject to gravity and will fall if not externally supported (Keil, 1979; Kestenbaum, Termine, & Spelke, 1985), or that objects tend to be relatively homogeneous in form and substance (Kellman & Spelke, 1983; Kestenbaum et al., 1985; Schmidt & Spelke, 1984). Nevertheless, one would hesitate to define the object concept as the sum of all an adult's knowledge about objects, ascribing this concept to children and to members of other cultures only if and when they attained all this knowledge. Indeed, if the object concept were defined as everything an adult knows about objects, then no two adults could be said to have the same concept. It seems necessary, therefore, to attempt to specify a set of core properties of objects: those properties without which an adult would hesitate to consider something an object. Infants would then be said to perceive objects if, and only if, they organized the perceived world into units with those core properties.

Although the adult's conception of objects has received little attention from experimental psychologists, it has been studied extensively by philosophers, especially in the context of the problem of physical identity (see Hirsch, 1982, for a recent discussion). These studies have provoked much debate about the existence and the coherence of the mature concept of objects (see especially

Hume, 1738/1962; Wiggins, 1980). Nevertheless, it appears that certain properties figure prominently in the adult's organization of the world. Adults tend to consider as objects those entities that are spatially connected and bounded, that are solid and space occupying, and that exist and move continuously in space and time without jumping from one place and time to another (see Hirsch, 1982). It is entities with these properties that adults tend to name, to categorize, to count, to act on, and to perceive. If an entity lacked any of these properties, adults would hesitate to treat it as an object. In contrast, adults are disposed to consider something an object even if it hangs weightless in the air and is not regular in shape or homogeneous in substance (see Spelke, 1983, for discussion). These considerations suggest that spatial unity and boundaries, substantiality, persistence, and spatio-temporal continuity are core properties of objects, and that response to gravity, homogeneity of substance, and simplicity of shape are not.

Within this framework, what can one say of the infant? Studies of perception of adjacent objects, partly occluded objects, and objects that are separated in depth provide evidence that infants group visual arrays into entities that are spatially continuous, bounded, and separately moveable (e.g., Hofsten & Spelke, 1985; Kellman & Spelke, 1983; Kestenbaum et al., 1985). Studies of reaching for moving objects provide evidence that infants anticipate that objects will move smoothly and will persist over their movements (Hofsten, 1980). Finally, recent studies of perception of events in which an object is fully occluded provide evidence that young infants perceive objects to persist when they are hidden from view (Baillargeon, Spelke, & Wasserman, 1985; Hofsten & Lindhagen, 1982; Spelke & Kestenbaum, in press, to be substantial and space-occupying (Baillargeon et al., 1985), and to move only on paths that are spatio-temporally continuous (Spelke & Kestenbaum, in press).

These studies suggest that some and perhaps all of the human adult's core conception of objects is discernible in the 5-month-old infant, although various peripheral conceptions are not. Knowledge of objects appears to develop around a core set of capacities for organizing experience, capacities that are already present in infancy and that are functional before the child has learned to talk or to act in complexly coordinated ways. These core capacities, moreover, appear to remain at the center of human thinking. They are not overturned or overshadowed by subsequent notions or by the subsequent development of language, action, and thought.

### Summary

When our studies of object-directed reaching are considered in the context of other studies of action and perception in infancy, and in the context of analyses of adults' conceptions of objects, we believe that the most plausible interpretation of our findings is the interpretation we originally offered. Infants organize the visual world into units that are spatially connected, separately and continuously moveable, substantial, and persisting. These are the units on which they seek to act; they grasp and manipulate them by reaching for their boundaries. Finally, these are the units that constitute the core of the mature conception of objects and the base from which further knowledge of objects will grow.

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