

Research Report

HOW SPECIAL ARE OBJECTS? Children's Reasoning About Objects, Parts, and Holes

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Abstract—Discrete physical objects have a special status in cognitive and linguistic development. Infants track and enumerate objects, young children are biased to construe novel words as referring to objects, and, when asked to count an array of items, preschool children tend to count the discrete objects, even if explicitly asked to do otherwise. We address here the question of whether discrete physical objects are the only entities that have this special status, or whether other individuals are salient as well. In two experiments, we found that 3-year-olds are just as good at identifying, tracking, and counting certain nonobject entities (holes in Experiment 1; holes and parts in Experiment 2) as they are with objects. These results are discussed in light of different theories of the nature and development of children's object bias.

Discrete physical objects—entities such as dogs and cups—have a special status in cognitive and linguistic development. Even infants can parse the world into distinct physical objects, enumerate sets of such objects, and track them over time and space (Spelke, 1994; Wynn, 1995). Object names constitute a much larger proportion of young children's vocabularies than they do of the vocabularies of older children and adults (Brown, 1957; Macnamara, 1982). And when 2- and 3-year-olds are shown an object (such as a rabbit) and given a name for it, their default assumption is that the word refers to the entire object (the rabbit), and not to a part of the object (the tail), a property (white), or the stuff that the object is made of (rabbit meat; e.g., Golinkoff, Mervis, & Hirsh-Pasek, 1994; Macnamara, 1972; Markman & Wachtel, 1988; Waxman & Markow, 1995). It is often argued that this whole-object assumption plays a central role in word learning, allowing children to determine which of the infinity of logically possible meanings that a word could have is actually the correct one.

Shipley and Shepperson (1990) provided a particularly striking demonstration of the importance of objects. They showed children arrays of objects and gave them specific instructions as to what to count. For example, the children were shown the array depicted in Figure 1 and asked, "Can you count the forks?" Adults shown this display answer "five," but the 3- and 4-year-olds in Shipley and Shepperson's study tended to ignore the wording of the question and answer "six." Similarly, when shown different arrays and asked to count the kinds ("Here are some airplanes and some cars. How many different kinds of toys do I have here?") or colors ("Here are some red ducks, and some green ducks, and some yellow ducks. How many different colors do I have here?"), the dominant response was again to count the total number of objects. As Shipley and Shepperson concluded, "Young children are evidently predisposed to process discrete physical objects" (p. 109).

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The experiments we report here explored the precise nature of this predisposition. One plausible theory is the one advanced by Shipley and Shepperson: Children are specifically biased to attend to objects—to bounded solids that are separately movable. This is also the proposal advanced by Spelke (1994) with regard to infants' individuation and tracking, by Markman and Wachtel (1988) with regard to the whole-object bias in word learning, and by Dehaene (1997) with regard to the origins of numerical cognition. There is an alternative, however. Perhaps it is not objects per se that have a special status in the mind of the child. Instead, there may exist certain features or properties that are particularly relevant to how children parse the world into distinct individuals—properties such as permanence; cohesive movement (the entire region moves as a whole); boundaries that are defined in terms of discontinuities of color, material, and contour; internal complexity; and nonrandom structure (e.g., Bloom, 1996, 2000; Hoffman & Richards, 1984; Imai & Gentner, 1997; Langacker, 1987; Prasada, 1999; Wynn, 1995). Discrete physical objects are special only because they tend to possess such properties; nonobject entities that also possess such properties should be salient as well.

To explore this hypothesis, we asked 3-year-olds questions about three types of entities: whole objects, parts, and holes. The objects were pieces of foam-core board shaped like either novel artifacts (Experiment 1) or novel animals (Experiment 2). The parts were designed to be as natural as possible (Tversky, 1989); they were segmented from the rest of the objects by abrupt changes in contour and (in Experiment 2) were familiar to children and had obvious functions. Young children will readily learn names for such salient parts (Kobayashi, 1998) and will categorize objects on the basis of their presence or absence (Smith, Jones, & Landau, 1996).

There is no developmental research thus far that has explored how children deal with holes. In certain regards, holes resemble parts, as both require a "host" object and do not typically undergo independent motion (Casati & Varzi, 1994). In fact, holes can be viewed as mirror images of objects: Objects are connected portions of matter surrounded by space, holes are connected portions of space surrounded by matter. It might be that these parallels make objects and holes equally salient as individuals. The holes in our experiments were constructed to be (by our own intuitions) salient: They were reasonably large and of a regular shape (round).

In the experiments, children were asked to perform three tasks: to identify the objects, parts, and holes; to count them; and to track them through space.

EXPERIMENT 1

Method

Subjects

Participants were twenty-two 3-year-old children from preschools in Tucson, Arizona. The data from 3 children was discarded because

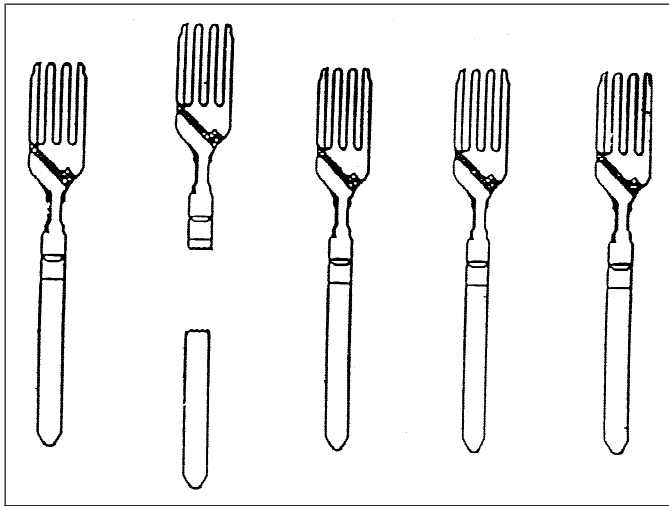


Fig. 1. Fork stimuli from Shipley and Shepperson (1990).

they were unable to complete the tasks, and the data from another child were discarded because of experimenter error. The remaining 18 children ranged in age from 3 years, 2 months to 3 years, 9 months, with a mean age of 3 years, 5 months. There were 13 girls and 5 boys.

Materials and procedure

Figure 2 depicts the stimuli and the procedure. The objects used were made of foam-core board. Including the parts, the objects were between 15 and 17 cm wide, and from 10 to 19 cm high. The objects used in the identification task were green, those in the counting task were yellow, and those in the tracking task were blue.

Children were tested individually in their day-care centers while seated at a table with an experimenter. All subjects participated in three different tasks: identification, counting, and tracking, in that order. Each of the three tasks involved questions about whole objects (described to the children as “toys”), holes (“holes”), and parts (“handles”). Each subject was assigned to one of six possible orders of these questions (e.g., object, then part, then hole), and this order was maintained across the three tasks.

In the *identification* task, the children were presented simultaneously with three novel objects, each with one hole and one handle (see Fig. 2a). The experimenter gave each child a pile of several pieces of colored felt (about 7 × 5 cm each) and asked the child, in one part of this task, “Using these, can you cover the toys?” If the child did not respond, the question was repeated. If the child paused in the midst of putting down the pieces of felt, he or she was prompted with “Can you cover *all* the toys?” Once the child made it clear that he or she was finished (by refusing to put down any more felt pieces, or by saying that he or she was done), the trial was over. The identical procedure was carried out for parts (“Using these, can you cover the handles?”) and holes (“Using these, can you cover the holes?”)

In the *counting* task, the children were presented with three sets of novel objects (see Fig. 2b). For each set, the children were asked: “How many toys/handles/holes are here? Can you count the toys/handles/holes?” The sets were presented in a fixed order; the first set had two objects, three parts, and four holes; the second had two holes, three objects, and four parts; and the third had two parts, three holes, and four objects.

In the *tracking* task, the stimuli were different according to whether the children were being asked to track objects, holes, or parts (see Fig. 2c). For the object question, each child was shown two objects. The experimenter then pointed to one of the objects and asked the child, “Can you point to this?” After the child pointed, the experimenter said, “Look carefully at what I’m doing,” and moved the object in a circular motion from the left of the second object to the right of the second object. The subject was then asked, “Can you point to it again?” For the handle and the hole, the procedure was identical except that subjects were presented with one object that had two handles or two holes. The object was rotated using the same sort of circular motion, so that the original hole was displaced from the right side to the left side, and the original handle was displaced from the top to the bottom.

Results and Discussion

We carried out a 6 × 3 × 3 analysis of variance, with order as a between-subjects variable and with task (identification vs. counting vs. tracking) and entity (object vs. hole vs. part) as within-subjects variables. There was no effect of order, and no interactions involved order. There were significant main effects of both task, $F(2, 24) = 23.56, p < .001$, and entity, $F(2, 24) = 6.22, p < .005$; there was also a marginally significant task-by-entity interaction, $F(4, 48) = 2.53, p = .05$. The results are shown in Table 1.

Subjects found identification to be the easiest task (83% correct), followed by counting (78%), and then tracking (37%). Post hoc tests revealed that the children did significantly worse on tracking than on both identification, $t(17) = 6.02$, and counting, $t(17) = 5.02$ (both $p < .001$).

The main focus of this study was children’s relative performances with objects, parts, and holes. Overall, children’s performance with objects and holes was roughly identical (77% and 74%), but they did less well with parts (48%).

To explore the nature of the interaction between task and entity, we analyzed performance on each of the three tasks separately. For each task, there was a significant or marginally significant effect of entity: counting, $F(2, 34) = 3.50, p < .05$; identification, $F(2, 34) = 2.90, p = .07$; tracking, $F(2, 34) = 6.69, p < .005$. Post hoc tests revealed that for the counting task, performance was significantly worse with parts than holes, $t(17) = 2.40, p < .05$. For the identification task, performance was also significantly worse with parts than holes, though only marginally, $t(17) = 2.05, p = .06$; for the tracking task, performance was significantly worse with parts than objects, $t(17) = -4.42, p$

Table 1. Percentage correct in the identification, counting, and tracking tasks in Experiment 1

Task	Entity		
	Object	Hole	Part
Identification	88.9 (32.3)	94.4 (23.6)	66.7 (48.5)
Counting	79.6 (23.3)	88.9 (28.0)	64.8 (37.0)
Tracking	61.1 (50.2)	38.9 (50.2)	11.1 (32.3)

Note. Standard deviations are in parentheses.

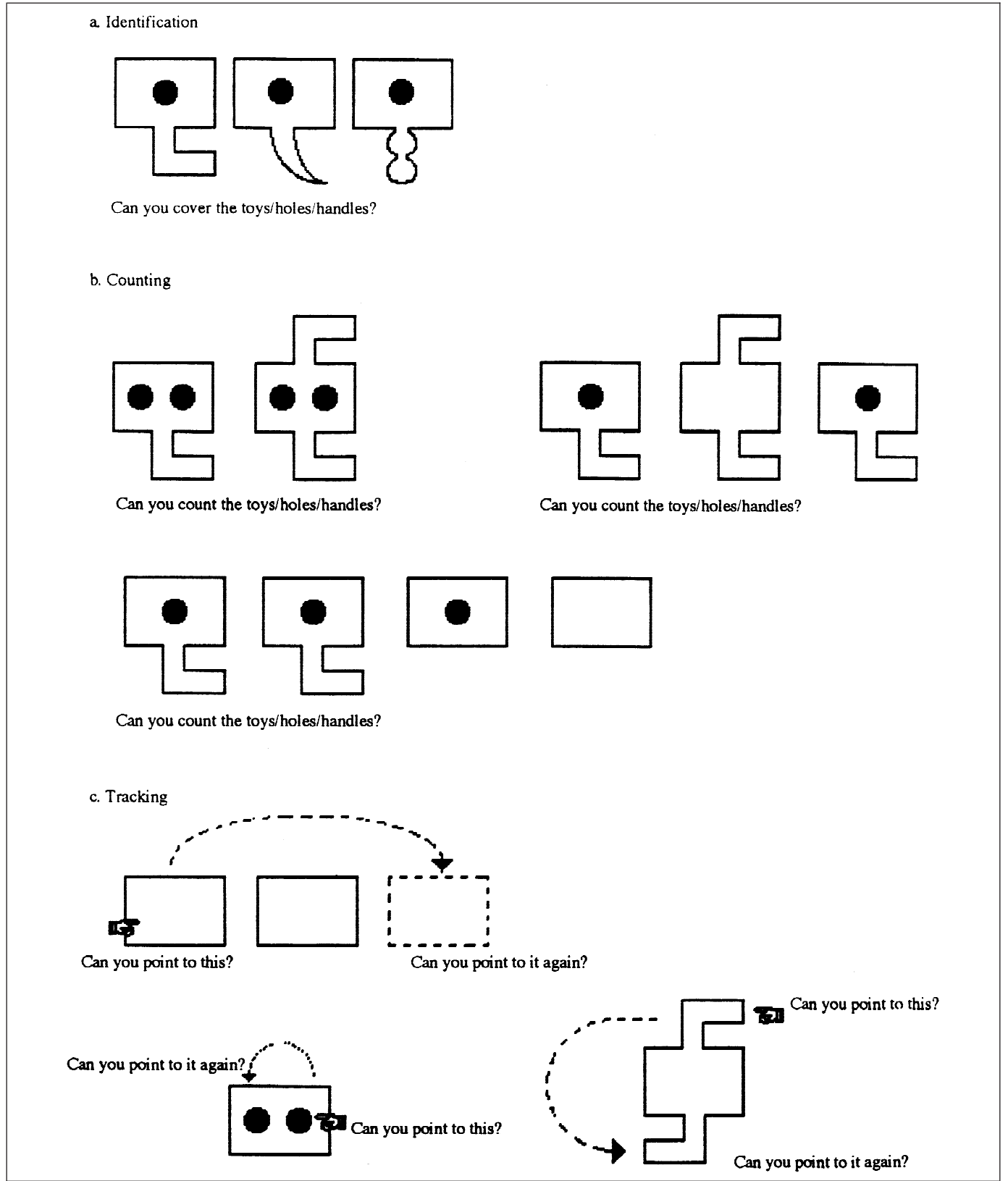


Fig. 2. Stimuli and procedure for Experiment 1. See the text for details.

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< .001, and, again to a marginal extent, worse with parts than holes, $t(17) = 2.05$, $p = .06$.

In sum, there are three main findings. First, for all tasks, the children did just as well with holes as with objects. The counting result is particularly interesting, as it shows that children can count holes even if the correct count conflicts with the number of distinct physical objects. Second, the children tended to do worse with parts than with holes and objects. And third, the children found the tracking task particularly difficult.

It might be, however, that some of these findings were due to particular features of this experiment. One concern is that children's relatively poor performance with the parts might have been due to language problems. Although the words "toy" and "hole" are likely to be familiar to young children, perhaps the word "handle" was not. Another concern is that the tracking task might have been made unduly difficult by the fact that, in all cases, the resulting configuration of the display after movement was identical to the original configuration. This might have confused children; when they were asked, "Can you point to it again?" they may have interpreted the question as referring to the location, not the entity.

Experiment 2 addressed both of these concerns, and included a further modification to make the tasks simpler. In Experiment 1, the questions were ordered by tasks, so that all of the identification questions were done together, followed by the counting questions, followed by the tracking questions. One consequence of this ordering was that a question about an entity tended to be immediately followed by a question about a different type of entity; for instance, for a given child, every question about holes would usually be followed by a question about parts. (The exception to this was the counting questions, because there were three of these for any given entity.) Children might do better if the questions were instead ordered by entity, so that all of the questions about a given type of entity would be asked together.

EXPERIMENT 2

Method

Subjects

Participants were eighteen 3-year-old children from preschools in Tucson, Arizona. They ranged in age from 3 years, 2 months to 3 years, 11 months, with an average age of 3 years, 9 months. There were 7 girls and 11 boys, none of whom participated in the first experiment.

Materials and procedure

The stimuli were two blue, elongated animals, each with two feet. One animal had two holes and the other had one hole. The animals were 35 cm wide and 15 cm tall.

There were three differences between this study and Experiment 1. First, the word used for the object was "animal," and the word for the part was "foot." Second, questions were grouped by entity and not by task. For instance, a given subject might complete the identification, counting, and tracking tasks with objects, then with holes, and then with parts. (As with Experiment 1, there were six possible orders in which the entities could be presented.) And third, in the tracking task, the animal was rotated 180° and slid to the right, so that the object, hole, and part all changed positions.

Results

We carried out a $6 \times 3 \times 3$ analysis of variance, with order as a between-subjects variable and with task (identification vs. counting vs. tracking) and entity (object vs. hole vs. part) as within-subjects variables. The only significant effect was that of task, $F(2, 24) = 16.26$, $p < .001$: Counting and identification were equally easy (93% and 91% correct), but tracking was much harder (48%). Post hoc tests revealed significant differences between tracking and identification, $t(17) = 4.11$, and tracking and counting, $t(17) = 4.97$, both $ps < .001$. The results are shown in Table 2.

Unlike in Experiment 1, children did just as well with parts as they did with objects and holes, presumably because the questions, instead of using "handle," used the more familiar word "foot." The modification to the tracking task and the different ordering of the questions did not lead to any improvement with regard to performance on the tracking task.

GENERAL DISCUSSION

The first experiment found that children were equally good at tasks involving objects and holes, but worse at tasks involving parts. The second experiment, in which the name of the part was changed from "handle" to "foot," found equal levels of performance with objects, holes, and parts.

How can we reconcile these findings with the research discussed earlier, especially with evidence that children are biased to count objects (Shipley & Shepperson, 1990)? It is clear that objects are salient to children, more so than certain other entities. What our findings suggest, however, is that objects are not the only salient individuals. Children had no special problems counting the holes and parts we used in the experiments reported here.

These studies do not prove that objects, parts, and holes are on an equal psychological footing. For one thing, even if this were the case for 3-year-olds, it might not be so for babies and younger children. We know that infants can identify, track, and enumerate objects, but there is no evidence that they can identify, track, and enumerate holes and parts. It might be that infants have innate object principles that govern how they make sense of the physical world (Spelke, 1994) and that an understanding of other sorts of entities emerges only later, sometime before the age of 3.

In fact, objects might have a special status even for 3-year-olds. Our experiments suggest that objects are not so salient that they preclude children from individuating parts and holes. But they might nonetheless be easier to process. In a situation that forces children to choose between these types of entities (such as deciding the interpre-

Table 2. Percentage correct in the identification, counting, and tracking tasks in Experiment 2

Task	Entity		
	Object	Hole	Part
Identification	83.3 (38.3)	94.4 (23.6)	94.4 (23.6)
Counting	94.4 (23.6)	88.9 (32.3)	94.4 (23.6)
Tracking	44.4 (51.1)	50.0 (51.4)	50.0 (51.4)

Note. Standard deviations are in parentheses.

tation of a name), objects might win out. There have been studies in which objects and parts were contrasted in this way (with somewhat ambiguous results; see Kobayashi, 1998; Markman & Wachtel, 1988), but none yet have dealt with holes.

Alternatively, perhaps objects are not easier to deal with than parts and holes, at least not always. The discussion thus far has treated objects, holes, and parts as homogeneous categories. But this is likely to be an oversimplification. Imagine, on the one hand, if we did the same studies reported here but with tiny pinpricks as holes, or with small bumps as parts. It is conceivable that 3-year-olds would have problems counting them, and would favor the objects. On the other hand, imagine that the holes were very large, taking up just about all of the objects, and were of interesting shapes (such as animal shapes). Or imagine that the parts were long, shiny dragon tails, affixed to small uninteresting bodies. In such cases, children might be more prone to focus on the holes and parts than on the objects. In general, a promising area of research would be to explore the conditions under which different entities are thought of as individuals by children and adults.

At the very least, the studies reported here show that the strongest version of the object-bias claim—that young children can cope only with whole objects—is mistaken. More tentatively, the results are consistent with the theory that objects have no special status in children's individuation. Instead, there are several factors that determine whether something is or is not a good individual. Objects are good individuals—for children and for adults—but so are some parts and some holes.

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