Continuity and the Persistence of Objects: When the Whole Is Greater Than the Sum of the Parts

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In three experiments, a total of 480 participants heard a version of the story of the ship of Theseus (Hobbes, 1672/1913), in which a novel object, labeled with a possessive noun phrase, underwent a transformation in which its parts were replaced one at a time. Participants then had to decide which of two objects carried the same possessive noun phrase as the original: the one made entirely of new parts (that could be inferred to be continuous with the original) or one reassembled from the original parts (that could not be inferred to be continuous with the original). Participants often selected the object made of new parts, despite the radical transformation. However, the tendency to do so was significantly stronger (1) if the object was described as an animal than if it was described as an artifact, (2) if the animal’s transformation lacked a human cause than if it possessed one, and (3) if the selection was made by adults or 7-year-olds than if it was made by 5-year-olds. The findings suggest that knowledge about specific kinds of objects and their canonical transformations exerts an increasingly powerful effect, over the course of development, upon people’s tendency to rely on continuity as a criterion for attributing persistence to objects that undergo change. © 1998 Academic Press

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Humans experience physical objects as persisting over time. This fact is remarkable, because our perceptual encounters with objects are typically brief and interrupted. For many years, philosophers have devoted attention to explicating the concept of a persisting object (e.g., Hirsch, 1982; Hume, 1739/1962; Wiggins, 1980). Experimental psychologists have recently begun to draw on some of the ideas from the philosophical literature, in an attempt both to illuminate the competence that underlies adults’ attributions of persistence to objects, and also to understand the origins of this competence in childhood (e.g., Spelke, 1985; Spelke, Gutheil, & Van de Walle, 1995; Spelke, Kestenbaum, Simons, & Wein, 1995; Xu & Carey, 1996). This article continues that psychological investigation.

According to some philosophers, one criterion that is central to the persistence of a physical object is *continuity* (e.g., Hirsch, 1982). Continuity is linked to object persistence in two ways. First, persisting objects are spatiotemporally continuous: They do not leave gaps in the paths they trace across space over time. Second, persisting objects are qualitatively continuous: They do not abruptly alter their qualities from moment to moment. To examine whether people attribute persistence to physical objects on the basis of inferences about continuity, psychologists have recently started to explore whether the tendency to impute persistence is linked to (1) the locations that objects occupy over time and (2) the properties (e.g., color, shape, texture) that objects possess from moment to moment.

Spelke et al. (1995; also Xu & Carey, 1996) obtained evidence suggesting that people use information about the locations occupied by objects over time to guide attributions of persistence. Participants saw one of two events enacted in a display containing two opaque screens that were separated by a 10 cm gap. In one event, an object started at one end of the display and then moved behind the first screen. Next, an object appeared from behind the far side of the second screen and moved to the other end of the display. No object ever occupied the gap between the two screens. Adult participants reported that this event, repeated a number of times, involved two objects. The other event was identical, except that an object traced a visible path between the two screens. When this event was repeated a number of times, adults were more likely to judge that it involved only one object. Strikingly, 4-month-old infants appeared to construe the two events in the same way as adults, as indicated by the results of a visual preference-for-novelty task. These findings suggest that, beginning as early as four months of age, children fail to see two objects observed in close succession as spatiotemporally continuous if there is a gap (e.g., 10 cm) in the path connecting them. Failing to infer continuity, people fail to see the two as corresponding to one persisting object.

Xu and Carey (1996) reported evidence suggesting that people use information about objects’ *properties* to guide attributions of persistence, though not until several months later in development. Participants saw one of two
events enacted in a display containing one opaque screen. In one event, an object with one set of properties (e.g., a yellow rubber duck) emerged from one side of the screen, then returned behind it. Next, an object with a different set of properties (e.g., a white foam ball) emerged from the other side of the screen, then returned behind it. According to the authors, adults see this event, when repeated a number of times, as involving (at least) two objects (e.g., one duck and one ball). The other event was identical, except that the two objects had the same properties (e.g., two white foam balls). Adults are more likely to judge this second event, repeated a number of times, to involve only one persisting object. In contrast to adults, 10-month-old infants who were tested in a visual novelty-preference task behaved as if they failed to see either event as involving two objects. However, by the age of 12 months, infants’ behavior suggested that they judged the event containing objects with different properties to involve two objects. These findings suggest that, by one year of age, children do not infer two objects observed in close succession to be qualitatively continuous if their properties are radically different (e.g., yellow, rubber, and duck-shaped, as opposed to white, foam, and ball-shaped). The result of a failure to infer continuity is, again, a failure to see the two as corresponding to one persisting object.1

The findings of Spelke et al. (1995) and Xu and Carey (1996) suggest that people attribute persistence to physical objects through inferences of continuity: These attributions were tied to observations of objects’ locations and properties over time. The results also suggest that people expect an object at one time to demonstrate a certain amount of locational and qualitative similarity to an object in the following moment in order to be seen as continuous with it and, hence, as persisting. At the same time, however, such findings do not imply that people fail to impute continuity and persistence in the face of any perceptible changes to an object over time.

Inferring Continuity through Part Replacement

Some philosophers have proposed that objects may suffer substantial changes from moment to moment, yet remain continuous and persisting. For example, Hirsch (1982; see also Hume, 1739/1978; Wiggins, 1967) noted that many objects may lose or gain parts (e.g., a branch may snap off a tree, or a new bumper may be added to a car), resulting in glaring dissimilarities

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1 One interpretation of Xu and Carey’s (1996) result with older infants is that it reflects knowledge about the properties of different objects belonging to a general object kind, such as PHYSICAL OBJECT (e.g., the duck-shaped object could not be continuous with the ball-shaped object and so could not be one persisting object). However, another interpretation of the result is that the infants were guided by knowledge about the properties of objects from more specific kinds, like DUCK and BALL (e.g., the duck could not be continuous with the ball and so could not be one persisting object). Xu and Carey (1996) acknowledged this point by referring to the information their participants used to guide their ascriptions of persistence as “property/kind” information.
between closely-timed object observations (i.e., both in the precise location an object occupies, and also in the object’s properties). Hirsch (1982) suggested that such changes often do not stop an object from demonstrating continuity and, thus, from persisting.

In fact, one of the most famous puzzles in philosophy deals with the issue of whether an object that suffers a change of parts remains a continuous and, therefore, persisting object (see Hobbes, 1672/1913). This puzzle involves a ship that belonged to the Athenian hero, Theseus. Over the years of sailing the seas, the parts of Theseus’ ship wore out, and were discarded and replaced, one part at a time. Eventually, a day arrived when the ship contained none of its original parts. A question that has generated extensive debate in the philosophical literature is whether this ship, made entirely of new parts (henceforth, the continuant), is Theseus’ persisting ship (e.g., Hirsch, 1982; Hume, 1739/1978; Wiggins, 1980). If the continuant is Theseus’ ship, then this fact would suggest that continuity provides a criterion for the persistence of an object across a complete transformation of its parts.

It is not obvious, however, that the continuant really is Theseus’ persisting ship. Suppose that someone had, over the years, collected all the original ship parts. If this person reassembled them all to create a ship that was structured exactly like the original ship, then there would be a second ship (henceforth, the replica) that might be Theseus’ persisting ship, rather than the continuant. The replica could not be Theseus’ ship because of continuity. For example, there was an obvious gap in the path connecting the original ship to the replica, during the extended period of disassembly into parts. Instead, if the replica is Theseus’ ship, then this fact would suggest that the sameness of an object’s parts, and the sameness of their arrangement within the object, provides a criterion for its persistence, even in the absence of continuity.

There are many situations in which an object is disassembled at one time and then subsequently reassembled (e.g., a pipe may be taken apart for cleaning and then reassembled; a car may undergo extensive disassembly at the garage during repairs before being put back together again). Such events clearly involve discontinuity (of the whole object, when it goes out of existence during the period of disassembly), but it is not clear that they necessarily involve a loss of persistence. Hirsch (1982) suggested that the objects before and after disassembly may nonetheless correspond to one persisting object. The reason is that there is another criterion for object persistence, which could be called compositional identity: Two objects observed at different times correspond to one persisting object if the parts comprising both objects are the same parts and if the parts of both objects are assembled in the same fashion.²

² Hirsch (1982) has stressed that, as a persistence criterion, compositional identity must be supplementary to, and dependent upon, a more fundamental criterion such as continuity. The
In the following research, we adapted the puzzle of Theseus’ ship to study the basis for people’s attributions of persistence to whole objects that undergo change: whether they would judge the continuant to be Theseus’ persisting ship, appearing to rely on continuity to ascribe persistence, or whether they would choose the replica, seeming to base their attributions on compositional identity. Despite centuries of discussion by philosophers, Wiggins (1980, p. 97) noted that “it is not . . . obvious that outside philosophy anybody has really made any of the judgments” about persistence that any proposed solution to the puzzle would require. Thus, the first question we sought to answer was whether people show any agreement with those philosophers who have suggested that Theseus’ persisting ship is the continuant rather than the replica (e.g., Hirsch, 1982; see also Wiggins, 1967). If people showed such agreement, then this would suggest that they will attribute continuity and, hence, persistence to an object in an extreme and limiting situation: following the replacement of all its parts. If people favored the continuant as Theseus’ persisting ship, this would also be consistent with the view that they are psychological essentialists, believing that objects possess hidden natures that make them the things that they are, distinct from their surface properties (in this case, the parts of which they are made) (e.g., Gelman, Coley, & Gottfried, 1994; Medin, 1989; Medin & Ortony, 1989).

In adapting the puzzle of Theseus’ ship, however, we immediately encountered the following problem: Specific details concerning how we presented it to participants (e.g., the number of parts composing the object, the amount of qualitative similarity between the replacement parts and the original parts, and the duration of the interval between each step in the transformation) might affect people’s tendency to select the continuant. For example, Hirsch (1982) suggested that the greater the number of parts composing an object, the greater the likelihood that an object’s part-by-part transformation involves continuity and, thus, persistence. Furthermore, an all-part transformation that takes place gradually, over an extended period of time, might be more likely to result in an ascription of continuity and persistence than one that takes place more abruptly (see Hume, 1739/1978; Liittschwager, 1994). In addition, replacing the original parts with new parts that are identical to the originals might lead to more frequent attributions of continuity and persistence than replacing them with parts that differ from the originals in

reason is that compositional identity cannot, by itself, account for the persistence of an object’s parts during a period of disassembly. What allows them to persist as the same parts? For example, even though compositional identity accounts for how a whole car persists through a period of disassembly into parts at the garage, it does not explain the persistence of the wheels, the engine, or the bumpers during the period of disassembly. Hirsch (1982) suggested that some other criterion, such as continuity, must be invoked to account for the persistence of the parts. Yet despite Hirsch’s (1982) observation, it seems clear that, at least at the level of the whole object, compositional identity provides a persistence criterion that is distinct from continuity.
any perceptible way (e.g., in color), because of their greater qualitative similarity to the originals. Not knowing the impact of any of these details on people’s tendency to choose the continuant, we began by simply fixing the details of the puzzle in the following way: We used an object that had a relatively small number of parts (i.e., either three or four); we stipulated that the steps of the transformation took place at weekly intervals; and we used replacement parts that were either identical to the original parts or that differed from the original parts in one perceptual feature (i.e., color).

Factors Affecting Inferences of Continuity

We also used our adapted version of the puzzle of Theseus’ ship to address a second question: Does the object’s specific kind influence people’s tendency to choose the continuant? Many philosophers have argued that the conditions under which objects show continuity and persist over time are intimately tied to the objects’ kinds (which are lexicalized as count nouns, words like “ship”, in languages like English; e.g., Hirsch, 1982; Wiggins, 1980; see also Hall, 1993; Hall & Waxman, 1993; Macnamara, 1986). An example from Hirsch (1982) helps make this point. Consider an old car sent to the scrap yard to be crushed. Crushing is a continuous process, and so from moment to moment, an object being crushed should remain continuous. If continuity were sufficient to account for object persistence, then the crushing event should involve only one persisting object. Yet Hirsch (1982) noted that there would come a point at which the car would cease to persist and would be replaced by a block of plastic and metal. Continuity thus seems insufficient to account for object persistence in this case. However, if the object at the beginning of the event were said to belong to a particular kind (e.g., CAR), then continuity would suffice to explain persistence: The crushing event would involve one continuous car that persisted up until the point at which it stopped being a car, when it ceased to persist because it no longer belonged to the kind, CAR.

Adults have knowledge about thousands of different object kinds. Some of this knowledge concerns the typical properties of objects falling under the kinds (e.g., their appearance or behavior) as well as any characteristic changes that these properties suffer over time. Yet in its original formulation, Theseus’ ship puzzle involved an object from only one particular kind (the artifact kind, SHIP) undergoing a transformation caused by a person (who removed and added parts). It is not clear, however, that people’s tendency to select the continuant in this original version of the puzzle would be the same as it would be in a version that involved an object of a different kind undergoing a transformation with a different cause. In fact, recent evidence from the psychological literature suggests that the tendency to select the continuant following a part-by-part transformation might vary systematically as a function of (1) the domain of the kind under which a person construed the object (e.g., an artifact or an animal), (2) the specific mechanism per-
ceived to be the cause of the transformation (e.g., a change with a human cause or one lacking a human cause), and (3) the age of the person making the selection.

a. Kind domain. First, people may be more likely to attribute continuity and, thus, persistence in the face of a complete part replacement to an *animal* (something classified under a kind like DOG) than to a man-made *artifact* (something classified under a kind like SHIP). A number of philosophers have suggested that there is a relationship between the domain of an object’s kind (e.g., animal or artifact) and the tendency of the object to persist through change (e.g., Gupta, 1980; Schwartz, 1979; Wiggins, 1980). In addition, several psychologists have recently documented the role of object kind domain in attributions of persistence following object transformations. For example, Rosengren, Gelman, Kalish, and McCormick (1991) found that children as young as three years old appeared to believe that animals may undergo spontaneously-occurring qualitative changes (size increases) without ceasing to persist. In contrast, children of this age knew that artifacts do not spontaneously undergo such changes. Moreover, by the age of five years, children seemed to understand that animals may spontaneously change both their size and shape (metamorphose) without a loss of persistence.

In addition, Keil (1989) found that 7-year-olds, 9-year-olds, and adults judged that animals but not artifacts can undergo certain human-caused changes while persisting as a member of their original object kind. When told that doctors surgically altered the properties of a raccoon so that it resembled a skunk, participants judged it to persist as a raccoon. In contrast, when told that doctors surgically changed the features of a coffeepot so that it resembled a birdfeeder, participants judged that it did not persist as a coffeepot and was now a birdfeeder. Previous research has not established clearly that attributions of object *kind* persistence (e.g., judging that something is still an X) are influenced by the same variables as those that affect ascriptions of *individual* object persistence (e.g., judging that something is still the same X). If they are, however, then Keil’s (1989) results (like those of Rosengren et al., 1991) raise the possibility that people’s tendency to impute persistence to an individual object undergoing a complete transformation is influenced by the domain of the object’s kind.

b. Causal mechanism. Second, people may be more likely to ascribe continuity and, thus, persistence to an animal if it suffers a total part transformation that has *no human cause* (e.g., an internal, biological cause) than one that has a *human cause*. Some philosophers have discussed the idea of a link between the cause of an object’s change over time and the persistence of that object through the change (e.g., Schwartz, 1979; Wiggins, 1980). However, we do not know of a direct comparison of people’s judgments of animal persistence following matched transformations that either lack a human cause (e.g., growth, seasonal color changes, metamorphosis) or have a human cause (e.g., plastic surgery). There is evidence that preschool children believe
that certain transformations that lack a human cause (e.g., size increases) occur without threatening an animal’s persistence (Rosengren et al., 1991). In contrast, some human-caused changes (e.g., surgical alterations) may lead preschoolers (though not older children or adults) to judge the loss of persistence of object kind (e.g., Keil, 1989). Again, if ascriptions of kind persistence are affected by the same variables as those that influence attributions of individual object persistence, then the preceding results are consistent with the possibility that the mechanism causing an animal’s complete part transformation influences judgments of its persistence as the same individual.

c. Development. Finally, the tendency to impute continuity and, thus, persistence to animals undergoing part-by-part transformations may increase with age. More specifically, there is evidence to suggest that the tendency may be greater for adults or older children (e.g., 7-year-olds) than for younger children (e.g., 5-year-olds). Recall that Keil (1989) found that 7-year-olds, 9-year-olds, and adults judged that an animal of one kind, surgically transformed to resemble an animal from a different kind, persisted as a member of its original kind. In contrast, Keil (1989) discovered that 5-year-olds judged that kind membership ceased and that the animal was now a member of the new kind (but see also Gelman & Wellman, 1991, and other studies in Keil, 1989, for evidence that preschoolers and 5-year-olds will judge that an animal can persist as a member of the same kind through some human-caused transformations). It is plausible that the age-related changes in attributions of object kind persistence documented by Keil (1989) reflect changes in children’s knowledge about animals or living things, occurring after the preschool years (see Carey, 1985; Keil, 1989; see also Gelman, 1988). Once again, if attributions of object kind persistence are influenced by the same factors as those that affect ascriptions of individual object persistence, then these findings raise the possibility of an increase across development in the tendency to impute continuity and persistence to individual animals following complete transformations of their parts.

Overview

Three experiments were conducted (1) to test whether there are any conditions under which people will attribute continuity and thus persistence to an object through a radical transformation in which all its parts are replaced, and (2) to explore whether such conditions are affected by the object’s kind, the mechanism responsible for its transformation, and the age of the participant making the judgment. We gave participants an adapted version of Theseus’ ship puzzle. Instead of a ship, the puzzle involved a novel plasticene object that had either three or four parts. By using a novel object, we ensured that no one had any background knowledge about its particular properties or about any changes that it normally underwent. The object had an ambiguous form, and so we were able to manipulate its kind, by describing it either as an animal (as a creature like a starfish) or as an artifact (as a tool like a
paperweight) to different groups of participants. We then depicted each step of a complete part-by-part transformation of the object, by showing a single sequence of photographs that were said to have been taken at weekly intervals. In separate experiments, the replacement parts were either a different color than the originals or the same color. To manipulate the cause of the transformation, we described the change that took place in between each snapshot in the sequence differently to different groups: We either said nothing about the cause of the change, said that the change had a human cause (someone did it) or said that the change had no human cause (no one did it). We thus manipulated between groups (1) the domain of the object’s kind (artifact or animal), and (2) the cause of the transformation (unspecified cause, human cause, or no human cause). We then administered each version of the story (animal or artifact; unspecified cause, human cause, or no human cause) to separate groups of 5-year-olds, 7-year-olds, and adults.

EXPERIMENT 1

Participants saw a transformation event that involved replacing the original parts of a four-part object of one color with identical-looking new parts of a different color. The cause of the transformation was not specified.

Method

Participants

There were 96 participants: 32 5-year-olds, 32 7-year-olds, and 32 adults. Within each age group, 16 participants were assigned to the Artifact condition and 16 were assigned to the Animal condition, as follows:

Five-year-olds. Artifact ($M = 67.6$ months; $SD = 4.9$ months; Range = 60 to 74 months) and Animal ($M = 66.8$ months; $SD = 5.1$ months; Range = 60 to 74 months).

Seven-year-olds. Artifact ($M = 85.8$ months; $SD = 3.4$ months; Range = 80 to 90 months) and Animal ($M = 85.3$ months; $SD = 3.6$ months; Range = 79 to 91 months).

Adults. The adults were university students or people drawn from the surrounding community.

Children were tested individually in their schools during regular hours. They were from a range of socio-economic backgrounds. Adults were tested individually or in small groups (maximum 4 per group) either in the laboratory or in their homes.

Stimuli

Teaching photos. There were six 3 in. $\times$ 5 in. color photographs taken with a 35 mm camera. Three of them were used in the Artifact condition, and the three others were used in the Animal condition. See Fig. 1 for schematized depictions.

Text photos. There were fourteen 3 in. $\times$ 5 in. color photographs, taken with a 35 mm camera, used in both conditions. Figure 2 presents schematized depictions.

A puppet named “Sam” was also used during the interviews with children.
FIG. 1. Schematized teaching phase photographs from Experiments 1 and 2. The parts depicted in black were green.

Procedure

The following describes the procedure used with children. The procedure for adults was identical, except that adults (1) did not see the puppet and (2) were not asked the open-ended explanation question at the end of the procedure (see below). The procedure involved two phases: a teaching phase and a test phase.

Teaching phase. The purpose of this phase was to assign the novel object to a particular kind, either an animal kind or an artifact kind. Children sat at a table across from the experimenter. The experimenter introduced them to the puppet, named Sam. Children were asked, “Have you ever heard of a quiggle before? Let me show you some photographs of Sam’s quiggle.” The procedure varied from this point according to whether children were in the Artifact or the Animal condition.

a. Artifact condition. The three artifact teaching photos were placed in front of the child. See the left column of Fig. 1. They showed a novel, green, four-part plasticene object. Children were told that a quiggle was an artifact, a kind of tool. In the first photograph, the quiggle was shown on a desktop, on a piece of letterhead stationery. In the second, the quiggle was depicted stopping the piece of paper from blowing away in the wind. In the third, the quiggle was pictured still on top of the piece of stationery, the wind having subsided. Children heard the following: “These photos show Sam’s quiggle. A quiggle is a tool that is built by people in a factory. You buy it in a shop. See? It’s made to stop papers from blowing off your desk.”

b. Animal condition. The three animal teaching photos were placed in front of the child. See the right column of Fig. 1. They showed the same novel, green, four-part plasticene object as in the artifact teaching photos. However, children in this condition were told that a quiggle was a kind of animal. In the first photograph, the quiggle was shown on the ground, about three feet from a small dish of seeds. In the second, the quiggle appeared about a foot from
FIG. 2. Schematized test phase photographs from Experiments 1 and 2. The parts depicted in black were green, and the parts depicted in white were red.

the dish. In the third, the quiggle was at the edge of the dish, with two of its four parts touching the dish. Children heard the following: “These photos show Sam’s quiggle. A quiggle is an animal that comes from the jungle. It likes to eat these seeds. See! It likes to crawl over to the dish of seeds.”

In both conditions, the experimenter asked children to repeat the new label and then asked, “What color is Sam’s quiggle?” Children answered, “Green.” The experimenter then said, “And you know what? Quiggles come in all different colors.” This comment was meant to make children open to accepting that an identical-looking red-colored object could also be a quiggle. (The replacement parts in this experiment were red; see below.) The experimenter finally asked, “How many parts does a quiggle have?” Children answered, “Four.”

Test phase. The goal of this phase was to elicit attributions of persistence from participants, after they witnessed the part-by-part transformation of the novel object. Children in both conditions saw the same sequence of 14 photographs, one at a time. See Fig. 2. The experimenter said, “One day, Sam decided to go on holiday, and so he put his quiggle into this box here. See the photograph that I took? (Figure 2—Step 1). Then Sam had to go away. But before Sam went away, he asked me to come to the box every week while he was away to take another photograph of the box. Do you know why? So that when Sam came back from his holidays, he could look at all the photographs, and then he would know what had happened
while he had been away. Do you understand? So Sam went away on holiday.‘‘ The experimenter placed the puppet behind his back, reassuring the child that it would come back at the end of its holidays.

The experimenter then said, ‘‘Well, Sam went away for a long time, and then one day he decided to come back. He’s about to come back now. But before he comes back, let’s you and I look at the photos of the box that I took while Sam was away. Then you can explain to Sam what happened while he was gone. Can you do that? Shall we have a look?’’ The experimenter pointed to the photograph taken just before Sam went away, saying, ‘‘Remember, here’s the photo I took just before Sam went away.’’

The experimenter continued by saying, ‘‘Well, I went away and one week passed. And when I came back the next week, look!’’ The experimenter placed Fig. 2—Step 2 directly on top of Fig. 2—Step 1. With his finger, the experimenter pointed to the precise location in the photo where the change had occurred: One of the four original parts was now lying on the floor of the box, detached from the object.

Next, the experimenter said, ‘‘Well, I went away again and another week passed. And when I came back the next week, look now!’’ The experimenter placed Fig. 2—Step 3 directly on top of Fig. 2—Step 2. With his finger, the experimenter again pointed to the precise location in the picture where the change had occurred: A new red part was now in the place where the green part had been originally, the original green part remained where it had been lying on the floor of the box.

The experimenter continued to repeat these statements, placing successive photos directly on top of the previous ones, and drawing attention with his finger to each successive change (Fig. 2—Step 4 through Fig. 2—Step 9). Note that the ‘‘body’’ of the quiggle shifted its position in the photograph in the transition between each pair of photographs from Fig. 2—Step 1 to Fig. 2—Step 9.

After showing Fig. 2—Step 9, the experimenter said, ‘‘Well, watch what I did now. I reached my hand into the box [showing Fig. 2—Step 10]. Then I did this [showing Fig. 2—Step 11, and pointing to the place where the two green parts were being held together]. Then I did this [showing Fig. 2—Step 12, and pointing to the place where the three green parts were now together]. Then I did this [showing Fig. 2—Step 13, and pointing to the place where the four green parts were now together]. And then I took my hands away [showing Fig. 2—Step 14].’’

The experimenter continued by saying, ‘‘Well, did you see all that? I hope so, because Sam is now coming back and he’s going to ask for your help. Will you help him?’’ The experimenter then brought the puppet out from behind his back. The puppet looked at the top photograph (Fig. 2—Step 14), and asked ‘‘Where is my quiggle?’’ The experimenter repeated this question, asking, ‘‘Where is Sam’s quiggle?’’ The child had to point to one of the two objects in the photo. (No other photo was visible). Note that the question involved asking children to identify the object using the same possessive noun phrase that had been used to name the object at the beginning of the task. We did not phrase the question using the word ‘‘same,’’ given previous findings that children’s interpretation of this word may be systematically different from that of adults (e.g., Karmiloff-Smith, 1976). The puppet then asked, ‘‘Well, what happened to my quiggle while I was away on holiday?’’ We asked this open-ended final question to elicit information about the cause children perceived to be responsible for the transformation, especially about whether they tended to see the animal’s transformation as having an internal, biological cause. We tape-recorded the session in order to transcribe children’s answers.

Results and Discussion

We will call the quiggle made of replacement parts (the red one, depicted in white in Fig. 2—Step 14) the continuant and the quiggle made of the original parts (the green one, depicted in black in Fig. 2—Step 14) the replica. Table 1 shows the number of continuant selections in each condition.
TABLE 1
Results of Experiment 1: Number of Continuant Selections

<table>
<thead>
<tr>
<th>Age</th>
<th>Causal mechanism</th>
<th>Kind domain</th>
<th>Animal</th>
<th>Artifact</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-year-olds</td>
<td>No cause specified</td>
<td></td>
<td>5</td>
<td>0***</td>
</tr>
<tr>
<td>7-year-olds</td>
<td>No cause specified</td>
<td></td>
<td>8</td>
<td>1***</td>
</tr>
<tr>
<td>Adults</td>
<td>No cause specified</td>
<td></td>
<td>13‡</td>
<td>5</td>
</tr>
</tbody>
</table>

Note. N = 16 per condition; significantly below chance: ***p < .001; significantly above chance: ‡p < .01.

The two main predictions were these: First, within each age group, more participants would select the continuant when the object was described as an animal than when it was described as an artifact. Second, when the object was described as an animal, more older participants (adults or 7-year-olds) than younger ones (5-year-olds) would choose the continuant.

**Kind Domain Effects**

As predicted, there were significantly more continuant selections in the Animal condition than in the Artifact condition within each age group: For the 5-year-olds, χ²(1, N = 32) = 3.79, p = .051; for the 7-year-olds, χ²(1, N = 32) = 5.57, p < .05; and for the adults, χ²(1, N = 32) = 8.13, p < .005.

Comparisons to chance, calculated using the binomial theorem, were consistent with the preceding findings. Among 5-year-olds, the number of continuant selections in the Animal condition did not differ significantly from chance, but the number in the Artifact condition was significantly lower than chance, p < .001. Among 7-year-olds, the number of continuant selections in the Animal condition did not differ significantly from chance; in contrast, the number in the Artifact condition was significantly lower than chance, p < .001. Among adults, the number of continuant selections in the Animal condition was significantly greater than chance, p < .01; in the Artifact condition, this number did not differ significantly from chance.

**Age Effects**

As predicted, within the Animal conditions, older participants chose the continuant significantly more often than younger ones. In the Animal conditions, the number of continuant selections did not differ significantly between the 7-year-olds and the 5-year-olds. However, the difference between the number of continuant selections among adults and the number among 7-year-olds approached significance, χ²(1, N = 32) = 3.46, p < .10. In addi-

1 We applied Yates’ correction to all χ² statistics where any expected value was less than 5 (Ferguson, 1981).
tion, there were significantly more continuant selections among adults than among 5-year-olds, $\chi^2(1, N = 32) = 8.13, p < .005$.

Finally, we examined children’s explanations of the transformation event (which had no visible cause and whose cause was not specified in the story) in order to obtain more information about the perceived causal mechanism. We focused on whether these explanations ever appealed to an internal cause—specifically, a biological cause, such as growth or metamorphosis. We predicted that such allusions, if they occurred at all, would be more prevalent if the object was described as an animal than if it was described as an artifact. Only two children made reference to a biological cause, and both were 7-year-olds in the Animal condition (and both selected the continuant). (Recall that we did not ask adults for an explanation in this experiment.)

In sum, the results of Experiment 1 were consistent with the two main predictions. First, in all age groups, more participants selected the continuant if the object was described as an animal than if it was described as an artifact. Second, when the object was described as an animal, more adults than young children selected the continuant. These results provide support for the claim that both the domain of the object kind and the age of the participant making the judgment affect the tendency to attribute continuity and persistence to an object following an all-part transformation.

In Experiment 1, no information about the cause of the transformation was supplied in the story. To gather more direct evidence about the effect of the perceived causal mechanism on the tendency to select the continuant, we introduced a new factor into the design of Experiment 2. Now all participants were given specific information about the cause of the transformation—that a person either was or was not responsible. Providing participants with this added information allowed for a clearer test of the hypothesis that people are more likely to select the continuant if the animal’s change clearly lacks a human cause (and, thus, could plausibly have an internal, biological cause) than if it has a human cause.

**EXPERIMENT 2**

This was a replication of Experiment 1, with one main change. Within each age group, the two conditions from Experiment 1 (Artifact, Animal) were sub-divided. Half the participants in each condition heard that the transformation was caused by a person, and the other half heard that no human agent was involved.

**Method**

**Participants**

There were 192 participants: 64 5-year-olds, 64 7-year-olds, and 64 adults. None had taken part in the first experiment. Within each age group, 16 participants were assigned to each of four conditions, as follows:
Five-year-olds. Artifact–Human Cause ($M = 64.0$ months; $SD = 2.9$ months; Range = 60 to 70 months); Artifact–No Human Cause ($M = 64.2$ months; $SD = 3.0$ months; Range = 60 to 69 months); Animal–Human Cause ($M = 63.9$ months; $SD = 3.4$ months; Range = 60 to 69 months); and Animal–No Human Cause ($M = 63.8$ months; $SD = 2.3$ months; Range = 60 to 68 months).

Seven-year-olds. Artifact–Human Cause ($M = 86.2$ months; $SD = 3.6$ months; Range = 80 to 91 months); Artifact–No Human Cause ($M = 86.2$ months; $SD = 4.0$ months; Range = 80 to 92 months); Animal–Human Cause ($M = 86.2$ months; $SD = 4.1$ months; Range = 80 to 92 months); and Animal–No Human Cause ($M = 86.2$ months; $SD = 3.6$ months; Range = 80 to 91 months).

Adults. The adults were either university students or people drawn from the surrounding community.

Children and adults were tested under the same circumstances as in Experiment 1. Children were from a range of socio-economic backgrounds.

Stimuli

These were the same as in Experiment 1.

Procedure

We will describe the procedure used with children. The procedure used with adults differed from that used with children in the ways described in Experiment 1, except that in Experiment 2, we also asked adults for explanations of the event. As in Experiment 1, the procedure involved a teaching phase and a test phase.

Teaching phase. This was the same as in Experiment 1.

Test phase. This was the same as in Experiment 1, except that details about a mechanism of change were specified by the experimenter as he showed Fig. 2—Step 2 through Fig. 2—Step 9. Within each condition (Artifact and Animal), half the participants heard that there was a human cause for the transformation; and the other half heard that there was no human cause.

a. Human Cause conditions. The experimenter said, “Well, I went away (again) and one (another) week passed. While I was away, someone came to the box because it was (again) left wide open. When I came back the next week, look what someone had done (now)!“ The words in parentheses were used when the experimenter presented photographs following the one in Fig. 2—Step 2.

b. No Human Cause conditions. The experimenter said, “Well, I went away (again) and one (another) week passed. While I was away, no one came to the box because it was (again) locked up tight. When I came back the next week, look what had simply happened (now)!“ The words in parentheses were used when the experimenter presented photographs after the one in Fig. 2—Step 2. The information provided in the No Human Cause conditions was meant to rule out the possibility that participants would infer that the changes had a human cause. However, in order to provide sensible and matching information about both the animal and the artifact, the experimenter did not specifically indicate that the transformation had an internal cause (e.g., a biological one). This would have been misleading in the condition in which the object was described as an artifact, because artifacts do not undergo internally caused transformations (although the materials of which they are made may change with age, e.g., abrade, fade, decay, rust) (e.g., Schwartz, 1979). Thus, participants in the Animal–No Human Cause condition could plausibly have interpreted the transformation as having an internal, biological cause. In contrast, participants in the Artifact–No Human Cause condition should have had more difficulty in interpreting the transformation. One possible interpretation was that the material composing the artifact underwent some sort of spontaneous change related to aging, such as rotting or rusting. Alternatively, participants in the Artifact–No Human Cause condition, struggling to attribute a cause to the transformation, might have interpreted the event as having an internal cause (cf. Gelman & Gottfried, 1996).
TABLE 2
Results of Experiment 2: Number of Continuant Selections

<table>
<thead>
<tr>
<th>Age</th>
<th>Causal mechanism</th>
<th>Animal</th>
<th>Artifact</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-year-olds</td>
<td>Human cause</td>
<td>1***</td>
<td>0***</td>
</tr>
<tr>
<td></td>
<td>No human cause</td>
<td>4*</td>
<td>1***</td>
</tr>
<tr>
<td>7-year-olds</td>
<td>Human cause</td>
<td>1***</td>
<td>1***</td>
</tr>
<tr>
<td></td>
<td>No human cause</td>
<td>10</td>
<td>1***</td>
</tr>
<tr>
<td>Adults</td>
<td>Human cause</td>
<td>8</td>
<td>1***</td>
</tr>
<tr>
<td></td>
<td>No human cause</td>
<td>14‡</td>
<td>7</td>
</tr>
</tbody>
</table>

Note. N = 16 per condition; significantly below chance: *p < .05; ***p < .001; significantly above chance: ‡p < .01.

Results and Discussion

We again dubbed the quiggle made of replacement parts (the red one, depicted in white in Fig. 2—Step 14) the *continuant* and the one made of the original parts (the green one, depicted in black in Fig. 2—Step 14) the *replica*. Table 2 shows the number of continuant selections in each condition. There were three main predictions. First, within each age group, more participants would select the continuant when the object was described as an animal than when it was described as an artifact. Second, when the object was described as an animal, more participants within each age group would select the continuant when the transformation had no human cause than when it had a human cause. Third, when the object was described as an animal, and especially when the animal’s transformation event had no human cause, more older participants (adults or 7-year-olds) than younger ones (5-year-olds) would select the continuant.

**Kind Domain Effects**

As predicted, there were significantly more continuant selections in the combined Animal conditions than in the combined Artifact conditions, within all age groups except the 5-year-olds. Among 5-year-olds, there was no significant difference between the number of continuant selections in the combined Animal conditions and the number in the combined Artifact conditions. There were, however, significantly more continuant selections in the combined Animal conditions than in the combined Artifact conditions among both 7-year-olds ($\chi^2 (1, N = 64) = 7.82, p < .01$) and adults ($\chi^2 (1, N = 64) = 12.30, p < .0005$). The failure of 5-year-olds in Experiment 2 to show a significant effect of kind domain (as they did in Experiment 1) is consistent with the possibility that this effect may not be as strong at this young age as it is at a more advanced age. It is also possible that the difference between the results of the two experiments reflects the fact that 5-year-olds in Experi-
ment 2 heard that the transformation had a specific causal mechanism, whereas those in Experiment 1 did not. Another possibility is that the difference stems from the fact that the 5-year-olds in Experiment 2 were, on average, about 3 months younger than those in Experiment 1.

The results of comparisons to chance, computed using the binomial theorem, were consistent with the preceding findings. First, among 5-year-olds, the number of continuant selections was significantly below chance in both Animal conditions and in both Artifact conditions, all \( p's < .05 \). Among 7-year-olds, the number of continuant selections was significantly below chance in the Animal–Human Cause condition, \( p < .001 \), but it was at chance in the Animal–No Human Cause condition. However, the number was significantly below chance in both Artifact conditions, \( p's < .001 \). Finally, among adults, the number of continuant selections was at chance in the Animal–Human Cause condition and significantly above chance, \( p < .01 \), in the Animal–No Human Cause condition. In contrast, the number was significantly below chance in the Artifact–Human Cause condition (\( p < .001 \)) and at chance in the Artifact–No Human Cause condition.

**Causal Mechanism Effects**

As predicted, within the Animal conditions, there were significantly more continuant selections in the No Human Cause condition than in the Human Cause condition, within all age groups except the 5-year-olds. Among 5-year-olds, there was no significant difference between the number of continuant selections in the No Human Cause condition and the number in the Human Cause condition. There were, however, significantly more selections of the continuant in the No Human Cause condition than in the Human Cause condition among both 7-year-olds (\( \chi^2(1, N = 32) = 11.22, p < .001 \)) and adults (\( \chi^2(1, N = 32) = 5.24, p < .05 \)).

We also examined participants' answers to the explanation question in order to gather more information about the perceived causal mechanism underlying the transformation event. Again, we focused on whether participants ever alluded to an internal cause—specifically, a biological cause, such as growth or metamorphosis. If they did, we predicted that they would be most likely to do so when the object was described as an animal and when the animal's transformation lacked a human cause. We first examined children's answers, starting with the 5-year-olds. Within the Human Cause conditions, no one explained the transformation by invoking a biological cause in either the Animal or the Artifact condition. Within the No Human Cause conditions, one 5-year-old (6%) mentioned a biological cause in the Animal condition (and this child chose the continuant); none did so in the Artifact condition. We next considered the answers from the 7-year-olds. Within the Human Cause conditions, references to a biological cause were again rare. One child (6%) mentioned one in the Animal condition (this child chose the continuant), but no one mentioned one in the Artifact condition. Within the
No Human Cause conditions, however, seven children (44%) made references to a biological cause in the Animal–No Human Cause condition (of whom six chose the continuant); only one child (6%) did so in the Artifact–No Human Cause condition (and this child chose the replica).

Next, we examined adults’ responses. Within the Human Cause conditions, eight adults (50%) mentioned a biological cause in the Animal condition (seven of whom chose the continuant); but no one mentioned a biological cause in the Artifact condition. Within the No Human cause conditions, fifteen adults (94%) mentioned a biological cause in the Animal condition (of whom fourteen chose the continuant); so too did eleven adults (69%) in the Artifact condition (of whom seven chose the continuant). Three of these findings deserve further comment. First, as predicted, adults were most likely to mention an internal, biological cause if the object was an animal undergoing a transformation that lacked a human cause. Second, adults sometimes described an internal, biological cause to explain an animal’s transformation when the transformation was said to have a human cause. This finding suggests a powerful tendency to attribute changes that occur to animals as stemming from internal causes, regardless of whether these changes are said to involve a human agent. Similarly, Gelman and Gottfried (1996) found that preschoolers often denied that the movement of an animal carried by a human hand had an external cause. Third, adults often appealed to an internal, biological cause to explain an artifact’s transformation when the transformation was said to lack a human cause. This finding suggests a strong belief that object transformations that lack a human cause (and that have no visible cause) have internal causes, regardless of the kind of object. Similarly, Gelman and Gottfried (1996) discovered that preschoolers often inferred that an artifact’s transformation lacking a visible human cause had an internal cause.

In sum, the explanation data provided evidence suggesting that adults (and to a lesser extent, 7-year-olds) often construed the transformation event as having an internal, biological cause, most frequently (as predicted) in the condition in which the object was described as an animal undergoing a change with no human cause.

Age Effects

As predicted, within the Animal conditions, there were significantly more continuant selections among older participants than among younger ones. First, within the combined Animal conditions, there was no significant difference between the number of 7-year-olds and the number of 5-year-olds who selected the continuant. However, there were significantly more continuant selections among adults than among 7-year-olds, \( \chi^2(1, N = 64) = 7.57, p < .01 \). There were also significantly more continuant selections among adults than among 5-year-olds, \( \chi^2(1, N = 64) = 18.52, p < .0001 \).

Second, focusing specifically on the Animal–No Human Cause condi-
tions, we found significantly more continuant selections among 7-year-olds than among 5-year-olds, $\chi^2(1, N = 32) = 4.57, p < .05$. There was no significant difference in the number of continuant selections between 7-year-olds and adults. However, there were significantly more continuant selections among adults than among 5-year-olds, $\chi^2(1, N = 32) = 12.70, p < .0005$.

In sum, the results of Experiment 2 provided support for the three main predictions. First, more participants (excluding 5-year-olds) selected the continuant if the object was described as an animal than if it was described as an artifact. Second, when the object was described as an animal, more participants (excluding 5-year-olds) selected the continuant if the transformation had no human cause than if it had a human cause. In addition, adults’ and 7-year-olds’, but not 5-year-olds’, explanations of the transformation event suggested that they often construed it as having an internal, biological cause, especially when the object was an animal, and especially when it underwent a transformation with no human cause. Third, when the object was described as an animal, and when the animal’s transformation had no human cause, more older participants (adults or 7-year-olds) than younger ones (5-year-olds) selected the continuant. These results bolster the claim that the domain of the object kind, the cause of the transformation, and the age of the participant making the judgment all affect the tendency to infer continuity and to impute persistence to a physical object following a radical transformation in which all its parts are replaced.

Experiment 3 was a modified replication of Experiment 2. Recall that in many of the conditions in Experiment 2, few participants chose the continuant, especially if the object was described as an artifact. One possibility is that the weak tendency to select the continuant in the Artifact conditions reflected an unwillingness to infer continuity and, thus, to impute persistence when an object’s parts were replaced by differently colored parts. Of course, any such reluctance cannot explain all the results of Experiment 2, because the tendency to select the continuant was greater in other conditions, notably the Animal–No Human Cause condition, and especially for the 7-year-olds and adults. Nonetheless, the possibility that the change in color associated with the replacement parts depressed the general tendency to select the continuant motivated an experiment in which the color of the replacement parts was kept the same as the color of the originals. In addition, we switched to using a three-part object rather than a four-part object, in order to shorten the sequence of steps in the transformation and, thus, to simplify the task.

EXPERIMENT 3

This was a modified replication of Experiment 2, in which the transformation event involved replacing the object’s original parts with new parts that
were the same color rather than a different color. In addition, the object was made of three parts, rather than four parts.

Method

Participants

There were 192 participants: 64 5-year-olds, 64 7-year-olds, and 64 adults. None had taken part in either previous experiment. Within each age group, 16 participants were assigned to each of four conditions, as follows:

Five-year-olds. Artifact–Human Cause ($M = 66.9$ months; $SD = 5.4$ months; Range = 60 to 74 months); Artifact–No Human Cause ($M = 67.4$ months; $SD = 5.0$ months; Range = 60 to 74 months); Animal–Human Cause ($M = 67.2$ months; $SD = 4.2$ months; Range = 61 to 74 months); and Animal–No Human Cause ($M = 67.4$ months; $SD = 4.6$ months; Range = 60 to 74 months).

Seven-year-olds. Artifact–Human Cause ($M = 89.5$ months; $SD = 3.9$ months; Range = 83 to 96 months); Artifact–No Human Cause ($M = 89.7$ months; $SD = 3.6$ months; Range = 83 to 96 months); Animal–Human Cause ($M = 89.5$ months; $SD = 3.4$ months; Range = 83 to 96 months); and Animal–No Human Cause ($M = 89.5$ months; $SD = 3.6$ months; Range = 83 to 94 months).

Adults. The adults were either university students or people drawn from the surrounding community.

Children and adults were tested under the same conditions as in Experiment 2. Children were from a range of socio-economic backgrounds.

Stimuli

Teaching photos. There were four 3 in. × 5 in. color photographs taken with a 35 mm camera, two used in the Artifact condition and two used in the Animal condition. See Fig. 3 for schematized depictions. The “quiggle” now had three parts, each made of plasticene of a different color (red, green, and yellow).

![FIG. 3. Schematized teaching phase photographs from Experiment 3. The parts depicted in black were red; the parts depicted in white were green; and the parts depicted with dots were yellow.](image)
FIG. 4. Schematized test phase photographs from Experiment 3. The parts depicted in black were red; the parts depicted in white were green; and the parts depicted with dots were yellow. The side of the box depicted in gray was blue; the side depicted in white was white.

Test photos. There were eleven 3 in. × 5 in. color photographs, taken with a 35 mm camera, used in both conditions, and shown (schematized) in Fig. 4. Each new part that was introduced during the transformation was now the same color as the original part it replaced. In addition, the background of the box was colored blue on one side and white on the other.

“Sam,” the puppet was again used during the interviews with children.

Procedure

Teaching phase. This was identical to that of Experiment 2, except for the following: First, because children saw only two rather than three photographs in both Artifact and Animal conditions, the experimenter’s commentary was reduced accordingly. Second, children were not told that quiggles come in all colors, because the quiggle was now made of three different colors, and the replacement parts were the same colors as the originals (see below).

Test phase. This was also the same as in Experiment 2, with the following exceptions: First, when children saw the first picture of Sam’s quiggle in the box (Fig. 4—Step 1), they were asked to name the color of the side of the box on which it appeared. (They answered, “Blue.”) The rationale for adding this procedural detail was to provide children with a memory cue to
OBJECT PERSISTENCE

TABLE 3
Results of Experiment 3: Number of Continuant Selections

<table>
<thead>
<tr>
<th>Age</th>
<th>Causal mechanism</th>
<th>Kind domain</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Animal</td>
<td>Artifact</td>
</tr>
<tr>
<td>5-year-olds</td>
<td>Human cause</td>
<td>3**</td>
<td>2**</td>
</tr>
<tr>
<td></td>
<td>No human cause</td>
<td>2**</td>
<td>4*</td>
</tr>
<tr>
<td>7-year-olds</td>
<td>Human cause</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>No human cause</td>
<td>12†</td>
<td>4*</td>
</tr>
<tr>
<td>Adults</td>
<td>Human cause</td>
<td>8</td>
<td>2**</td>
</tr>
<tr>
<td></td>
<td>No human cause</td>
<td>12†</td>
<td>7</td>
</tr>
</tbody>
</table>

Note. N = 16 per condition; significantly below chance:
* p < .05; **p < .01; significantly above chance: †p < .05.

Results and Discussion

Using the terminology from previous experiments, we named the quiggle made of new parts the **continuant** (on the right side in Fig. 4—Step 11) and the quiggle made of the original parts the **replica** (on the left side in Fig. 4—Step 11). Table 3 shows the number of continuant selections in each condition. The three main predictions were the same as those in Experiment 2. We also predicted that, overall, there would be more selections of the continuant in Experiment 3 than in Experiment 2, because of the sameness of the color of the replacement parts in Experiment 3.

**Kind Domain Effects**

As predicted, there were significantly more continuant selections in the combined Animal conditions than in the combined Artifact conditions, within all age groups except the 5-year-olds. Among 5-year-olds, there was no significant difference between the number of continuant selections in the combined Animal conditions and the number in the combined Artifact conditions. However, there were significantly more selections of the continuant in the combined Animal conditions than in the combined Artifact conditions among both 7-year-olds ($\chi^2(1, N = 64) = 4.15, p < .05$) and adults ($\chi^2(1, N = 64) = 7.63, p < .001$). The finding that 5-year-olds in Experiment 3 showed no significant effect of kind domain is consistent with the results of Experiment 2, although the children in Experiment 3 were, on average, about 3 months older than those in Experiment 2 (and roughly the same age as those in Experiment 1).

The results of comparisons to chance, computed using the binomial theo-
rem, were consistent with the preceding findings. Among 5-year-olds, the number of continuant selections was significantly below chance in both Animal conditions and in both Artifact conditions, all \( p \)'s < .05. Among 7-year-olds, the number of continuant selections was at chance in the Animal–Human Cause condition and significantly above chance in the Animal–No Human Cause condition \( (p < .05) \). The number was at chance in the Artifact–Human Cause condition, but significantly below chance \( (p < .05) \) in the Artifact–No Human Cause condition. Among adults, the number of continuant selections was at chance in the Animal–Human Cause condition and significantly above chance in the Animal–No Human Cause condition \( (p < .05) \). However, it was significantly below chance in the Artifact–Human Cause condition \( (p < .01) \) and at chance in the Artifact–No Human Cause condition.

**Causal Mechanism Effects**

As predicted, within the Animal conditions, there were significantly more continuant selections in the No Human Cause condition than in the Human Cause condition among 7-year-olds, though not among 5-year-olds or (unexpectedly) adults. Among 5-year-olds, there was no significant difference between the number of continuant selections in the No Human Cause and the number in the Human Cause conditions. Among 7-year-olds, however, there were significantly more selections of the continuant in the No Human Cause condition than in the Human Cause condition, \( \chi^2(1, N = 32) = 6.15, p < .01 \). Among adults, there was no significant difference between the number of continuant selections in the No Human Cause condition and the number in the Human Cause condition. However, recall that the number of continuant selections was significantly above chance in the Animal–No Human Cause condition, but at chance in the Animal–Human Cause condition, consistent with the prediction. Nonetheless, the lack of a significant difference between the two conditions when compared directly suggests that the effect of causal mechanism among adults was weak.

We also examined participants’ answers to the explanation question in order to shed more light on the perceived causal mechanism underlying the transformation event. Again, we focused on whether participants ever appealed to an internal cause—specifically, a biological cause, such as growth or metamorphosis. If they did, we predicted that they would be most likely to do so when the object was described as an animal and when the animal’s transformation had no human cause. We first considered answers from children, beginning with the 5-year-olds. Within the Human Cause conditions, no one mentioned a biological cause in either the Animal or the Artifact condition. Within the No Human Cause conditions, one 5-year-old (6%) mentioned a biological cause in the Animal condition (and this child chose the replica); and one (6%) did so in the Artifact condition (and this child also chose the replica). We next examined 7-year-olds’ answers. Within the Human Cause conditions, one child (6%) gave a biological explanation in
the Animal condition (and chose the continuant); none did so in the Artifact condition. Within the No Human Cause conditions, five children (31%) alluded to a biological cause in the Animal condition (and four of them chose the continuant); only two children (13%) did so in the Artifact–No Human Cause condition (and they both chose the replica).

We then looked at adults’ explanations. Within the Human Cause conditions, four adults (25%) mentioned a biological cause in the Animal condition (of whom two chose the continuant); none did so in the Artifact condition. Within the No Human Cause conditions, eight adults (50%) in the Animal condition mentioned a biological cause (seven of whom chose the continuant); three adults (19%) in the Artifact condition also did so (and one of them chose the continuant). Thus, adults were most likely to appeal to an internal, biological cause if the object was an animal undergoing a transformation with no human cause. In addition, some adults (and some 7-year-olds) described an internal, biological cause to explain the human-caused transformation of an animal, and also to explain the transformation of an artifact that lacked a human cause. These last two results are consistent both with the findings from Experiment 2 and also with recent findings from children (e.g., Gelman & Gottfried, 1996).

In sum, the explanation data revealed that adults (and to a lesser extent, 7-year-olds) sometimes appealed to an internal, biological cause to explain the event, most frequently (as predicted) when the event involved an animal undergoing a transformation said to lack a human cause. The number of biological explanations was lower in Experiment 3 (25 out of 192) than it was in Experiment 2 (44 out of 192). However, the pattern of frequencies of biological explanations across conditions in Experiment 3 was similar to that of Experiment 2.

**Age Effects**

As predicted, within the Animal conditions, there were significantly more continuant selections among older participants than among younger ones. First, within the combined Animal conditions, there were significantly more continuant selections among 7-year-olds than among 5-year-olds, $\chi^2(1, N = 64) = 9.97, p < .005$. There was no significant difference in the number of continuant selections between adults and 7-year-olds. However, there were significantly more continuant selections among adults than among 5-year-olds, $\chi^2(1, N = 64) = 14.77, p < .0001$.

Second, focusing only on the Animal–No Human Cause conditions, we found similar results. There were significantly more continuant selections among 7-year-olds than among 5-year-olds, $\chi^2(1, N = 32) = 12.70, p < .0005$. There was no significant difference in the number of continuant selections between adults and 7-year-olds. But there were significantly more continuant selections among adults than among 5-year-olds, $\chi^2(1, N = 32) = 12.70, p < .0005$.

Finally, when we compared Experiments 2 and 3 in terms of the overall
number of continuant selections within each age group, we found no significant difference for either 5-year-olds or adults, but we found significantly more among the 7-year-olds in Experiment 3 than in Experiment 2, \( \chi^2(1, N = 128) = 6.23, p < .01 \). Changes to the parameters of the transformation event in Experiment 3 thus appeared to lead to an overall increase in the tendency to select the continuant for 7-year-olds. It is difficult to attribute the observed increase among 7-year-olds to one factor in particular: Experiments 2 and 3 differed in terms of both the color of the replacement parts (different than the originals or the same) and also the number of parts composing the object (four or three). It is, however, more plausible that the increased tendency to choose the continuant among 7-year-olds reflected the change to using same-colored parts than the change to using a 3-part object. Hirsch (1982) has suggested that decreasing the number of parts composing an object should, if anything, decrease the likelihood that an object stays continuous and, thus, persists through a part-by-part transformation. Thus, decreasing the number of parts might be expected to lead to a decrease in people’s tendency to select the continuant. Despite this consideration, the observed change among 7-year-olds from Experiment 2 to 3 was an increase in the tendency to select the continuant.

In sum, the results of Experiment 3 replicated the main results of Experiment 2, providing further support for the three central predictions. First, participants (excluding 5-year-olds) were more likely to select the continuant if the object was described as an animal than if it was described as an artifact. Second, when the object was described as an animal, participants (excluding 5-year-olds) showed a greater tendency to select the continuant if the transformation event had no human cause than if it had a human cause. In addition, adults’ and 7-year-olds’ (but not 5-year-olds’) explanations of the transformation event suggested that they often construed it as involving an internal, biological cause, especially when the object was an animal, and especially when the event had no human cause. Third, when the object was described as an animal, and when the animal’s transformation had no human cause, older participants (adults and 7-year-olds) were more likely than younger ones (5-year-olds) to select the continuant. The results of Experiment 3 thus support the claim that all three factors under investigation—domain of object kind, mechanism causing the transformation, and age of the participant making the judgment—affect the tendency to infer continuity and, thus, to ascribe persistence to an object following a radical transformation in which all its parts are replaced.

**GENERAL DISCUSSION**

Participants witnessed an event in which each part of a novel object (labeled with a possessive noun phrase) was replaced, one at a time, resulting in an object made entirely of new parts (the continuant). The set of original
parts was then reassembled to form a second object (the replica). Participants had to choose one of the objects as being the same persisting object as the original, by deciding which one carried the same possessive noun phrase. Choosing the continuant suggested a tendency to base an attribution of persistence upon an inference of continuity, whereas selecting the replica suggested a tendency to do so upon an inference of compositional identity (i.e., upon the sameness of the parts and of how they were assembled). We used people’s choices (1) to examine whether people’s reliance on continuity as a persistence criterion ever extends to the situation in which an object suffers the replacement of all its component parts; and (2) to explore whether the tendency to rely on continuity in such a situation is affected by the object’s kind, the mechanism responsible for its transformation, and the age of the person making the judgment.

Inferring Continuity through Part Replacement

First, both adults and children sometimes did choose the continuant as being the same persisting object as the original, appearing to infer continuity through a complete change in an object’s constituent parts, when (1) the object had either three or four parts, (2) the transformation took place at weekly intervals, and (3) the color of the replacement parts was either the same as, or different than, that of the originals. This result suggests that people are willing, under at least some conditions, to judge a whole object to be greater than the sum of its parts. To the extent that participants did select the continuant as being the same persisting object as the original, their behavior confirms the intuitions of several philosophers (e.g., Hirsch, 1982; Wiggins, 1967).

In choosing the continuant, people behaved consistently with claims that they are psychological essentialists, acting “as if things (e.g., objects) have essences or underlyng natures that make them the thing that they are” (Medin, 1989, p. 1476; see also Gelman & Medin, 1993; Gelman et al., 1994; Medin & Ortony, 1989). Among the sources of evidence that have been argued to provide support for psychological essentialism is a willingness to ascribe persistence to an object through changes to its features (see Gelman et al., 1994). For example, previous research has revealed that people will sometimes judge that an object can persist as a member of the same kind (e.g., Gelman & Wellman, 1991; Keil, 1989) or as the same individual within a kind (e.g., Guthiel & Rosengren, 1996; Rosengren, et al., 1991) following a dramatic change to its surface properties. In the current studies, participants’ willingness to choose the continuant is consistent with a belief that the essence of an object is immaterial, in that it does not reduce to any of its component parts.

The discovery that people were sometimes willing to select the continuant as being the same persisting object as the original raises several issues. One of these concerns the generalizability of these findings to other versions of
Theseus’ ship puzzle. First, as discussed in the Introduction, it remains to be shown that people’s attributions of persistence in this task are the same, regardless of the number of parts composing the object, the duration of the transformation, or the perceptual similarity of the replacement parts to the originals (e.g., in color, in material kind, in texture). Experiments 2 and 3 differed both in terms of the number of parts making up the transformed object and also in terms of the sameness of the color of the replacement parts, but it would be of interest in future work to determine more systematically how such variables affect judgments in the task.

Second, these experiments involved objects with same-shaped parts undergoing complete material transformations. As a result, the studies did not allow an assessment of whether some object parts are seen as more important than others in fostering attributions of continuity and persistence. For example, a dog’s brain or heart may be seen as more important than its leg, and a car’s engine may be viewed as more important than its bumper. Johnson (1990) has provided evidence that, by the fourth grade, children view the brain as central to the identity of a person or an animal. Gelman and Wellman (1991) have shown that preschoolers conceive of internal parts as more central to object kind persistence than external parts. They found that preschoolers were more likely to attribute object kind persistence if an object’s outsides were removed than if its insides were eliminated. It would be of interest to document whether people’s attributions of persistence in the current task depend on the perceived role of particular parts with respect to the whole object, perhaps by examining people’s intuitions following partial transformations.

Third, the status of the post-transformation objects in these experiments was left unspecified, so it was not clear whether the animals were meant to be viewed as alive or whether the artifacts were meant to be viewed as functional. It is possible that this type of information could influence people’s performance in the task. For example, Wiggins (1980) pointed out that an answer to the question of whether the continuant or the replica should be identified as Theseus’ persisting ship might depend upon whether we are trying to identify an historical relic (in which case we might favor the replica) or a seaworthy functioning object (in which case we might prefer the continuant). This issue also arises in the case of an animal, where an answer to the question of which object should be identified as the persisting original may depend upon whether either or both are seen as alive. It would be of interest in further work to furnish, and perhaps manipulate, this type of information about the objects.

Factors Affecting Inferences of Continuity

For the versions of the transformation event presented in these studies, the tendency to select the continuant varied with the domain of the kind under which the object was described, the mechanism said to cause the object’s transformation, as well as the age of the participant making the choice.
a. *Kind domain.* The number of selections of the continuant was higher if the object was described as an *animal* than if it was characterized as an *artifact,* for adults and 7-year-olds in all experiments, and even for 5-year-olds in Experiment 1. This finding suggests the existence of a stronger tendency to ascribe continuity and, thus, persistence to an animal than to an artifact undergoing a complete change in its material composition. The result is consistent with previous research indicating that people are more likely to judge an individual to persist as the same object (Rosengren et al., 1991) or as a member of the same kind of object (Keil, 1989) following a transformation if it is an animal than if it is an artifact. The finding is also compatible with claims that people’s essentialist beliefs are stronger in association with animals than in conjunction with man-made objects (e.g., Gelman et al., 1994; Keil, 1994).

These experiments contrasted artifacts with animals, raising the question of whether the strong tendency to select the continuant is specific to animals (undergoing a change with no human cause) or whether it would be the same for all living objects (e.g., including plants) or even all natural objects (e.g., also including rocks and minerals). Further work assessing attributions of persistence across a wider range of object kinds would be necessary to answer this question. In addition, these experiments focused on a single kind of animal and a single kind of artifact, both of which were novel. This novelty ensured that participants knew nothing about the objects’ properties or characteristic changes prior to the task. However, people have knowledge of many specific kinds of animals and artifacts. For example, within the domain of animals, we know that people, dogs, caterpillars, and chameleons have different perceptual features and suffer different types of changes over time. It would be of interest to know whether (and if so, when in development) people differentiate among familiar object kinds within a given domain in terms of the tendency to infer continuity and ascribe persistence through the sort of radical change shown in these experiments (see also Rosengren et al., 1991).

b. *Causal mechanism.* The number of continuant selections for the object classified as an animal was higher if the transformation had *no human cause* than if it had a *human cause,* for adults and 7-year-olds, but not for 5-year-olds, in both Experiments 2 and 3. Some previous results had suggested that children as young as five years old might be sensitive to whether an animal’s transformation lacks or has a human cause in making ascriptions of continuity and, thus, persistence. For example, 5-year-olds have been shown to ascribe persistence to individual animals following dramatic transformations (e.g., size and shape changes) that are spontaneously occurring (e.g., Rosengren et al., 1991); but in other research, children of this age have been shown to be unwilling to attribute persistence of animal kind following certain transformations (e.g., radical plastic surgery) that are externally caused (e.g., Keil, 1989). However, when the cause of the transformation was directly manipu-
lated within the current experiments, only 7-year-olds’ and adults’ attribu-
tions of continuity and persistence to an individual object were significantly
affected.

In addition, explanations of the transformation event indicated that adults
and 7-year-olds (but not 5-year-olds) in Experiments 2 and 3 often construed
it as having an internal, biological cause (e.g., growth, metamorphosis), most
frequently when the object was described as an animal and when the transfor-
mation was said to lack a human cause. The strong tendency to infer an
internal, biological cause in the case of an animal undergoing a change with
no human cause meshes with other recent evidence suggesting that children
often infer an internal cause when asked to interpret objects’ spontaneously
occurring changes (e.g., movements) (see Gelman & Gottfried, 1996; Mas-
sev & Gelman, 1988).

Although many participants selected the continuant and appeared to infer
a biological cause in the condition where an animal suffered a transformation
that had no human cause, recall that no specific internal cause was ever de-
scribed, in order to keep the description sensible for both the animal and the
artifact (and also to keep the description equivalent in the two conditions).
It would, however, be of interest to examine whether people’s tendency to
select the continuant is even greater if the animal’s all-part transformation is
explicitly described as having an internal, biological cause (e.g., as involving
growth). It would also be interesting to compare this tendency to that of
another group who heard that the same transformation has a different type
of non-human cause, such as one that violates the laws of nature (e.g., magic;
see Chandler & Lalonde, 1994; Liittschwager, 1994; Rosengren, Kalish,
Hickling, & Gelman, 1994). Further work along these lines would enable a
more detailed analysis of the impact of the specific perceived causal mecha-
nism underlying an animal’s change upon persistence attributions.

c. Development. The number of selections of the continuant for the object
described as an animal (and, specifically, for the animal undergoing a trans-
formation with no human cause) was higher for older participants (adults or
7-year-olds) than for younger participants (5-year-olds), in all experiments.
These findings suggest that there is an increase in children’s tendency to
attribute continuity and, thus, persistence to animals through certain transfor-
mations (especially those that lack a human cause) in the years after kinder-
garten. The results are consistent with previous work indicating an increase
during this period in the tendency to ascribe persistence of object kind to
animals, but not artifacts, undergoing radical transformations to their surface
properties (Keil, 1989).

The findings of these experiments are consistent with claims that there
are changes after the age of five years in children’s understanding of animals
or living things (e.g., Carey, 1985; Solomon, Johnson, Zaitchik, & Carey,
1996; but see also Gelman, 1993; Simons & Keil, 1995; Springer, 1992). It
seems unlikely that these changes involve the initial emergence of essential-
ist beliefs about animals: A growing body of evidence suggests that children already reason essentialistically about animals during the preschool years (e.g., Gelman et al., 1994). Nonetheless, it is possible that there is an increase, over this period of development, in children’s tendency to invoke essentialist beliefs to reason about the continuity and persistence of animals undergoing certain radical changes to their physical structure. This increase may stem from the acquisition of knowledge about animals from specific kinds, including details of the broad range of transformations that characteristically occur to their properties over time.

Our daily encounters with objects are typically different from the controlled encounters participants experienced in these experiments. We rarely have the chance to track objects over extended periods of time (e.g., to monitor carefully any changes to their locations and properties from week to week) and thus to base ascriptions of persistence on well-informed inferences about their continuity (or their compositional identity). As noted in the Introduction, our perceptual experiences with objects are typically brief and interrupted. As a result, object-kind-specific knowledge (e.g., knowledge about the properties and canonical changes associated with objects of particular kinds, like dogs and chairs) likely plays a very important role in our everyday attributions of persistence to objects. This knowledge can assist us in making judgments about persistence, by informing us when it is reasonable to infer that an object of some familiar kind confronting us now is the same persisting object as one encountered at some time in the past.

However, it is important to stress that object-kind-specific knowledge likely guides ascriptions of persistence only to the extent that it does not enter into conflict with our more primary persistence criteria, like continuity. For example, knowledge about the kind DOG might tell us that an individual dog lives an average of 20 years. This knowledge could help us in deciding whether a dog observed right now is the same persisting dog as one encountered in the distant past. Yet as Spelke (1985; p. 105) noted, “if there is a continuous path connecting a bulldog living now with a bulldog that lived in 1930, we would probably conclude that this is the same, extraordinarily old dog.” Furthermore, knowledge about the kind PERSON might tell us that people maintain most of their physical properties from day to day. This knowledge could assist us in judging whether a man observed now is the same persisting man as one observed yesterday. However, as Spelke (1985; p. 105) also noted, “if there is no continuous path connecting a man seen today with a man seen yesterday, then we would probably conclude that they are distinct people, however similar they appear.” For example, the two men might be identical twins. Thus, object-kind-specific knowledge likely never takes precedence over more fundamental persistence criteria. Instead, it seems more plausible that such knowledge exerts its effects on attributions of persistence by signaling when it is sensible to infer that these core criteria are satisfied.
REFERENCES


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