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The role of historical intuitions in children's and adults' naming of artifacts

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Abstract

It is commonly assumed that artifacts are named solely on the basis of properties they currently possess; in particular, their appearance and function. The experiments presented here explore the alternative proposal that the history of an artifact plays some role in how it is named. In three experiments, children between the ages of 4 and 9 years and adults were presented with familiar artifacts whose appearance and function were then radically altered. Participants were tested as to whether they believed that the modified objects were still members of the artifact kind. Results indicate that object history becomes increasingly important over the course of development.

Keywords: Children; Adults; Artifacts; Object naming

1. Introduction

What determines the names that children and adults give to everyday artifacts? Why is it that we call one thing "a clock", another "a toy", and another "a painting"? In this paper we discuss a history-based perspective on this issue and explore the merits of this perspective in a series of experiments with children and adults.

Most contemporary theories focus on either object shape or function. For example, Landau, Smith, and Jones (1998) argue that artifact naming, at least for young children, is based primarily on object shape. If something is shaped like a knife, it is called "a knife".

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Other theorists (e.g. Miller and Johnson-Laird, 1976) propose that artifact naming, for both children and adults, is based on the object's current function. If something can function like a typical knife, it is called "a knife".

Despite their differences, these theories share an important feature. They assume that what something is called can be determined on the basis of properties that it currently possesses. In this regard, they assume that naming is ahistorical. Something is called "a knife", for instance, if it has a certain appearance or the ability to fulfill a certain function *right at the moment it is being named*. This assumption might seem so mundane that it is not worth stating, but it could be wrong. The origins – and more generally, the history – of an artifact may also play a key role in determining its kind status.

After all, history is plainly relevant for other important aspects of our mental lives. It is highly relevant for how we think about, evaluate, and track individuals. Most people cannot tell an authentic Picasso from a forgery. Indeed, with a good enough fake, nobody could. Most of us, however, would much prefer to own Picasso's original work – that is, the specific painting that Picasso himself painted (for discussion, see Dutton, 1979). Or imagine seeing a baby and hearing it called "Emily". Emily will have a certain appearance, a shape, smell and texture, as well as a distinctive genetic structure. But when you learn the name, you do not associate the name with any entity that possesses these properties; instead you learn that *that individual* is Emily (Kripke, 1980). Suppose that Emily is a twin and you find yourself later exposed to two babies that each look the same as the one you first encountered. The intuition here is not that they are both Emily; it is that one of them is Emily and the other one is not. There is by now abundant evidence that even young children share this intuition and, more generally, that they map proper names onto specific individuals (e.g. Hall, 1996; Katz, Baker, & Macnamara, 1974; Liittschwager & Markman, 1993; see Bloom, 2000 for review).

Do these historical intuitions apply to the naming of kinds as well? There are at least some kinds that appear to have a historical component. To be a widow is to be an unmarried woman whose husband has died. One cannot be certain that someone is a widow without appeal to her history (i.e. without asking: Was she ever married?). A forgery is something that was created with the intent to defraud; a felon is someone who has committed a felony in the past; a virgin has never had sex; a veteran has served in the military, and so on. We classify such individuals as falling into certain kinds based at least in part on their histories.

This paper addresses two questions. First, can a historical theory of categorization be extended to adults' naming of garden-variety artifacts such as chairs and clocks? And how well does such a history-based approach fare with regard to the naming patterns of children?

1.1. Adults' naming of artifacts

Adults use words such as "chair" and "clock" to refer to objects of a range of shapes and sizes. There are beanbag chairs, basket chairs, deck chairs, chairs for dolls, chairs shaped like hands and chairs suspended from ceilings on chains. There are grandfather clocks, digital clocks, clocks shaped like coke bottles and clocks for the blind that tell the time at the press of a button. This diversity of form suggests that what makes these things chairs and clocks does not reduce to facts about current appearance.

Intuitions about current function also fail to fully explain adult patterns of categorization. Chairs are typically used for sitting, and clocks are typically things that tell time. But one can sit on the floor, and this doesn't make it a chair. A fragile antique chair that would break if you tried to sit on it is nonetheless still a chair. One can tell the time by looking at the shadow of a tree, but a shadow is not a clock, and if Big Ben could no longer tell time it would not cease being a clock (see Bloom, 2000).

One potential solution to this problem is an appeal specifically to the function that the artifact was originally created to fulfill (e.g. Hall, 1995; Keil, 1989). This focus on intended function is one version of a historical account of artifact labeling. From this perspective, broken clocks and fragile chairs are still called clocks and chairs because they were created with the intention that they fulfill the function of those artifact kinds. In contrast, trees and floors cannot be members of those kinds because they were never created with the required intent.

There are problems with this form of historical account, however. It is difficult, if not impossible, to establish a one-to-one mapping from intended functions to artifact categories. Do cans necessarily have a different intended function from bottles, or cups from mugs? (If so, what are these functions?) Indeed, when form and function are contrasted in controlled experiments, there is little evidence that function wins out with regard to adult category judgment (e.g. Malt & Johnson, 1992).

One response to these concerns is a historical theory of artifact naming that makes reference to intentions that are more fine grained. What makes a fragile chair a chair, and makes Big Ben a clock, may be that both were created with the intent that they be members of their respective categories – to be a chair or to be a clock. This alternative historical approach provides an unequivocal basis on which to determine category boundaries. A chair is any object that has been created with the intent that it be a member of that artifact kind, i.e. a chair is anything that is intended to be a chair.

This proposal is not in conflict with the obvious fact that current appearance and function are highly important. It is very rare, after all, that we are given explicit information about the history of an object; we typically categorize and name artifacts on the basis of perceptible properties they have – what they look like, and what they can do. But, according to the historical theory, appearance and function are highly relevant just because they typically reflect the creator's intent. If something currently resembles a typical chair and has the function of a typical chair, for instance, then it is highly likely that it was created with the intent to be a chair. As Dennett (1990) notes, "There can be little doubt what an axe is, or what a telephone is for; we hardly need to consult Alexander Graham Bell's biography for clues about what he had in mind."

This historical proposal has its limits. There is more to being a member of an artifact kind than having the proper history. If a child, or an adult who is mentally ill, crumbles up some paper and gum and (sincerely) declares that he or she has just created a clock, still, the resulting object would not be named a clock. Also, the most extreme version of this proposal would state that once a clock, always a clock – and this plainly is not true. While a clock that no longer tells time might still be a clock, some severe forms of damage might cause it to cease being a member of that category

– if the clock is melted into a featureless cube, this cube is not a clock. The proper way to handle these exceptions is a matter of some debate (e.g. Bloom, 1996; Malt and Johnson, 1992); we raise them only to note that an object's history, on any account, cannot entirely determine what an object currently is. We will return to the issue below, when we discuss the logic of the experimental design.

1.2. Children's naming of artifacts

The developmental data are notoriously messy. Gentner (1978) found that 2- to 5-year-olds generalized object labels on the basis of current appearance, 5- to 15-year-olds generalized on the basis of current function, and adults went back to generalizing on the basis of appearance. More recent studies have found support for both an early shape bias (e.g. Landau et al., 1998), and an early function bias (e.g. Kemler-Nelson & 11 Swarthmore College Students, 1995; Kemler-Nelson, Frankenfield, Morris, & Blair, 2000).

One explanation for these conflicting results is historical: shape and function are only relevant to the extent that they are seen as reflecting the assumed original intention of the artifact's creator (Bloom, 2000; Diesendruck, Markson, & Bloom, 2003). For instance, Landau et al. (1998) showed children simple novel target objects, which could perform broad functions (e.g. a "Rif" which could soak up a spill). They were then shown test objects that were similar to the target in either shape or function, and asked to label these objects. The children responded that objects shaped like the target were "Rifs" regardless of their functional ability to soak up water, and objects not shaped like the target were not "Rifs" even if they could perform this function. While this is consistent with a shape bias, it could also be that children ignored function because the functions used were dependent only on the substances the artifacts were made of, providing little motivation to believe that these objects were created with the express intent that they fulfill these functions. With these stimuli, shape best reflects the designer's intent.

Two recent studies directly tested the hypothesis that the importance of shape vs. function is determined by the extent to which these factors are seen as reflecting intentional design. Kemler-Nelson et al. (2000) showed 4-year-olds a novel target object and either a "plausible" or "implausible" function for that artifact. Plausible functions were specific and strongly connected to the shape and component parts of the object (e.g. "It can draw circles and curves."). Similar to Landau et al. (1998), implausible functions were more general and not tied to specific shape/parts (e.g. "A snail can spin on it."). Children were then shown a perceptually similar but non-functional test object and a perceptually different but still functional test object. Participants were given a chance to interact with all the objects and then asked to label the two test objects. As predicted, children based their category judgments on function but only for meaningful (plausible) functions. When faced with implausible functions, children's function-based responses dropped significantly. Four-year-olds then use function as a basis for labeling only in those cases where that function was clearly specialized and reflected intentional design (see also Kemler-Nelson et al., 1995).

In another study, 3-year-olds used meaningful function to differentiate between two objects of similar shape. Specifically, when shown two novel objects of similar size and shape, 3-year-olds predictably generalized a novel label from one to the other. However, when told that the second object was the cover or container for the first, these generalizations dropped significantly. Despite strong similarity in shape these children seemed to recognize that there was an explanation for this sameness that did not require sameness of label (Diesendruck et al., 2003).

Other research explicitly manipulates the creator's intent. Gelman and Bloom (2000) showed 3-year-olds, 5-year-olds, and adults a series of objects that were described as either purposefully or accidentally created. Even 3-year-olds were more likely to provide artifact names for the objects (e.g. "a knife") when they believed the objects were intentionally created than when they believed the objects were accidentally created. These results suggest that preschoolers are sensitive to at least this component of object history when that history is not in conflict with the current status of the artifact.

When current status and history conflict, however, the results are less clear. Matan and Carey (2001) presented children with a neutral object partially obscured by a wall, and told them two competing stories in which one person creates the object to fulfill a specific function (e.g. make tea) and a second individual finds the object and uses it successfully for a different function (e.g. watering plants). When asked to label the object, 4-year-olds' reliance on designer intent and history was inconsistent. Matan and Carey argue that it is not until about age 6 that children begin to show any meaningful use of the intentional stance in artifact naming.

1.3. Goal of current experiments

All the research to date focuses on artifacts in which current state is consistent with either the shape of typical kind members, their function or both. These experimenters explore the relative importance given to shape vs. function (Diesendruck et al., 2003; Kemler-Nelson et al., 2000), intended function vs. current function (Diesendruck et al., 2003; Hall, 1995; Matan & Carey, 2001), or purposeful vs. accidental creation (Gelman & Bloom, 2000). Our goal in these experiments is to provide a stronger test of the historical hypothesis by exploring if, and under what conditions, participants will judge something to be a member of a kind solely on the basis of its history, even if it currently lacks the typical shape and function of that kind. Our focus is developmental, looking at the role of history from preschool to adulthood.

In the experiments that follow participants are presented with triads of familiar artifacts like paper cups and then watch as one of these objects is significantly altered. Participants are then asked if the transformed cup is still a member of that artifact kind. The transformations vary in their severity in order to assess the potential interaction between increasing alteration of current status and stable history as member of given kind. For example, a cup might be crushed, or cut into pieces, or both.

If history is a core component of artifact concepts independent of the object's current state, then an object that loses its current shape and/or functional status should still maintain its original kind membership as long as the history and designer intent of the object as a kind member are still known. If, however, current status plays a more pivotal role, change in that status should cause a loss of kind membership. Finally, if history and current status both play important roles in determining kind membership, the severity of the transformation should affect intuitions that the object is no longer a member of the artifact kind.

There are some methodological concerns that arise when asking about the outcome of transformations. For example, identifying an object as a member of a given kind (e.g. “This is a cup.”), then transforming that object and asking, “Is it *still* a cup?” may imply it is not. We try to avoid this problem by asking participants to count the number of kind members in the array. For instance, we would start with three cups, transform one of the cups in some way, and then ask: “How many cups are there right here in front of us?” If the transformed object is judged to remain a cup, then the total number of cups in the array remains unchanged (i.e. three cups). If it is no longer a member of that object kind, the number of kind members in the array changes as well (i.e. two cups). This provides a straightforward test of kind membership.

Given the conflicting results in the preschool literature, and the limited investigation of object history in adult artifact concepts, we first focused on 4- and 5-year-olds, and adults.

2. Experiment 1

2.1. Method

2.1.1. Participants

Twenty-two 4- and 5-year-olds (7 girls, 15 boys, range 4-1 to 5-8, M = 4-10) and 20 adults (17 females, 3 males, range 16-0 to 22-11, M = 18-3) participated. Two additional children were dropped due to an inability to complete a counting pretest. Children were recruited from public daycare centers and adults from a summer course in introductory psychology. Adults received course credit for their participation. All participants were taken from a predominantly middle and upper-middle class population.

2.1.2. Materials

Materials consisted of five sets of simple artifacts. Each set contained three similar members of the same artifact kind: paper cups, paper plates, foam-core squares, mailing envelopes and plastic drinking straws. Within each set, objects varied in color or color pattern, but were otherwise identical (i.e. same size, shape and material). An additional distracter object (a pencil) was also used (see Fig. 1 for sample items).

2.1.3. Design and procedure

The design consisted of (1) a counting pretest trial, (2) an object replacement trial, (3) a square-to-circle transformation, (4) a crush transformation, (5) a cut transformation, and (6) a crush + cut (combination) transformation. The counting pretest was always presented first, followed by object replacement. The remaining trials (3–6) followed in random order across participants. With the exception of the square-to-circle transformation (see below) all the remaining transformations and object set pairs were partially counterbalanced across participants. Children were tested in their preschool and adults were tested in a laboratory observation room. The procedure was otherwise identical for all participants.

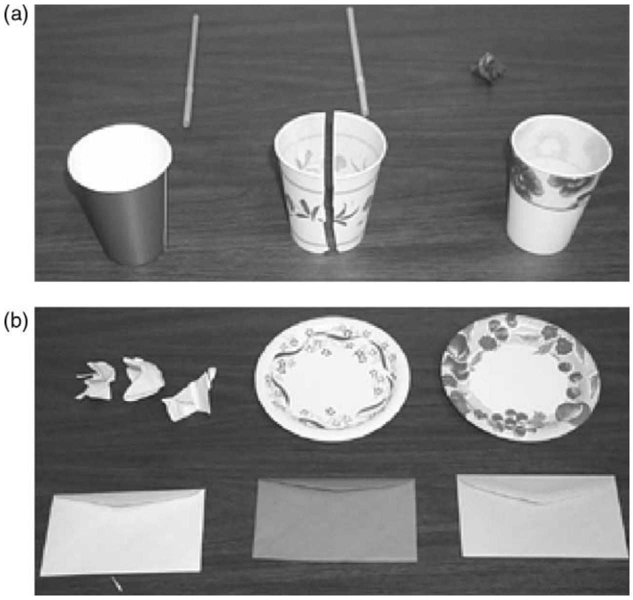

Fig. 1. Sample objects and transformations used in Experiments 1–3. (a) Straws (crush transformation) and cups (cut transformation). (b) Plates (combination transformation) and envelopes.

2.1.3.1. Counting pretest. Participants were told "We're going to play a game where we try to figure out what things are, and how many we have." The experimenter then presented an object set (e.g. three cups), and asked the participants to both identify the object kind and count the number of objects in the array. For example, participants were asked: "What are these things? That's right they're Xs (e.g. cups). How many Xs (cups) are there right here in front of us?" If children responded incorrectly to either question, they were told the object kind in the array and/or given a second chance to count the objects. If they were still incorrect on either question, they were dropped from the analyses.

2.1.3.2. Object replacement. Using the same object set, the experimenter told the participants to "Watch what I do" as she removed one object in the array from their line of sight and replaced it with a pencil. She then asked, "Did you see what I did?" and then asked, "How many Xs (e.g. cups) are there right here in front of us?" When asking this question the experimenter gestured to include all the objects in the array. This trial was intended to demonstrate that the number of kind members in the array could change from three to two.

For the trials that followed the experimenter would (a) introduce the object set, (b) ask the child to identify and count the objects, (c) state "Watch what I do", (d) transform a target object in the array in some manner and (e) ask the participant to count the objects again. The target object chosen varied randomly within each array.

2.1.3.3. Square-to-circle transformation. This transformation was always performed with the foam-core square object set. The experimenter cut the target square in the array into a circle and returned it to its original location, removing the cut pieces from view. Participants were then asked, "How many squares are there right here in front of us?" Given that shape is the sole determinant of membership in this category, this transformation was meant to provide an unambiguous example of change in kind membership within the context of the experiment.

The three remaining (destruction) transformations disrupted the target object's current status to increasing degrees (see Fig. 1).

2.1.3.4. Crush transformation. The experimenter crumpled the target object, and placed it back in its prior location in the array. This transformation altered the target's shape and impaired its intended function, but in such a way that it could potentially be "repaired" and resume that function relatively easily.

2.1.3.5. Cut transformation. The experimenter cut the target object into (two or three) equal pieces and placed the pieces in the shape and location of the original object, maintaining a small but clearly perceptible distance between them. This transformation clearly destroyed the target's intended function (it could not be repaired without the use of additional material), and destroyed its shape by producing two/three distinct objects. The placement of the pieces, however, resembled the original intact target and so maintained some aspect of the original target's overall shape.

2.1.3.6. Combination transformation. The target was first cut, and then the individual pieces were crushed and placed as a group in the target's original location. This transformation permanently destroyed the object. No significant aspect of its current shape or function remained.

2.2. Results and discussion

For each trial, there were originally three objects of a given type, one of the objects was altered, and participants were asked how many members of that type remained. Responses of "two" indicated that the participants believed that this transformation involved destruction of kind membership. For instance, if a participant answered that there were two straws after one of the three straws was crumpled, this suggests that the crumpling caused the object to cease being a straw. The numbers of participants responding in this way served as the dependent measure and are shown in Table 1.

The object replacement and square-to-circle transformations were intended to have obvious answers, and were included to ensure that participants would be willing to alter their judgments of number/kind membership in clearly appropriate cases. Indeed, all children and adults responded as predicted to these transformations, believing that both changes reduced the number of kind members in the array from three to two.

The question of interest was how participants responded when the target object was damaged in some manner. All adults either responded "two" (indicating a probable loss of kind membership), or "three" (indicating probable stability). Their responses were therefore first compared to chance at 50% using binomial probability. Few adults believed that crushing the object (15% judgments of kind change, $P < 0.001$), or cutting it

Table 1
Percentage of participants responding that there were two kind members in the array after each transformation (Experiment 1)

Transformation	Adults	Preschoolers	
		Total ($n = 22$)	Without counters ($n = 17$)
Object replacement	100	100	100
Square-to-circle	100	100	100
Crush	15	82	82
Cut	30	59	76.5
Combination	55	73	82

(30% judgments of kind change, $P < 0.04$) altered its kind status. They were somewhat more prone to believe that both combined did so (55%, $P = 0.16$). Still, even when the object was cut into separate pieces and the pieces were crushed, only about half of the adults believed it lost its kind status. Adult judgments of kind change for all three destruction transformations were also significantly lower vs. both the object replacement and square-to-circle trials (χ^2, $P < 0.001$ or lower).

Preschoolers sometimes counted the individual pieces of the target, as well as the remaining whole objects, after the cut and/or combination transformations. For example, when asked to count the plates after the combination transformation depicted in Fig. 1, such children might respond that there were now five plates. This occurred for 23% of the cut trials, and 14% of the combination trails. This is consistent with findings by Shipley and Shepperson (1990) that children will sometimes ignore specific task instructions, and count all of the distinct physical objects in an array (though see also Giralt & Bloom, 2000 for questions about the scope of this effect). We therefore focused our analyses in Experiments 1–3 on those children whose responses were limited to "two" and/or "three" on the destruction transformations (see the column marked "Without counters" in Table 1).

In contrast to adults, binomial analyses indicated that the 4- and 5-year-olds possessed a consistent belief in loss of kind membership as a result of all three damage transformations (crush (14 of 17, $P < 0.005$), cut (13 of 17, $P < 0.02$) and combination (14 of 17, $P < 0.005$)) (see Table 1). Chi-square analyses vs. adults showed significant overall differences ($\chi^2(1, N = 111) = 24.66$, $P < 0.001$), as well as significant differences for both the crush and cut transformations specifically (Ps < 0.005). The combination transformation showed a marginally significant difference in the same direction ($\chi^2(1, N = 37) = 3.14$, $P = 0.08$). Preschoolers seemed to believe that the impact of the three destruction transformations on kind membership was generally similar to that of both the object replacement and square-to-circle trials. Only the cut transformation was seen as significantly less powerful ($\chi^2(1, N = 28) = 4.53$, $P < 0.04$).

In sum, adults clearly relied on object properties beyond current state when making kind judgments. Even in the most extreme case, in which the objects were both cut and crushed, roughly half (45%) of the adults believed that the target's kind was unaffected. These results suggest a strong, but not exclusive role for history in adults' artifact concepts. The majority of preschoolers, in contrast, tied their kind judgments to current state. This suggests a developmental progression in which object history becomes increasingly more important over the course of development.

Our procedure may, however, have biased preschoolers to view the transformations as altering the number of objects in the array. The object replacement and square-to-circle trials were intended to test preschoolers' willingness to alter their judgments of number/kind membership in cases where this was clearly warranted, but these trials might have also biased children to respond that *any* transformation in the task has this result. This possibility could be addressed by adding a transformation in which the appearance of the target object is significantly altered without potentially impacting its kind status.

An additional possible issue in Experiment 1 was the requirement that children count the number of objects in each array both pre- and post-transformation. Although confirming that they could accurately count, this process may have biased some children to alter their responses (from three to two) the second time they were asked on a given trial, simply because they believed they were expected to do so in response to getting the same question a second time. These issues were addressed in Experiment 2.

Finally, the results of Experiment 1 suggest a meaningful change in the relationship between history and current object state at some point between preschool and adulthood, but do not directly address when this change might occur. Matan and Carey (2001) suggest that this may begin at around age 6. We therefore expanded our investigation to older children.

3. Experiment 2

3.1. Method

3.1.1. Participants

Twenty-three preschoolers (9 girls, 14 boys, range 4-1 to 5-7, M = 4-7) recruited from public daycare centers participated. Twenty first-graders (12 girls, 8 boys, range 6-4 to 7-6, M = 6-9), and 20 third graders (11 girls, 9 boys, range 8-3 to 9-8, M = 8-10) recruited from a private elementary school participated. Twenty-four adults (17 female, 7 male, range 18-4 to 22-9, M = 19-10) recruited from undergraduate courses in psychology also participated. Adults were given course credit for their participation. None of the participants had taken part in Experiment 1. All participants were taken from a predominantly middle and upper-middle class population.

3.1.2. Materials

Materials were identical to Experiment 1 with the following additions: three plastic spoons, one black erasable marker and six kinds of small toys (i.e. crayons, watches, scissors, sunglasses, airplanes, and cars).

3.1.3. Procedure

3.1.3.1. Training trials. As in Experiment 1, participants were tested individually and told at the start of the procedure that “We're going to play a game where we try to figure out what things are and how many we have." At this point, however, participants were shown a set of four training trials in random order. All four used sets of three objects. Two of the sets contained three different members of a given kind (e.g. three different crayons) and two contained two different members of one kind, and a single exemplar of a different kind (e.g. two different watches and one pair of scissors). For each set, participants were asked to (a) identify all the objects in the array, and (b) count the (larger number of) objects. These training trials demonstrated that the number of kind members in a given array was free to vary, and that both "three" and "two" were appropriate responses. The object sets used for the training trials (crayons, watches, scissors, sunglasses, airplanes, and cars) varied randomly across participants.

3.1.3.2. Color and square-to-circle trials. These were presented in random order across participants directly following the training trials. The square-to-circle trial was identical to Experiment 1. The color trial was performed on a set of three plastic spoons that had been colored with black erasable marker prior to the start of the experiment. Participants were asked to identify the objects and told to "Watch what I do" as the experimenter wiped one spoon clean, changing its color from black to white, and replaced it in the array. At this point, children were asked, "How many spoons do we have right here in front of us?" These two trials were presented prior to the crush, cut and combination transformations in order to demonstrate the general object transformation process, and show that any given transformation could either alter object kind membership (square-to-circle) or not (color). The object replacement trial was dropped in Experiment 2 due to its redundancy in this revised design.

3.1.3.3. Destruction trials (crush, cut and combination). These were again presented in random order, and identical to Experiment 1 with the exception that participants were only asked to count the number of objects in a given array after a specific transformation had occurred. This was done to avoid any bias to alter responses simply due to repetition of the question. Based on the results of Experiment 1 and the current training trials we were confident that preschoolers were capable of counting the objects in the array successfully without practice prior to each destruction transformation.

3.2. Results

Results were analyzed in the same manner as Experiment 1 and are shown in Table 2. Virtually all participants responded as expected to both the color and square-to-circle transformations. Only a small number of preschoolers (14%, $P < 0.001$ binomial probability) believed that a change in color altered object kind. As in Experiment 1 a minority of preschoolers (35%) counted individual object pieces for the cut and combination transformations. These children were therefore excluded from the analyses.

Adults' responses to the three destruction transformations were consistent with Experiment 1. The crush transformation had a minimal impact (17% change, $P < 0.001$). There was a similar but less dramatic pattern for the cut transformation (37.5% change, $P = 0.08$), and a split response pattern for the combination transformation (58% change, $P = 0.12$). As expected, adult responses to each of the three destruction transformations

Table 2
Percentage of participants responding that there were two kind members in the array after each transformation (Experiment 2)

Transformation	Preschoolers		First-graders ($n = 18$)*	Third-graders ($n = 19$)*	Adults
	Total ($n = 23$)	Without counters ($n = 14$)			
Color change	17	14	0	0	0
Square-to-circle	100	100	100	100	100
Crush	52	79	67	47	17
Cut	48	79	61	47	37.5
Combination	52	86	72	53	58

* Two first graders and one third grader counted pieces in this experiment. Their exclusion has no significant impact on the results.

were also significantly different from those for the square-to-circle trial (χ^2, $P < 0.001$ or less). These responses were also significantly different (χ^2, $P < 0.04$ or less) vs. those for the color transformation.

Chi-square analyses further indicated no significant difference between adults' responses across Experiments 1 and 2 for either the three destruction transformations combined ($\chi^2(1, N = 132) = 0.25$, $P = 0.62$) or each destruction transformation considered separately ($P = 0.60$ or higher). When the adults in Experiments 1 and 2 were combined, the average kind change responses for the crush and the cut transformation were significantly below chance (16% change, $P < 0.001$, and 34% change, $P < 0.02$, respectively). Combined change responses to the combination transformation in contrast were still at chance (57% change, $P = 0.08$).

As in Experiment 1 preschoolers' responses (vs. chance) across the crush, cut and combination transformations indicated that they viewed the transformations as changing artifact kind (crush: 11 of 14, $P < 0.03$; cut: 11 of 14, $P < 0.03$; combination: 12 of 14, $P < 0.007$). In addition, preschoolers' responses to the crush, cut ($\chi^2(1, N = 28) = 3.36$, $P = 0.07$) and combination ($\chi^2(1, N = 28) = 2.15$, $P = 0.14$) transformations were not significantly different from their responses to the square-to-circle trial, but were markedly different vs. the color trial ($\chi^2(1, N = 28) = 11.63$, $P < 0.001$ (vs. crush) or less).

The majority of first graders responded in a similar manner on the cut (12 of 18, $P = 0.07$) and crush transformations (11 of 18, $P = 0.12$), but this was significantly different from chance for only the combination transformation (13 of 18, $P < 0.04$). In further contrast to preschoolers, first graders' responses on all three destruction transformations were significantly different from their responses to the square-to-circle trial ($\chi^2(1, N = 36) = 5.81$, $P < 0.02$ (vs. combination) or less). These children also believed, however, that all three destruction transformations had a greater impact than a change in color ($\chi^2(1, N = 36) = 15.84$, $P < 0.001$ (vs. cut) or less).

As with the first graders, third graders' responses to the three destruction transformations were also at chance (9–10 of 19, $P = 0.16$–0.17). These responses were also all significantly different from both the square-to-circle trial

($\chi^2(1, N = 38) = 13.57$, $P < 0.001$ (vs. combination) or less), and color trial ($\chi^2(1, N = 38) = 13.57$, $P < 0.001$, (vs. crush) or less).

The predominantly chance responses for first and third graders in Experiment 2 are open to at least two interpretations. First, these children may have been legitimately confused about the impact of the destruction transformations, and so responded randomly across these three items. Alternatively, the overall chance responses may mask conflicting, but consistent, response patterns. For example, some children may have responded that all three destruction transformations altered kind membership (much like the preschoolers in Experiment 1) and others may have responded that kind membership was unaffected by any of the destructive changes (more similar to adults).

To investigate this possibility we next examined the consistency of individual children's responses to the three destruction transformations in Experiment 2. Specifically we looked at how many children at each age responded that all three destruction transformations altered the target's kind membership, or all three had no impact on that membership. As expected, although the majority of preschoolers responded consistently (9 of 14), all of these youngest children indicated that the target had lost its kind membership. Fifteen of 18 first graders responded consistently across all the transformations with the majority (10 of 15) responding that kind membership had been destroyed in all cases, and five responding that it had remained stable in all cases. If we then move to the third graders, 17 of 19 children responded consistently, with 9 of 17 responding that kind membership changed for all three, and 8 of 17 responding that it remained stable. Rather than random confusion, first and third graders' responses in Experiment 2 then show a gradual increase in ability to move beyond current state as the primary basis of artifact labeling, with first graders responding similarly to preschoolers and third graders moving toward a more adult response pattern. This interpretation is further supported by several children who spontaneously commented on the importance of either history (e.g. "It's a cup because that's how it was made") or shape/function (e.g. "It can't be a cup. You wrecked it").

Finally, overall χ^2 analysis indicated a significant difference across age for the destruction transformations combined ($\chi^2(3, N = 225) = 24.13$, $P < 0.0001$). More specifically, preschoolers were significantly more likely than either third graders ($\chi^2(1, N = 99) = 10.47$, $P < 0.002$) or adults ($\chi^2(1, N = 114) = 20.13$, $P < 0.0001$) to believe that the target had lost its kind membership. First graders were marginally more likely to respond in this manner than third graders ($\chi^2(1, N = 111) = 3.50$, $P = 0.06$), and significantly more likely to do so than adults ($\chi^2(1, N = 126) = 10.50$, $P < 0.002$).

Preschoolers were marginally more likely than the third graders to respond that the target was no longer a kind member for the crush and cut transformations ($\chi^2(1, N = 33) = 3.29$, $P = 0.07$), and significantly more likely to do so for the combination transformation ($\chi^2(1, N = 33) = 3.97$, $P = 0.05$). Preschoolers' responses were also significantly different from those of adults for the crush and cut transformations ($\chi^2(1, N = 38) = 14.18$, $P < 0.001$), and marginally different for the combination transformation ($\chi^2(1, N = 38) = 14.18$, $P < 0.001$). Adults and first graders ($\chi^2(1, N = 42) = 10.90$, $P < 0.002$) and adults and third graders ($\chi^2(1, N = 43) = 4.74$, $P < 0.04$) differed significantly on the crush transformation. No other comparisons produced significant differences.

3.3. Discussion

Results to this point show a clear pattern of development. When object history is placed in direct conflict with current state, preschoolers rely predominantly on current state when making labeling decisions. This focus on current state then begins to shift to an awareness of history as a more central aspect of artifact kind membership at around age 6–7. By this age the majority of children still rely on current state when determining kind membership, but unlike preschoolers, they do not view a loss of that state as equivalent to changing a square into a circle. A small number of first graders also based their decisions on object history despite loss of current state. By age 8 or 9, the results are split: about half for object history and half for current status. This leads finally to a stronger reliance on history in adults' artifact concepts. This developmental progression is shown in Fig. 2, which plots the gradual increase in the use of history across age.

The interaction of current state and history in adults' judgments is also apparent from Fig. 2. As the severity of the transformation increased adults were less likely to respond that it was still a kind member (84% crush, 66% cut and 43% combination). These differences are significant across all three destruction transformations (crush vs. cut: $\chi^2(1, N = 88) = 3.88$, $P = 0.05$; cut vs. combination: $\chi^2(1, N = 88) = 4058$, $P < 0.04$; crush vs. combination: $\chi^2(1, N = 88) = 15.91$, $P < 0.001$). In contrast to children then, adults seem to weigh both current state and object history together when making their judgments of kind membership.

These results may, however, underestimate younger children's history understanding. In Experiments 1 and 2, participants' attention was never drawn to the pre-transformation state of the target object (e.g. its identity as a cup). The destructive transformations of

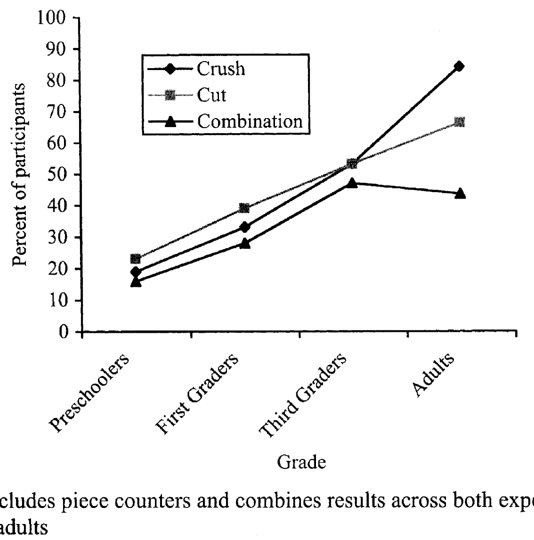

Fig. 2. Percentage of participants responding that there were three kind members in the array after each destruction transformation in Experiments 1 and 2 (excludes piece counters and combines results across both experiments for preschoolers and adults).

the target were, in contrast, quite active and potentially captivating. Preschoolers' sensitivity to the importance of history may have been overwhelmed by the salience of these transformations. We investigated this possibility in a final preschool experiment, in which we explicitly highlighted several aspects of the object's history.

4. Experiment 3

4.1. Method

4.1.1. Participants

Seventeen preschoolers (6 girls, 11 boys, range 4-2 to 5-11, M = 5-0) participated. All were recruited from local daycare centers. None took part in Experiments 1 or 2. All participants were taken from a predominantly middle and upper-middle class population.

4.1.2. Materials and procedure

These were identical to Experiment 2 with the exception of the following changes. Preschoolers in Experiment 2 were consistently able to count and identify the objects in the four counting training trials. In order to counter the increased length of the procedure in Experiment 3 (see below), these were reduced to one trial each of "three" and "two" kind members presented in random order. The straw object set was replaced with balloons. In addition, the square-to-circle item was altered to a square-to-triangle item in which the triangle was "popped out" of the square by hand.

Finally, after children had identified the objects in the three item training trial (e.g. three scissors) they were told, "That's right, these are Xs. They were made in a factory. A factory is a place where people go when they want to make things. So these Xs were made in a factory by people who wanted to make Xs." This information was intended to highlight the origins and designer intent inherent in the objects' history. In addition, after children had identified the objects on successive trials, the history and origins information was repeated for each set (e.g. "That's right, these are cups. They were made in a factory by people who wanted to make cups.").

4.2. Results and discussion

Data were analyzed in the same manner as previous experiments. Children responded as expected to both the square-to-triangle and color change trials (see Table 3). Two children (12%) counted object pieces on the cut and combination trials and so were excluded from further consideration.

Highlighting the history and origins of the objects had no impact on preschoolers' judgments of kind membership. As in Experiments 1 and 2, preschoolers consistently responded that there were two kind members in the array after each of the destruction transformations. This response pattern was even slightly stronger in Experiment 3. The number of children responding in this manner was significantly greater than chance for all three trials (see Table 3) ($P < 0.003$ or less). In addition, preschoolers in this experiment saw little difference between the square-to-triangle transformation and any of the three

Table 3
Percentage of participants responding that there were two kind members in the array after each transformation (Experiment 3)

Transformation	Preschoolers	
	Total ($n = 17$)	Without counters ($n = 15$)
Color	6	7
Square-to-triangle	94	93
Crush	88	93
Cut	76.5	87
Combination	88	93

destruction transformations ($\chi^2(1, N = 30) = 0.37$, $P = 0.54$ (vs. cut) or higher) (see Table 3). Responses to the destruction trials were, however, significantly different from those on the color trial ($\chi^2(1, N = 30) = 19.28$, $P < 0.001$ (vs. cut) or less). These results support the conclusion drawn from Experiments 1 and 2 that although they are aware of history as a component of artifact kind membership, preschoolers will not use history as a basis of judgment if it is placed in direct conflict with the current state of the artifact. This is the case even when that history is explicitly highlighted in the task.

5. General discussion

The research reported here concerns the nature and development of artifact naming. In particular, we explore the hypothesis that history is a fundamental component of children's and adults' artifact concepts. This predicts that when an artifact is damaged so that its current state cannot be used as a basis of kind membership it might still retain its kind status. We examined this claim in a series of experiments in which common artifacts were increasingly damaged/destroyed and participants were tested on their understanding of the kind status of the altered objects. We tested 4- and 5-year-olds (Experiments 1–3), 6–9-year-olds (Experiment 2), and adults (Experiments 1 and 2).

Two main findings emerged from these experiments. The first is that object history is a central component of a mature theory of artifact kind membership. If an artifact was crushed or cut into pieces, most adults still believed that it remained a member of its original kind. This was not due to an overall bias to preserve membership across any change, since if a square was cut into a circle, adults never judged that it remained a square. This use of history, however, is combined with current status. The more severe the destruction, the less likely adults were to accept it as a kind member.

The second finding was a clear developmental trend. Preschoolers in Experiments 1–3 relied consistently on the objects' current status when making their kind membership judgments. They made no significant differentiation between crushing the target, and cutting it into pieces and crushing those pieces. This was the case even when object history and origins were explicitly highlighted in the task (Experiment 3). This response pattern could not be solely due to an overall bias to assume that any change leads to a shift in response, because when exposed to a color change, few preschoolers said that the object altered its original kind membership.

By about the age of 6, children began to move beyond current state in artifact naming. While only 1 of 46 preschoolers (2%) in Experiments 1–3 consistently responded that kind membership remained stable across all three destruction transformations, 5 of 18 6- and 7-year-olds (28%), and 8 of 19 8- and 9-year-olds (42%) did so. As shown in Fig. 2, there was a monotonic increase with age in children's willingness to ignore current status, and to instead focus on object history, across all three destruction transformations. In addition, children's responses were less fine-grained than adults' responses: either all of the changes altered kind membership, or none of them did.

5.1. Potential developmental explanations

We see three potential explanations for the developmental changes present in the current experiments.

The first is that there is a radical difference between the artifact understanding of children and that of adults. Young children categorize artifacts on the basis of ahistorical properties – what they look like, and what they can do. The design stance (Dennett, 1987) or intentional-historical understanding (Bloom, 1996) of adults is a relatively late developmental accomplishment, acquired through some combination of experience and conceptual restructuring. Young children do not appeal to object history because they have no inkling that history has anything to do with artifact naming or categorization.

There are reasons to doubt, however, that 4- and 5-year-olds are really so limited. As discussed earlier, there is evidence that even 3-year-olds attend to information about origins when naming artifacts such as knives and hats (Gelman & Bloom, 2000). Furthermore, even when they do attend to shape and function, they are highly sensitive to the meaningful correspondences between the two, and possibly to the relation of both to designer intent and object history (e.g. Diesendruck et al., 2003; Kemler-Nelson et al., 2000).

A second possibility assumes that there exist multiple ways of understanding artifact categories even early in development, but that the priority given to these "explanatory frameworks" shifts as the product of experience. This proposal has mainly been applied to understanding of living kinds (see for example, Gutheil, Vera, & Keil, 1998; Keil, 1995), but it may be useful to examine it in the current context as well. The central claim of this approach is that children and adults possess multiple explanatory framework theories or biases (e.g. a naive biology) that they use in evaluating information within a given domain (e.g. living kinds or artifacts). One bias may be more widely applied than others at a given age, but children and adults possess multiple frameworks that they can apply quite effectively where they believe these are appropriate.

From this perspective, developmental differences in artifact naming would be based on changes in emphasis given to one framework over another. The experiments reported here find that preschoolers focus on the current state of the object; any significant alteration of that state led to a loss of kind membership. Current state may then form the primary (default) framework for preschoolers' artifact naming. In other contexts, however, children of the same age clearly recognize the relevance of intent and history – so long as these cues do not conflict with current status (e.g. Gelman & Bloom, 2000; Kemler-Nelson et al., 1995, 2000; Kemler-Nelson, Herron, & Morris, 2002). Intent and history may then form a second explanatory framework for children but one that is less central than current status. More generally, the development of artifact naming might then best be characterized as movement among several concurrent biases (e.g. shape, function, intended function, designer intent and history) starting with a default bias in favor of shape and/or function and leading to a mature theory incorporating intent/history and current status consistent with the results for adults in the current experiments.

A third potential explanation also posits a real conceptual difference between children and adults, but this difference is subtler. Perhaps children and adults are sensitive to intent and history in different ways when naming artifact kinds. In our experiments, there were, after all, two sources of intention with regard to the object. The first is the intent of the object's creator grounded in its history. The second is the current intent of the experimenter who is consciously transforming it. While adults give priority to the original creator when assessing what an artifact's function is (i.e. when responding to the question "What is this for?"), there is considerable debate as to whether young children do the same (see German & Defeyter, 2000; German & Johnson, 2002; Kelemen, 1999). It may be that, in general, children are more even-handed, and more willing to take into account the intentions of agents that are not the object's creator, when reasoning about and naming artifacts. For instance, children might reason that since the experimenter plainly intended to obliterate the form and function of a cup, then the object was no longer a cup. That is, children may not be dismissing intent and history; they may be allowing one aspect of intent to override another.

In a direct investigation of the hypothesis that children view intentional modification (as opposed to accidental change) as relevant to artifact naming, Kemler-Nelson et al. (2002) presented participants with familiar objects that had either been damaged or intentionally redesigned. For example, a damaged cup had an irregular piece taken out of its side and an intentionally redesigned cup had a hole drilled in its base with a washer inserted. Both conditions impaired object function but preserved overall shape. Preschoolers were significantly more likely to respond with the category label ("cup") when the object was damaged than when the object was intentionally modified. Kemler-Nelson et al. conclude that the intent of people other than the object's creator, for example its user, is relevant to how it is named.

Regardless of which of these accounts is correct, the experiments reported here show that there is clearly a developmental difference that needs to be explained: adults will often call something a cup even after it has been cut, crushed, or both; children are far less likely to do so. The importance of history in artifact naming changes radically over the course of development, for reasons that are at this point unclear.

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