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Preschool ontology: The role of beliefs about category boundaries in early categorization

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Abstract

These studies examined the role of ontological beliefs about category boundaries in early categorization. Study 1 found that preschool-age children ($N=48$, ages 3–4) have domain-specific beliefs about the meaning of category boundaries; children judged the boundaries of natural kind categories (animal species, human gender) as discrete and strict, but the boundaries of other categories (artifact categories, human race) as more flexible. Study 2 demonstrated that these domain-specific ontological intuitions guide children's learning of new categories; children ($N=28$, 3-year-olds) assumed that the boundaries of novel animal categories would be narrower and more strictly defined than novel artifact categories. These data demonstrate that abstract beliefs about the meaning of category boundaries shape early conceptual development.

Adult categories are embedded in systematic, domain-specific ontological beliefs about the structure of the world (Murphy & Medin, 1985). In particular, adults view some categories (e.g., mammals) as reflecting objective reality, and others (e.g., tools) as more subjective and flexible (Gelman & Coley, 1991; Kalish, 1998; Malt, 1990; Rhodes & Gelman, 2009a). This ontological distinction has implications for a number of cognitive processes, including categorization (e.g., adults view membership in the category *mammal* as absolute, but allow for partial membership in the category *tool*; Diesendruck & Gelman, 1999; Estes, 2003, 2004) and induction (e.g., adults expect mammals to share many underlying similarities, but tools to be more variable; Gelman, 1988; Gelman & O'Reilly, 1988).

The present research examines the role of these ontological intuitions in early conceptual development. The extent to which young children incorporate abstract theories into their concepts continues to be an area of ongoing debate. According to traditional theories, young children's categories are atheoretical, based on superficial similarities, and do not reflect abstract concepts (Piaget, 1929). Contemporary researchers from this perspective suggest, for example, that early induction is based on perceptual similarity, not abstract conceptual categories (Sloutsky & Fisher, 2004; Sloutsky, Kloos, & Fisher, 2007). In contrast, others have argued that early concepts are grounded in rudimentary domain-specific theories, and that these abstract theories guide and propel conceptual development (Gelman & Koenig, 2003; Wellman & Gelman, 1992).

In support of this second position, two recent studies provide direct evidence that, by age five, children share adults' domain-specific ontological beliefs. Rhodes and Gelman (2009a) found evidence of domain-specificity in children's beliefs about category objectivity; in this work, 5-year-olds rejected animal categories that were inconsistent with their own beliefs

about how to categorize animals, but were more likely to accept unusual ways of categorizing artifacts. This pattern suggests that children view animal categorization as objective, but artifact categories as more subjective and flexible. Similarly, Rhodes and Gelman (2009b) found that 5-year-olds rejected the possibility of partial membership in animal categories (e.g., they responded that something cannot be “sort of a bird”), but accepted this possibility for artifacts (e.g., they responded that something can be “sort of a tool”). Thus, 5-year-olds have domain-specific intuitions about both the discreteness and objectivity of category boundaries.

The studies described above indicate that children’s categories are embedded in rudimentary ontological theories by the early school-age years. The goal of the present work is to examine whether these theories play a role in shaping early conceptual development. This research extends prior work in two key ways. First, the present studies examine the ontological intuitions of younger preschool-age children. Because the previous studies examined early school-age children (age 5), it remains unclear from prior work whether domain-specific ontological beliefs shape early conceptual development, or alternately, whether such beliefs develop only after a period of conceptual reorganization during the preschool years (cf. Carey, 1995). Previous work has demonstrated that younger preschoolers have many systematic domain-specific beliefs about animals and artifacts, including about how category membership is determined (Disendruck, Markson, & Bloom, 2003; Gelman & Kremer, 1991), category stability (Gelman & Wellman, 1991; Keil, 1989; Siegel & Callanan, 2007), characteristic properties (Simons & Keil, 1995), and causal processes (Hatano & Inagaki, 1994; Massey & Gelman, 1988; Rosengren, Gelman, Kalish, & McCormick, 1991). Yet, whether preschoolers have systematic ontological beliefs about category boundaries (e.g., viewing some categories as more objective and discrete than others) has not been addressed in prior work. Thus, the present studies directly test whether preschoolers have such beliefs.

Second, the present studies examine whether children’s ontological intuitions influence how they learn about new categories. If children believe that the boundaries of animal categories are strict and objectively defined—and this belief contributes to how children make sense of the world—then when they encounter a new animal category, they should assume that its boundaries have this status. Thus, children should treat membership in new animal categories as strict and discrete, and should assign category membership conservatively. In contrast, children should assume that the boundaries of new artifact categories are relatively subjective and graded, and thus, assign category membership more flexibly. No prior work, however, has examined whether children’s ontological intuitions guide how children view the boundaries of new categories (see Barrett, Abdi, & Murphy, 1993; Booth & Waxman, 2002; Brandone & Gelman, 2009; Greif, Kemler-Nelson, Keil, & Guitierrez, 2006; for related work). Thus, it remains unclear whether ontological intuitions shape how children learn about categories, or alternately, whether these intuitions develop only after children have specific experiences with or knowledge about particular categories (e.g., after repeated experiences seeing birds categorized in a uniform way and tools categorized more variably).

The Present Studies

Study 1 tests whether preschoolers’ ontological beliefs about the status of category boundaries vary by domain. To do so, Study 1 assesses preschoolers’ beliefs about familiar categories, similar to those used by Rhodes and Gelman (2009a), using a new task designed for younger children. This study included two domains that Rhodes and Gelman (2009a) found that 5-year-olds construe as objective (animal species and human gender) and two domains that 5-year-olds construe as subjective and flexible (artifact categories and human

race). Study 2 tests whether preschoolers rely on domain-specific ontological intuitions when learning about new categories, by examining novel animals and artifacts.

Study 1

Method

Participants—Participants included 48 preschoolers ($M_{\text{age}} = 4.16$ years, range = 3.0–4.98 years; 22 male, 26 female; 36 Caucasian, 3 African American, 4 Hispanic, 5 Asian American) recruited from private preschools. All children completed items about animals, artifacts, and one social category (by random assignment, either gender, $n = 25$, or race, $n = 23$). Children were asked to make judgments about only one type of social category in order to keep the task short enough for young preschool-age children and also to avoid introducing any additional difficulty by asking children to consider multiple, different criteria for social categorization across items.

Procedure

Warm-up—The task was based on a procedure used by Gelman, Croft, Fu, Clausner, and Gottfried (1998) to study word learning. To introduce the task, the experimenter presented a card that showed one visible picture (a television) and one picture (flowers) that was hidden by a screen. The experimenter asked the child to “point to the television”, and children pointed to the visible picture. The experimenter then asked the child to “point to the flowers”. Children were encouraged to look under the screen to find the flowers, and then to point to the hidden picture. This procedure helped children understand that when the visible picture did not match the experimenter’s request, they should select the hidden picture. Children completed two warm-up questions in this matter.

For the subsequent two warm-up questions, the experimenter requested category matches, instead of specific named objects. For these items, children were shown a card that contained a target picture and two response options: a “visible picture” and a “hidden picture”, as shown in Figure 1. For the first item, the target was an ice-cream cone, the visible picture was a brownie, and the hidden picture was broccoli. The experimenter pointed to the ice-cream cone and said, “I’m looking for one that is the same kind as this one. Where is it? Is it here (pointing to the visible picture)? Or under here (pointing to the screen covering the hidden picture)?” Since an ice-cream cone was not visible, most children initially lifted the screen to see the hidden picture, where they encountered broccoli. Unless children immediately then responded by pointing to the (visible) brownie, the experimenter explained, “See this ice-cream? This is for dessert. I’m looking for another one that is the same kind as this one.” Most children then successfully pointed to the brownie. If not, the experimenter explained further (“Do you see another one that is for dessert?”). Children then completed a second warm-up item (with feedback) following this structure. For the second warm-up, the correct answer was the hidden picture.

Experimental trials—The experimental trials were presented as shown in Figure 1. Unlike in the warm-up trials, the screen covering the hidden picture was underneath the lamination, so that it could not be lifted to identify the hidden picture. Children completed items for three domains: animals, artifacts, and one social category. For each domain, there were six trials, including four experimental trials and two control trials. The items were blocked by domain, the items within each domain were randomized across participants, and the blocks were presented in one of three orders, counter-balanced following a Latin square design.

For the experimental trials involving animals and artifacts, the target picture and the visible picture were from different basic level categories, but from the same superordinate (see Table 1). For the social categories, the four experimental trials presented targets and visible pictures that differed only in one key criterion (e.g., for gender trials, the people differed in gender—one boy and one girl—but were of the same race and age; for race trials, the people differed in race—for all trials, one white child and one black child—but were of the same gender and age). These items provide a test of how strictly children view the relevant category boundaries. For example, if children view it as impossible for a dog and cat to be considered the same kind, but as more possible for a hammer and saw to be considered the same kind, they should select the hidden picture more often for animals than for artifacts.

The control trials included one item per domain for which the visible picture matched the target at the basic level for animals and artifacts and based on both gender and race for social categories (children should select the visible picture on this item). There was also one item per domain in which the visible picture was from a more distant class (e.g., a different superordinate for animals and artifacts, differing based on gender, race, and age for social categories; children should select the hidden picture on this item).

For each trial, the experimenter pointed to the target picture, and said, “I’m looking for one that is the same kind as this one. Where is the one that is the same kind?” If children did not respond right away, the experimenter said, “Is it here? (*pointing to the visible picture*)? Or under here (*pointing to the hidden picture*)?” Responses were coded as “0” for the visible picture and as “1” for the hidden picture. Thus, higher scores indicate increase beliefs in the strictness of category boundaries. The order in which the experimenter pointed to the possible response choices was counter-balanced across participants. For each participant, half of the time, the visible picture was on the left, and half the time it was on the right.

Results and Discussion

Control trials—On the items in which the visible picture was from a more distant class, more children selected the hidden pictures than expected by chance, according to binomial tests (for animals, 86% of children, $p < .001$; artifacts, 82%, $p < .001$, social categories 70%, $p = .007$). On the items where the visible picture was a category match, more children selected the visible picture than expected by chance (animals, 86%, $p < .001$; artifacts, 90%, $p < .001$, social categories, 70%, $p = .007$). These control items confirm that children could make sense of the experimental format, and responded sensibly to items in each domain.

Experimental trials—Because responses were composed of a series of dichotomous choices, data were analyzed via binomial regression models, using the GEE procedure in SPSS 20. These analyses yield Wald χ^2 values as indicators of main effects and interactions. Descriptive statistics are presented as the probability of selecting the hidden picture for each domain, accompanied by Wald 95% confidence intervals (CIs). Whenever these 95% confidence intervals do not include .50 (the probability expected by chance), the obtained probability is different from that expected by chance (referred to as reliably different from chance, below; p values for tests comparing to chance are obtained by examining intercept-only binomial regressions for each probability; these analyses test whether the obtained probability differs from equal probability responding).

First, we compared the probability of selecting the hidden pictures for animals, artifacts, and social categories (initially examining both social categories together, and then subsequently testing for differences across race and gender categories), via a binomial regression model with Domain as a within-subjects factor. Children’s responses indeed varied by Domain, Wald $\chi^2(2) = 33.94$, $p < .001$ (see Figure 2). Children selected the hidden picture more often for animals ($M = .69$, $CI = .59, .78$) than for artifacts ($M = .42$, $CI = .32, .53$), $p < .001$, or

for social categories ($M = .53$, $CI = .41, .64$), $p = .03$. Selections of hidden pictures for artifacts and social categories did not significantly differ (children selected the hidden picture marginally more often for social categories than for artifacts, $p = .07$, following sequential Bonferroni adjustments, used throughout).

Next, to examine possible differences in responses for gender and race, the effect of Domain was tested separately for children who received each type of social category. Responses varied by Domain for children who received both social categories (Gender condition, Wald $\chi^2(2) = 17.70$, $p < .001$; race, Wald $\chi^2(2) = 23.38$, $p < .001$). Yet, the patterns differed across the two conditions. In the Gender condition, children selected the hidden picture as often for the social category items ($M = .69$, $CI = .54, .81$) as for animals ($M = .68$, $CI = .53, .80$), and they did so for each more often than for artifacts ($M = .46$, $CI = .32, .60$), $ps < .01$. In contrast, in the Race condition, children selected the hidden picture for social categories ($M = .35$, $CI = .20, .54$) as often as they did for artifacts ($M = .38$, $CI = .24, .55$), and they did so for each *less* often than for animals ($M = .71$, $CI = .56, .82$), $ps < .01$. Directly comparing the social categories by type (via a binomial regression model predicting responses for social categories, with type of social category as a between-subjects variable) confirmed that children picked the hidden picture more often for gender than for race, Wald $\chi^2(1) = 7.95$, $p < .01$; children who completed items for gender vs. race did not differ from each other in their responses to animals or artifacts ($ps > .30$). These data indicate that preschoolers view the boundaries of animal and human gender categories more strictly than the boundaries of artifact and human race categories. Thus, these data suggest that preschool-age children's concepts include abstract ontological intuitions about the meaning of category boundaries.

Study 1A

The aim of Study 1A was to confirm that children were equivalently familiar with the categories used in Study 1 across domains. This study tests whether preschoolers, when allowed to apply their own criteria, group hammers separately from saws as often as they group dogs separately from cats, for example. Demonstrating that children have equivalent familiarity with the categories of interest across domain rules out an alternate interpretation of Study 1; namely, that children took a more flexible approach to artifact categorization simply because they were less certain of how to categorize them.

Methods

Participants included 25 of the children who participated in Study 1 ($M_{\text{age}} = 4.43$ years, range = 3.40 – 4.98 years; 9 male, 16 female). The trials were presented in a similar manner as Study 1, except that this time, a visible category match was provided instead of the hidden pictures. For animals and artifacts, the new visible pictures were drawn from the same basic level category. In Figure 1, for example, children would now have a choice between the cat (the visible picture used in Study 1, scored as “0”), and a collie dog (a new visible picture, drawn from the same basic level as the target, scored as “1”). For human social categories, the new visible pictures matched for both gender and race. Children completed four items each for animals, artifacts, and one social category (the same social category they were asked about in Study 1), with all procedures for randomization and counter-balancing following those used in Study 1. Descriptive statistics are presented as the probabilities of categorizing based on the expected category (at the basic level for animals and artifacts, and based on gender and race for human social categories).

Results and Discussion

A binomial regression model predicting the probability of categorizing based on the expected criteria revealed a main effect of Domain (Animal, Artifact, Social), Wald $\chi^2=$

9.60, $p = .008$, see Figure 2. Children were less accurate for social categories ($M = .77$, $CI = .67, .85$) than for animal categories ($M = .92$, $CI = .84, .96$), $p = .005$, and marginally less accurate for social categories than for artifacts ($M = .88$, $CI = .74, .95$), $p = .07$. Yet, children categorized based on the expected criteria more often than expected by chance in all three domains, $ps < .001$. Thus, when category matches were available, children categorized using the expected criteria as often for artifacts as for animals. They also did so as often for race ($M = .77$, $CI = .62, .88$) as for gender ($M = .77$, $CI = .62, .87$). Study 1a confirms that the domain differences found in Study 1 do not reflect domain differences in category knowledge or familiarity, but rather reflect systematic differences in beliefs about the strictness of category boundaries.

A possible issue to consider in interpreting the results of Study 1 is whether children selected the hidden pictures more often for animals than artifacts simply because they interpreted the request to find one that is the “same kind” as implying that a basic level match was needed for animals, but that superordinate category matches would suffice for artifacts. They might do so, for example, because of previous experiences with how the phrase “same kind” is used across domains (e.g., perhaps children more often hear talk of “kinds of animals,” with this talk often referring to basic level species categories).

Several features of the present studies and prior work provide evidence against this interpretation. First, Diesendruck and Bloom (2003) found that preschool-age children generally interpret the phrase “same kind” as referring to basic level artifact categories (e.g., artifacts that share function). Thus, it is not the case that the phrase “same kind” only cues basic level categories for animals.

Second, in the present studies, there are two features of the data that are inconsistent with the interpretation raised above. If the phrase “same kind” only cued basic level categories for animals, then we should have found fewer basic level matches for artifacts in Study 1a. Yet, when asked to find artifacts that were the “same kind,” children in Study 1a selected basic level matches 88% of the time, as often as they did for animals. Furthermore, domain differences in how children interpret the phrase “same kind” cannot explain differences in children’s responses to the different types of social categories. Although children categorized by race and gender equally often in Study 1a, children treated gender, but not race, as marking fundamentally distinct kinds of people. Thus, all of this evidence indicates that domain differences in children’s responses to Study 1 do not reflect domain differences in how children interpreted the phrase “same kind.” This point is also further addressed by Study 2, which shows robust differences in responses to animals and artifacts using yet another wording of this prompt.

Study 2

The aim of Study 2 was to extend this investigation to examine children’s intuitions about category boundaries when learning about new kinds. In this study, children were introduced to two novel categories, and were told that they reflected kinds of animals or kinds of artifacts. Then, they completed an assessment similar to that used in Study 1, designed to test how strictly they construed the boundary of the new category. Thus, if children rely on abstract ontological intuitions to make sense of novel categories, they should view the novel animal categories as more strictly defined than the novel artifact categories. In Study 2, identical perceptual stimuli were used across domain (to represent animals or artifacts). Thus, domain differences (if found) cannot reflect either differences in previous experiences (as the categories are novel) or differences in the levels of perceptual coherence (as the perceptual features of the stimuli are held constant). Rather, these differences can be attributed to abstract, domain-specific beliefs about the meaning of category boundaries.

Method

Participants—Because the interest of this work was in the early preschool years; recruitment focused on 3-year-olds. Participants included 28 preschoolers (M age = 3.48 years, Range: 2.82 – 4.17; 14 male, 14 female; 16 Caucasian, 2 African American, 2 Asian American, 1 Hispanic, 6 multi-ethnic, 1 did not report), randomly assigned to an animal condition or artifact condition. An additional four children were tested, but excluded for failing to learn the novel categories (see below). Children were recruited from and tested at the Children’s Museum of Manhattan.

Procedures

Materials and procedures were very similar to Study 1. First, children completed the same four warm-up trials as in Study 1. Then, there was a new phase to the experiment, in which children were introduced to two novel categories. Subsequently, children completed a series of test items following a similar structure as those used in Study 1.

Category Introduction—To introduce the categories, the experimenter presented a card containing one exemplar of each category and said, “These are toys/pets from a place far, far away. They don’t really look like the pets/toys we have around here. But remember even though they look different, they are still pets/toys. This is a wug (point). This is a modie (point)” (see Figure 3). Then, the experimenter brought out another card containing an exemplar from each category, and labeled each. The experimenter then brought out a third card containing one exemplar from each category, and asked the child to “point to the wug” and to “point to the modie” (see Figure 3). This was then repeated for two more exemplars. Children who failed to point correctly on more than half of these comprehension questions ($n = 4$) were excluded from analyses. All of the “modies” presented during category learning were highly similar to each other, as were all of the “wugs” (each new exemplar showed only one individuating feature).

Test Items—Children completed 16 test trials, following the same structure and procedures as for Study 1. For these items, the target was always a “modie”, similar to the exemplar presented during category learning. There were four different types of test items (with four trials of each type), which differed in the type of the visible picture (see Figure 3).

On control items, the visible picture was a modie, which was highly similar to the target. Children should select the visible picture on these trials. On “possible modie” items, the visible picture was similar in shape to the target modie, but with a number of unusual features. If children expect the boundary of the category modie to extend broadly, they should select these visible pictures. On the other hand, if they apply the boundary more conservatively, they should select the hidden picture. On “wug” items, the visible picture was a “wug” (similar to those presented during category learning), and on “possible wug” items, the visible pictures looked similar to the wugs but with unusual features. If children view the boundary between “wugs” and “modies” as reflecting strict, distinct kinds, they should select the hidden pictures on both of these types of items, but if they treat this boundary as flexible, they should select the visible pictures. Thus, if children rely on domain-specific ontological intuitions to make sense of these categories, they should select the hidden pictures more often for animals than for artifacts.

Results and Discussion

Control Items—When a “modie” was the visible picture, children reliably selected the visible pictures; they selected the hidden pictures significantly less often than expected by chance, $p < .001$ ($M = .21$, $CI = .15, .30$). There was no effect of domain, $p > .60$ (see Figure

4). These items confirm that children successfully learned the new categories, and that they did so equally well for animals as for artifacts.

Experimental Items—On the “possible modie” items, overall, children selected the hidden picture less often than expected by chance, $p < .001$ ($M = .29$, $CI = .22, .39$), indicating that they generally viewed the unusual looking “possible modies” as members of the same kind as the more familiar modie. There was also a significant effect of domain, however, Wald $\chi^2(1) = 7.12$, $p = .008$. Children selected the hidden picture for animals ($M = .40$, $CI = .28, .53$) more than for artifacts ($M = .17$, $CI = .09, .30$), suggesting that they applied the category boundary more conservatively for animals than for artifacts.

Preliminary analyses revealed no differences between the “wug” and “possible wug” items, $ps > .50$; overall, children reliably selected the hidden pictures on these items, $p < .001$ ($M = .71$, $CI = .65, .77$), indicating that they generally viewed the wugs (both the familiar wugs, $M = .72$, $CI = .63, .80$, and the unusual looking “possible wugs”, $M = .70$, $CI = .61, .77$) as members of a different kind from the target modie. Responses to the familiar wugs and the possible wugs were combined for further analyses (referred to simply as responses to wugs). There was a significant effect of domain on responses for wugs, Wald $\chi^2(1) = 5.25$, $p = .022$. Children were more likely to select the hidden picture for animals than for artifacts (see Figure 4), suggesting that they viewed the boundary between the new categories as stricter for animals than for artifacts. Overall, Study 2 shows that children rely on abstract, domain-specific theories to make inferences about the meaning of new category boundaries; they expect the boundaries of new animal categories to be narrow and strict, and the boundaries of new artifact categories to be broader and more flexible.

General Discussion

In this work, preschool-age children demonstrated systematic, domain-specific intuitions about the meaning of category boundaries. Study 1 demonstrated that preschoolers view the boundaries of familiar animal and human gender categories as having stricter boundaries than the familiar artifact and race categories (even though they were equivalently familiar with the categories across domain, as shown in Study 1a). Study 2 demonstrated that these beliefs guide how children make sense of new categories. Children expected new animal categories to have narrower and stricter boundaries than new artifact categories, even though the perceptual features of the categories were held constant across domain.

These findings extend prior work in two key ways. First, these studies found evidence of domain-specific ontological beliefs in younger children than have been included in prior work (Rhodes & Gelman, 2009a, 2009b). Second, these studies demonstrated that children draw on these beliefs to make sense of new categories. Thus, these studies show that children’s ontological beliefs do not depend either on the accumulation or reorganization of biological knowledge across the preschool years (Carey, 1995) or on extensive experiences with particular categories. Rather, these beliefs may guide and help children make sense of such experiences.

In Study 2, children rejected the more unusual looking “possible” members of the target category more often for animals than for artifacts, suggesting that they expect the boundary of the new category to be narrower for animals than artifacts. How do these responses reflect ontological intuitions? We propose that these responses reflect ontological intuitions that animal categories are highly coherent (i.e., that the members of species categories are fundamentally similar to each other; Gelman & Coley, 1991), which lead children to expect less variation across members of animal categories. Consistent with this interpretation, prior work indicates that preschool-age children expect novel species categories to reflect

fundamental similarities (Brandone & Gelman, 2009) and often neglect within-category variation for animal categories (Rhodes & Brickman, 2010).

Yet, an alternate account of these data could suggest that this pattern reflects a learned higher-level association between domains and distributions of perceptual features (Kloos & Sloutsky, 2008). In the present Study 2, identical perceptual stimuli were used across domains. Thus, children's increased rejections of the unusual looking "possible member" for animals cannot reflect a purely perception-based judgment that the animal category (as presented) contained less variability than the artifact category. Yet, children could have previously learned association-based expectations about how perceptual properties vary by domains; in particular, that perceptual features are less variable for animals than for artifacts. If so, their judgments could reflect an expectation that animal categories generally contain less perceptual variability (even though the presented animal categories did not)—not ontological expectations that animal categories (more than artifact categories) mark fundamental similarities. The data on children's responses to the "possible category members" alone cannot distinguish between these accounts.

Children were also more likely to reject the members of the *other* category for animals than for artifacts, however. In particular, when asked to find an object of the same kind as a "modie", they rejected the possibility that a "wug" could be the same kind more for animals than artifacts. This pattern reflects a subtly different feature of their beliefs about category boundaries, but one that is more unambiguously "ontological." In particular, this finding indicates that children viewed the boundary between the two novel categories as stricter for animals than for artifacts; or in other words, that they treated the novel animal categories as reflecting fundamentally distinct kinds, but saw the boundary between the novel artifact categories as more flexible (or perhaps, as graded; Rhodes & Gelman, 2009b). Thus, the responses on these items provide clear evidence that abstract ontological intuitions about category boundaries guided how children learned the new categories. Again, because identical perceptual stimuli were used across domains—and thus the degree of perceptual coherence did not differ across domains—purely perceptual processes cannot account for children's responses. Rather, signaling the animal or artifact domain (by referring to the novel categories as "kinds of pets" or "kinds of toys") triggered abstract, domain-specific ontological beliefs.

An important area for future work is to identify how children develop these ontological intuitions by age three. One possibility is that these intuitions are supported by innate cognitive biases that shape the development of children's understanding of the biological world—for example, biases to assume that the biological world is composed of discrete, fundamentally distinct kinds (Atran, 1990). Another possibility, however, is that these abstract beliefs about the nature of category boundaries are either learned through rational learning mechanisms that support the acquisition of abstract, domain-specific knowledge (Dewar & Xu, 2010) or abstracted from learned patterns of associations (Kloos & Sloutsky, 2008). Although the present data do not shed light on the origins of these intuitions, they clearly show that abstract, domain-specific intuitions about the ontological status of category boundaries are in place by age three, with important implications for how children learn categories in various domains.

Examining the origins of children's ontological intuitions is particularly important in light of the differences between children's concepts of race and gender found in Study 1. In Study 1, although children classified people by race and gender equally often (Study 1a), they viewed the boundaries between gender categories as stricter than the boundaries between racial categories. This pattern is similar to Rhodes and Gelman (2009a); in those studies, 5-year-olds treated gender—but not race—as marking objectively accurate ways of categorizing

people. Rhodes and Gelman (2009a) found that children sometimes developed the belief that race marks fundamentally distinct kinds of people in older childhood (between ages 7–10), but that whether they did so varied by cultural context.

Why would the belief that gender marks fundamentally distinct kinds of people develop earlier and with less cultural variation than the belief that race does so? There are two general possible explanations for this pattern. First, because of the significance of gender to the processes involved in shaping evolution, some have argued that concepts of gender are particularly constrained by intuitive cognitive biases (Cosmides, Tooby, & Kurzban, 2003; Kinzler, Shutts, & Correll, 2010). In contrast, because categories based on race did not play a role in shaping human evolution, race categories would not be constrained in this manner and would instead depend more heavily on cultural experience. A second possibility, however, is that the development of this aspect of both gender and race concepts is shaped by forms of cultural input and that children receive this input more consistently and at a younger age for gender than for race. Clarifying the role of children's intuitive biases and cultural input in the development of beliefs about the boundaries of social categories is an important area for future work.

More generally, the present studies pave the way for a more detailed examination of how children's ontological intuitions shape conceptual development in future work. For example, future work could examine how ontological beliefs guide how children seek and interpret new evidence during the course of category learning. These studies add to prior literature documenting that early categories are embedded in abstract conceptual knowledge, rather than grounded in perceptual features (Booth, Waxman, & Huang, 2005; Wellman & Gelman, 1992). Thus, critical questions for future work include examining why children's categorization and induction behavior sometimes appears to be driven by superficial features, given that their concepts include abstract, theoretical beliefs.

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“I’m looking for one that is the same kind as this one!”

Target Picture



“Is it here?”

Visible Picture



“Or under here?”

Hidden Picture



Figure 1.
Sample Experimental Trial, Study 1

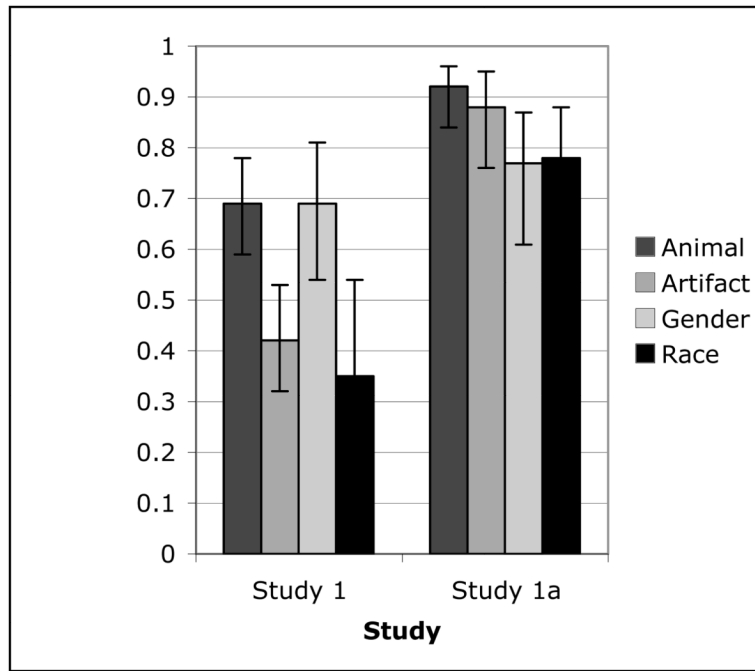


Figure 2. Probabilities with 95% Confidence Intervals of Selecting the Hidden Picture (Study 1) or the Expected Category Match (Study 1a), by Domain
Note. The columns presenting data for animals and artifacts include all of the children (collapsed across whether they completed social category items for gender or race), as these items were identical across the two social category conditions. The columns presenting data for gender and race present children divided by whether they were assigned to the gender or race condition.



Figure 3.
Sample Stimuli, Study 2

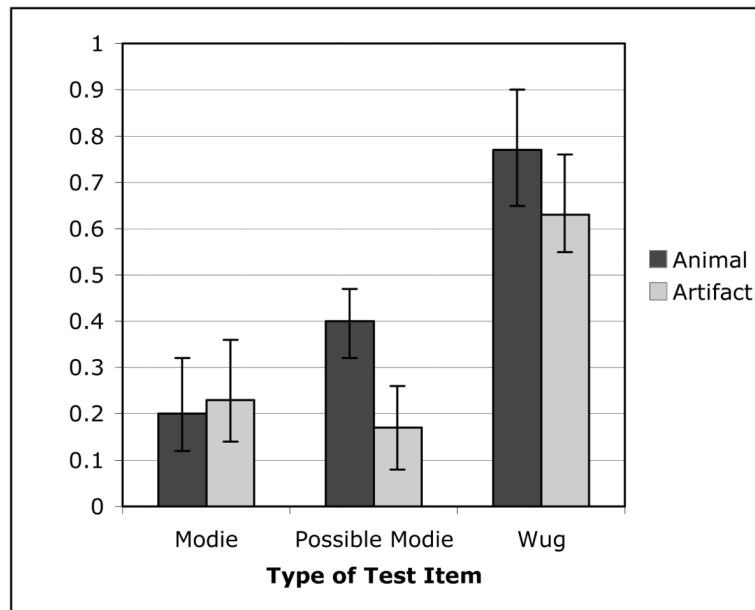


Figure 4. Probabilities with 95% Confidence Intervals of Selecting the Hidden Pictures, by Domain and Type of Test Item, Study 2

Table 1

Summary of Stimuli for Animals and Artifacts, Study 1.

Domain	Target Picture	Visible Picture
Animal	Dog	Cat
	Frog	Turtle
	Horse	Cow
	Goat	Pig
	Monkey ¹	Alligator
	Sparrow ²	Parrot
Artifact	Bus	Train
	Spoon	Fork
	Hammer	Saw
	Dress	Pants
	Rake ¹	Toaster
	Orange scissors ²	Blue scissors

¹Control items presenting objects from more distant classes; children should select the hidden picture

²Control items presenting objects from the same class; children should select the visible picture