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The animate–inanimate distinction in preschool children

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This study examined the development of the animate–inanimate (A–I) distinction in relation to other taxonomic categories in early childhood. Four- and 5-year-old children were administered two tasks measuring knowledge of taxonomic categories at various levels of inclusiveness. Across both matching-to-sample and object sorting tasks, the same pattern of categorization development was observed. Mastery of basic- and superordinate-level categories was demonstrated by 4 years of age. Although 5-year-old children performed above chance on A–I level categories, their abilities were not as mature as those of adults. Results of this study support and extend previous studies investigating the development of children's understanding of naïve biology during the preschool years.

Categorization involves the ability to group objects together on the basis of similarity in kind, or a given attribute. Categories may be organized according to a taxonomic structure, which involves a hierarchical system of rules that govern inclusion, (e.g., a taxonomy of species), or they may be formed on the basis of thematic relation (e.g., all things in the house), or perceptual similarity (e.g., all things of the same shape) (see Markman, 1989 for a review). Taxonomic categories are organized hierarchically by increasing level of abstraction, or inclusiveness. At the most inclusive level, animate–inanimate (A–I) level categories involve the distinction between living and non-living things. The animate category includes humans, plants, and animals, while the inanimate category includes non-living things (or artefacts), such as furniture and vehicles. Superordinate-level categories are narrower and may include a subset of the animate or inanimate category (e.g., people, animals, furniture, or vehicles). Basic-level categories are narrower still and comprise a subset of the superordinate-level category. To illustrate this hierarchical category structure, basic-level exemplars such as birds, fish, or dogs are all subsumed under the *animal* superordinate-level category, which is further subsumed under the *animate* category.

The developmental acquisition of different category levels has been investigated using a number of implicit and explicit measures throughout the infancy and childhood periods. During infancy, a superordinate-to-basic-level shift in category development has reliably been observed across experimental paradigms: Between 2 and 4 months of age with paradigms based on visual fixation (Arterberry & Bornstein, 2002; Quinn & Johnson, 2000), between 6 and 12 months with object examination tasks (Pauen, 2002), and between 18 and 30 months with sequential touching tasks (Bornstein & Arterberry, 2010;

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Mandler, Bauer, & McDonough, 1991). Although few studies have investigated the development of A–I categorization within this developmental timetable, some evidence using the sequential touching procedure suggests that A–I categorization emerges between 14 and 18 months of age (Rostad, Yott, & Poulin-Dubois, 2012), that is, around the same time, superordinate-level categories have also been shown to emerge with this procedure (18 months: Mandler *et al.*, 1991; between 12 and 18 months: Bornstein & Arterberry, 2010).

In childhood, the development of taxonomic categories has been typically measured using object sorting, matching-to-sample, or labelling tasks. The object sorting procedure measures children's grouping of objects into spatially distinct categories (Starkey, 1981). In this procedure, children are given an array of objects and are instructed to group objects that are 'the same kind of thing.' Unlike the implicit categorization procedures used in infancy, when children spontaneously group objects according to taxonomic relatedness, it is thought to reflect a more conceptual understanding that objects placed in the same group share common properties or functions. In contrast to the free-response format used in the object sorting task, the matching-to-sample task is more structured and allows various constraints to be placed on the types of associations that are possible. In the matching-to-sample procedure, one sample image is presented alongside two possible matches, whereby one may share a taxonomic relation, and the other may share a thematic relation with the sample. While the matching-to-sample task has been used to investigate children's preference to form either taxonomic or thematic categories, it has also served to document children's ability to form taxonomic categories by presenting a taxonomic match and an unrelated, rather than thematic, match. By contrasting children's performance on matching-to-sample and object sorting procedures, both the ability to form taxonomic associations (i.e., matching-to-sample), as well as children's relative preference to form taxonomic over thematic associations (i.e., object sorting) can be assessed. In this study, we sought to examine whether children possess knowledge about taxonomic categories at different levels of inclusiveness, and also consider the impact of salient thematic cues in potentially disrupting children's ability to demonstrate their knowledge of taxonomic associations.

In contrast to research examining the development of categorization abilities in infancy, a reverse pattern has been observed in the development of categories in childhood. Specifically, basic-level categories are mastered before broader superordinate-level categories (Mervis & Crisafi, 1982; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Tager-Flusberg, 1985). As early as 2 years of age, children have been shown to match objects belonging to the same basic-level category, more proficiently than objects belonging to the broader superordinate-level category (Daehler, Lonardo, & Bukatko, 1979). Mervis and Crisafi (1982) investigated the acquisition of 2.5-, 4-, and 5.5-year-old children's superordinate, basic, and subordinate level categories using a matching-to-sample task. Using simple geometric stimuli, mastery of basic-level categories was demonstrated as early as 2.5 years, while mastery of superordinate-level categories was acquired by 4 years of age, and mastery of subordinate level categories was acquired by 5.5 years of age. Children's ability to form A–I level categories, however, was not tested in this study. Using natural and artefact categories in the matching-to-sample procedure, Tager-Flusberg (1985) found that 4- and 5-year-olds categorized proficiently across a range of basic-level exemplars, obtaining nearly 100% accuracy. However, children's categorization at the superordinate-level was less accurate (82%) and much more variable across the various superordinate-level exemplars (66% for vegetables; 92% for animals; 95% for vehicles, 68% for furniture). Other evidence for a basic- to superordinate-level shift in children's category development has been reported across a number of studies using the object sorting procedure (Daehler *et al.*, 1979; Rosch *et al.*, 1976; Waxman & Gelman, 1986). In one of such studies, Rosch *et al.* (1976) showed that 3-year-olds' basic-level categorization was superior to their performance at the superordinate level.

Some theorists have suggested that the discrepancy in findings between the infant and early childhood literatures may be explained by differences in the mechanisms children use to form categories. It has been hypothesized that infants' ability to form taxonomic categories relies on the fact that members of the same category have correlated perceptual information (e.g., eyes, limbs, wheels, or wings) (Quinn, 2000; Quinn & Eimas, 1997; Quinn, Eimas, & Rosenkrantz, 1993; Rakison, 2003; Rakison & Butterworth, 1998; Rakison & Poulin-Dubois, 2001), as well as the fact that infants associate other information such as spatial structure and motion path with the *kind of thing* an object or entity is (Mandler, 1991, 1992, 2012). Although perceptual features continue to play a role in older children's categorization, the formation of categories, in particular, at the A–I level, also relies on children's ability to understand abstract biological properties such as independent motion, growth, possession of internal parts, and internal thoughts, which are not readily perceptable (Gelman & Markman, 1986; Massey & Gelman, 1988; Opfer & Gelman, 2011; Rhodes & Gelman, 2009; Rosengren, Gelman, Kalish, & McCormick, 1991). Thus, older children's categories are arguably more conceptually based. The different pattern of acquisition of category levels may also reflect a difference between pre-linguistic categories, and categories children form once language is acquired (Gelman & Koenig, 2003). For instance, studies examining maternal input demonstrate that mothers are more likely to label objects at the basic level (e.g., car), rather than using broader, superordinate level, or narrower, subordinate level, terms (e.g., vehicle or Mustang) (Callanan, 1985; Gelman *et al.*, 1998). Thus, it is not surprising that the basic-level category is both the first to develop and the first to be represented in children's expressive language. In this study, children's verbal abilities were measured to determine whether children's relative mastery of language was correlated with performance on the categorization tasks.

In one of the few studies to compare children's A–I categorization with other levels of category inclusiveness, Sigel (1953) presented 7-, 9-, and 11-year-old children with pre-formed categories (e.g., animals, vehicles, animates, inanimates) and asked children to name the category. Children demonstrated mastery of superordinate-level categories between 7 and 9 years of age. Identification of animate and inanimate categories, however, was unsuccessful at 7 years of age (0%), but improved by 9 years of age, wherein 40% of children identified the category 'living things', while only 15% identified the category 'non-living things'. Interestingly, no additional improvement in the identification of animate and inanimate categories was reported by 11 years of age. These results suggest that the animate and inanimate categories are the last to emerge in childhood and are not completely mastered by 11 years of age. Notably, children's ability to *form* animate and inanimate categories was not directly tested in this study. Instead, children were tested on their *identification* of A–I concepts using a task that heavily relied on children's verbal abstraction ability. Thus, the use of less verbally demanding tasks may provide a better measure of the development of animate and inanimate categories.

Other studies investigating how preschoolers reason about ontological kinds have asked children to generate questions about different A–I classes or determine whether various properties should be extended to animates or inanimates (i.e., an inferential categorization task). Margett and Witherington (2011) found that 4-year-old children asked more biological questions about plants and animals, compared with immobile artefacts. However, for the class of mobile artefacts, fewer functional questions and more biological questions were asked, suggesting that 4-year-olds overgeneralize the ability to move to be consistent with the category of living things. When asked to classify each exemplar as living or non-living, 4-year-olds classified animals and immobile artefacts correctly. However, when the non-living class engaged in movement (e.g., mobile artefacts such as vehicles), or the living class lacked observable movement (e.g., plants), 4-year-olds were less accurate in their A–I classifications. These results suggest that children's early concepts of living and non-living are biased by the ability to move, or lack thereof. In another study examining preschoolers' understanding of naïve biology, Massey and Gelman (1988) showed that 3-year-olds extended the biological property of self-propulsion to animates and not animal-like statues or wheeled vehicles on 78% of trials, while 4-year-olds responded correctly on 90% of trials. When asked explicitly whether each item was alive, 3-year-olds responded correctly on 61% of trials, while 4-year-olds were more accurate and responded correctly on 85% of trials. Children's spontaneous verbal responses justifying their categorical inferences were also coded. Animate–inanimate category membership comprised 25% of children's responses (e.g., animal, toy), while explanations relating to enabling parts (15%), general appearance (15%), agency (10%), real versus pretend (8%), capacity for independent motion (8%), and material composition (5%) comprised the other categories of responses children provided.

In a series of experiments comparing how children reason about biology and psychology, Jipson and Gelman (2007) tested whether children extend a number of other properties to animate and inanimate categories. Specifically, they tested whether 3-, 4-, and 5-year-olds extend biological properties (e.g., eat, grow), psychological properties (e.g., think, feel), perceptual properties (e.g., see things, feel ticklish), and artefact properties (e.g., man-made, breakable) to various animate and inanimate objects. By 5 years of age, children were found to extend biological and perceptual properties to animates, but not inanimates. Other research testing the depth of children's understanding of biological properties has explored the nature of internal parts (Gottfried & Gelman, 2005), ability to self-start (Rhodes & Gelman, 2009), and the capacity for growth (Inagaki & Hatano, 1996). Between 3 and 4 years of age children have been shown to develop knowledge of the internal parts of animates and inanimates (Gottfried & Gelman, 2005). However, by 4 years of age, children were not able to make the link between internal parts and external events such as movement, or growth. By 5 years of age, children have been shown to understand that animals, but not artefacts, are able to self-start, or move on their own (Rhodes & Gelman, 2009). Five-year-olds also have been shown to differentiate natural kinds from non-living things based on a capacity for growth and have an emerging understanding that natural kinds are also characterized by the need to take in food and water, as well as the possibility of falling ill (Inagaki & Hatano, 1996). Between 5 and 6 years of age, children have also been shown to attribute properties such as the ability to grow or die to animals and plants, but not artefacts. Thus, while it is apparent that children 4–6 years of age possess knowledge of animate and inanimate kinds, this research has focused primarily on how children generalize specific properties (e.g., kind of movement) to animates or inanimates, and has not addressed whether children spontaneously group objects according to A–I taxonomy.

While the body of research using inductive reasoning paradigms has shown that preschool children possess knowledge about various properties, which are consistent with different ontological kinds, children's ability to *form* animate and inanimate taxonomic categories has not been thoroughly investigated. That is, while previous studies have shown that children treat animates and inanimates differently when extending various properties to each, few studies have examined how children perform when asked to form, and verbally explain, animate and inanimate taxonomic categories. In this study, we ask children to group objects taxonomically, but do not provide inductive cues concerning which properties (e.g., biological, psychological, featural) children should attend to when making category decisions. Children's ability to form A–I taxonomic categories was tested using both 2-dimensional and 3-dimensional stimuli, and provided both implicit and explicit measures of children's category knowledge. Children's acquisition of taxonomic categories was measured implicitly using the matching-to-sample task. An object sorting task was also used to examine whether children prefer to conceive of category relations in a taxonomic, as opposed to thematic, manner. Specifically, the extent to which children's A–I level categorization is influenced by the presence of thematically related stimuli could help to explain why it has been difficult to document the early development of A–I categories in younger children. During the object sorting procedure, children were also explicitly asked to explain why they believe objects in each grouping were the same kind of thing. Thus, the aims of the present research were to (1) provide an implicit test of children's ability to form A–I taxonomic categories using matching-to-sample and object sorting tasks; (2) explore how children verbally reason about their categorization choices, specifically which properties they use to justify their decisions; and (3) examine the impact of different task demands on children's performance across categorization tasks.

Method

Participants

Two groups of 4- and 5-year-old children participated ($N = 46$). An additional group of 21 adults also participated to provide a validation of the matching-to-sample task. Of the 46 children tested, 3 were excluded due to language delay ($n = 1$) or neurodevelopmental disorder ($n = 2$). The 4-year-olds had a mean age of 4.65 years ($n = 20$; 12 males; $SD = 0.51$ years), while the 5-year-olds had a mean age of 5.87 years ($n = 23$; 12 males; $SD = 0.33$ years). One 5-year-old did not complete the matching-to-sample task due to technical difficulties, but was included on the object sorting task. All children were English-speaking and had normal or corrected to normal vision. General cognitive ability was assessed using the Differential Abilities Scale, Second Edition (DAS-II; Elliott, 2007). The verbal comprehension index provided an estimate of children's verbal mental age, which will henceforth be referred to as the child's verbal ability. Thirty-three of the 43 children included in the analyses completed the test.

Materials and procedure

Children completed the tasks in a fixed order, wherein the matching-to-sample task was administered first, the object sorting task second, and the test of cognitive ability administered last. Such an ordering of tasks was desirable to obtain reaction times (RTs) on the matching-to-sample task that were not influenced by fatigue or practice. Parents either sat behind the child as they completed the tasks, or in an adjacent room.

Matching-to-sample categorization task

The matching-to-sample task was administered using a 30-inch touch-screen computer. Each trial involved presenting children with three detailed colour drawings. To ensure that children's accuracy was not influenced by the presence of atypical members of a category, stimuli were selected based on typicality ratings described in previous research (Rosch & Mervis, 1975; Uyeda & Mandler, 1980; Van Overschelde, Rawson, & Dunlosky, 2004). That is, the most common instances of vehicles, furniture, and animals were selected as stimuli. The majority of images used were gathered from children's picture dictionaries. Exceptionally, photographs of adults in an up-right position were used as stimuli. Careful attention was paid in pairing each sample image with two response options that could not be matched based on size, directional orientation, colour, or thematic association.

The matching-to-sample task is a forced-choice test of categorical associations wherein a sample category exemplar is presented, and the participant must decide which of two options is the *same kind of thing*. Each trial began with one centrally located sample picture and two comparison pictures, which were located below, inside a rectangular box. Children completed 5 training trials to become familiar with the task, followed by 24 test trials. Test trials presented three different levels of categorization (each with 8 trials): animate-inanimate, superordinate, and basic level.

The training phase consisted of five subordinate level trials (e.g., breeds of dogs, types of chairs). Children were instructed to 'touch the picture here [pointing to both response options] that is the *same kind of thing* as this [pointing to the sample picture above].' If no response was made after 5 s, the experimenter prompted the child by asking, 'is a [name picture 1] or a [name picture 2] the same kind of thing as this [pointing to the sample picture]?' Feedback about the accuracy of the responses was provided on training trials only, whereby a green 'check mark' appeared over correct responses and a red 'X' appeared over incorrect responses. If a child responded incorrectly on training trials, the experimenter explained which picture was the correct response. Before the test trials began, children were told that 'the computer would not help them find the right picture, but to keep finding the picture they thought was *the same kind of thing.'*

Children were not given feedback on test trials but were simply encouraged to keep going. The presentation of test trials was fixed and pseudo-randomized so that trials of the same categorization level never occurred on more than two consecutive trials. For each categorization level, half of the trials showed an animate exemplar as the sample and half of the trials had an inanimate exemplar. To ensure that children did not develop a response bias, placement of the correct response option was pseudo-randomized so that the correct response never occurred on the same side for more than two consecutive trials; across trials, the correct response occurred equally often on the left and right side.

On A–I trials, sample images such as cow, chicken, airplane, or couch were presented with comparison images of animates (e.g., people) and inanimates (e.g., car, table, chair, truck, train). On superordinate-level trials, images of animals (e.g., bear, horse, donkey, pig), vehicles (e.g., jeep, bus, motorcycle, boat), and furniture (e.g., bed, desk, book case, chair) were presented as samples; one within-category image and one out-of -category image were used as comparison pictures. Basic-level trials presented different images of types of birds (e.g., cardinal, hawk), dogs (German Shepard, Golden Retriever), fish (goldfish, bass), chairs (rocking chair, living room chair), tables (night stand, coffee table), cars (sports car, sedan), and trucks (dump truck, pick-up truck). On basic-level trials, all three images belonged to the same superordinate class.

Coding

Presentation of trials and recording of responses was programmed using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) so that both accuracy and RT were recorded. Children received a score (proportion correct out of 8 trials) for each categorization level.

Content validation

How well each trial measures taxonomic associations at each category level was assessed by administering the procedure to a group of adults (n = 21). The percentage of adults who responded correctly was 85% or above on all but one trial, wherein only 10% of adults responded correctly. Thus, this trial was removed from the analyses.

Object sorting categorization task

The object sorting task was adapted from Markman, Cox, and Machida (1981). Children were provided with spatial cues using two transparent plastic bowls into which eight novel objects were sorted. Whereas other versions of this task (Vygotsky, 1962) measured children's category knowledge by analysing spatial grouping of objects on a table (e.g., distance of objects). Similar to the matching-to-sample task, typical exemplars of each category were selected. Figurines of people included children and adults of different ethnicities wearing different coloured clothing. Animal replicas included a horse, dog, cow, elephant, bird, and fish. Furniture replicas included a bed, desk, table, cabinet, chair, ottoman, and couch. Vehicle replicas included a car, pick-up truck, motorcycle, bus, helicopter, and train.

Children first participated in a brief training phase to become familiar with the task. During this phase, the experimenter demonstrated how to complete the task using simple objects. The experimenter began the demonstration by drawing the child's attention to two anchor objects, each placed in transparent bowls (e.g., ice-cream and grapes). The experimenter then demonstrated using a third object, while saying, 'if I gave you this one [ice-cream], you would put it here [with ice-cream anchor] because it is the same kind of thing.' Following the demonstration, children were given the remaining objects to categorize. Corrective feedback was provided if children made sorting errors. Following each training trial, the experimenter drew the child's attention to the toys placed in each bowl, 'we put all the [ice-cream] in this bowl because they are the same kind of thing, and we put all the [grapes] in this bowl because they are the same kind of thing.'

Two test trials were administered for each of the three categorization levels (animate-inanimate, superordinate, basic). A total of six test trials were administered, with the presentation order of each level counterbalanced. On test trials, children's attention was directed towards the placement of the anchor objects and children were subsequently handed objects to categorize, one by one. Children were instructed to place each object in the bowl with '*the same kind of thing*'. Each trial consisted of six objects to be sorted, three objects from each category. Following each sorting trial, children's attention was drawn to each bowl and children were asked, 'What makes these *the same kind of thing.'*

At the A–I level, four possible trial pairings (labelled according to the object anchors) were person–vehicle, person–furniture, animal–vehicle, and animal–furniture. Each child completed one trial with a person as the anchor and one trial with an animal as the anchor (paired with either a vehicle or furniture as the other anchor). At the A–I level, an additional superordinate-level object (matching the animate anchor) was included, but not scored, to ensure the A–I category contained at least two people and three animals, or vice versa. At the superordinate level, all children completed a vehicle–furniture trial, as well as either an animal–vehicle or an animal–furniture trial. At the basic level, all children completed one basic-level animate trial (dog–bird or cat–fish) and one basic-level inanimate trial (chair–table or car–plane).

Coding

The object sorting task was coded for two types of analysis, based on: accuracy of taxonomic sorting and verbal explanation why each group of toys was 'the same kind of thing.' The coding scheme for taxonomic accuracy was developed based on previous object classification studies (Sugarman, 1983). A total score of 2 was given if the child sorted both categories taxonomically without errors. A score of 1 was given if the child made one sorting error (one incorrect category), but sorted the other five objects correctly. A zero score was given if the child made two or more sorting errors. Notably, children who sorted objects according to a thematic, rather than taxonomic, association received a score of 0, having made more than two taxonomic errors. These children, however, are differentiated from children whose sorting did not demonstrate any clear strategy by analysing children's verbal responses about why the objects they grouped, belong together. Each category level was tested with two trials (possible score of 2); therefore, children's performance at each level was computed as a score out of 4.

Children's verbal responses were coded based on a scoring system described in previous research (Kagan, Moss, & Sigel, 1963; Sigel, Anderson, & Shapiro, 1966). Children's explanation of the relationship among objects was coded as *taxonomic, thematic, perceptual,* or *no response.* A *taxonomic* response was any reference to the kind of things the objects are (e.g., living things, animals, vehicles, dogs). A *thematic* response was any response that employed thematic associations to describe the objects' relationship (e.g., people and their pets [describing the relationship between people and animals], things people use [describing the relationship between furniture and vehicles],

Table 1. Coding scheme for verbal responses on the object sorting task

Taxonomic response	Thematic response	Perceptual response
Animate-Inanimate Level		
Living, non-living	People and their things/cars	With eyes, no eyes; with face, no face
Alive, not alive	They [people] take care of these [animals], in the house, not in the house	Moves, move by itself, walks, needs someone to push it, these stay
Superordinate Level		
Animals	At the zoo (animals)	Has feet (animals)
Furniture	For the house, dolly stuff (furniture)	Comfy, flat (furniture)
Vehicles, cars	Drive them, travel (vehicles)	Drive, have seats, has wheels, no wheels, go fast (vehicles)
Basic Level		
Dogs, cats, birds	Live on land, live in the sea, water	Crawl, has feet (cat), has fins (fish), has wings, beak (birds)
Chairs, tables	In the house, not inside	Sit on (chairs), put things on (tables)
Cars, planes	On the road, in the air	Have wings, flying things (planes), cannot fly (cars)

things in the house). A *perceptual* response was coded as any response that focused on common observable features of the objects (e.g., all have eyes, tails, legs, wheels, move on their own). Finally, *no response* was recorded for children who did not provide a verbal explanation for why they thought each group of objects were alike. Children's verbal responses on all six trials were coded. If children described the relation among objects within the same category level in more than one way, both responses were recorded. See Table 1 for examples of how children's responses were coded. A second experimenter coded 26.6% of the sample, and inter-rater reliability was calculated as $\kappa = .97$ (with 99% agreement) for children's sorting accuracy score. Inter-rater agreement for the classification of children's verbal responses for each category was calculated as $\kappa = .92$ (with 93% agreement).

Results

Matching-to-sample task

On the matching-to-sample task, a 3 (Age) $\times$ 3 (Level) ANOVA revealed a significant main effect for Age, $F(2, 60) = 37.67$, $p < .01$, $\eta^2 = .56$, a main effect for Level, $F(2, 120) = 20.92$, $p < .01$, $\eta^2 = .26$, and a significant Age $\times$ Level interaction, $F(4, 120) = 5.54$, $p < .01$, $\eta^2 = .16$. Pairwise comparisons were adjusted with Bonferroni correction for multiple comparisons. Comparisons for the effect of Level revealed that performance followed the same pattern, whereby basic-level performance ($M = 0.87$) was similar to superordinate-level performance ($M = 0.89$), which were both superior to A–I performance ($M = 0.74$). The main effect of Age showed significant improvement in categorization between 4 ($M = 0.73$) and 5 ($M = 0.80$) years of age, *M difference* = 0.07, $p = .04$, as well as significant improvement in categorization between 5 years of age ($M = 0.80$) and adulthood ($M = 0.97$), *M difference* = 0.17, $p < .01$. Pairwise comparisons for the Age $\times$ Level interaction are summarized in Figure 1. At the basic level, improvement in performance between 4 and 5 years of age was observed, *M difference* = 0.11, $p = .01$, while no additional improvements were found between 5 years and adulthood ($p = .17$). Thus, by 5 years of age, basic-level categorization was found to be mastered. At the superordinate level, a trend for improvement in performance between 4 and 5 years of age was found, *M difference* = 0.08, $p = .08$, and significant improvement in performance between 5 years of age and adulthood was also found, *M difference* = 0.10, $p = .02$. Thus, although superordinate-level categorization by 5 years of age is adequately mastered (>85% correct), these abilities continue to develop into adulthood. At the animate–inanimate level, performance between 4 and 5 years of age showed little improvement ($M = 0.61$ to $M = 0.64$, $p = 1.0$); however, significant improvements in A–I categorization abilities were demonstrated between 5 years ($M = 0.64$) of age and adulthood ($M = 0.97$), $p < .01$.

Further analyses were conducted to determine whether children and adults' categorization abilities differed significantly from chance (chance = .5). At the basic and superordinate levels, both 4- and 5-year-old children categorized significantly above chance ($p < .01$). While 4-year-olds' A–I level categorization was above chance at the trend level, ($M = 0.61$, $SD = 0.26$), $t(19) = 1.89$, $p = .08$, 5-year-olds' A–I categorization was significantly greater than chance ($M = 0.64$, $SD = 0.21$), $t(21) = 3.14$, $p < .01$. As expected, in adulthood, A–I categorization performance was also significantly greater than chance ($M = 0.97$, $SD = 0.08$), $t(20) = 27.16$, $p < .01$.

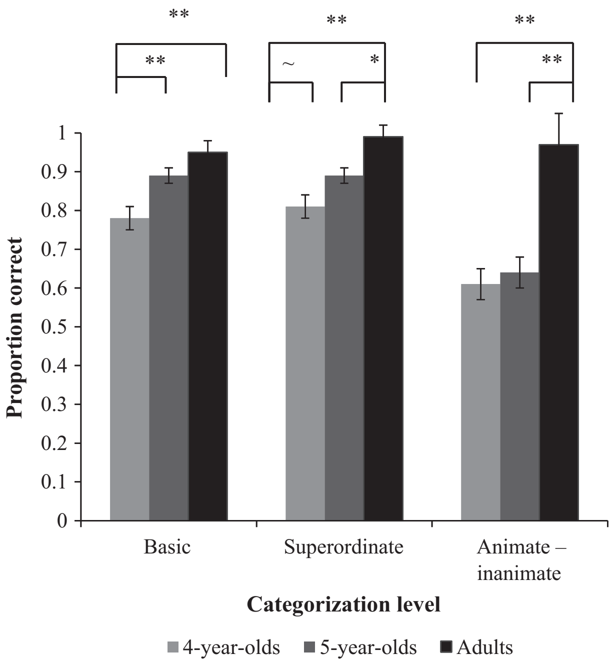

Figure 1. Proportion of correct responses as a function of taxonomic level for the matching-to-sample task. *Note*. ~ Indicates $p < .10$; $*p < 0.05$; $**p < 0.01$.

A second 3 (Age) × 3 (Level) mixed-model ANOVA examining RT on correct trials revealed a significant main effect for Level, $F(2, 98) = 15.89$, $p < .01$, $\eta^2 = .25$, a main effect for Age, $F(2, 49) = 16.18$, $p < .01$, $\eta^2 = .40$, and a significant Age × Level interaction, $F(4, 98) = 2.66$, $p = .04$, $\eta^2 = .10$. Pairwise comparisons with Bonferroni correction for the effect of Level revealed that children's performance followed the same pattern as their response accuracy. That is, RT for basic-level responses (3.22 s) was equivalent to superordinate-level responses (3.47 s), $p = 1.0$, which were both faster than the A–I level responses (5.14 s), $p < .01$. Pairwise comparisons for the effect of Age revealed similar RTs in 4- and 5-year-old children (M of 4-year-olds = 5.14 s, M of 5-year-olds = 4.39 s, $p = .58$), but significantly faster RTs in adulthood ($M = 2.31$ s), $p < .01$. Pairwise comparisons for the Age × Level interaction are shown in Figure 2.

To examine developmental changes in the acquisition of category levels between 4 and 5 years of age, children's performance and RT for each level were correlated with age (adults were not included in these analyses). At basic and superordinate levels, categorization performance was positively correlated with age, (basic level: $r(42) = .47$, $p > .01$, superordinate level: $r(42) = .31$, $p < .01$) and negatively correlated with RT (basic-level RT: $r(42) = -.43$, $p < .01$, superordinate-level RT: $r(42) = -.39$, $p < .01$). However, at the A–I level, no relationship between age and accuracy, $r(42) = .12$, $p = .44$, or RT, $r(42) = -.05$, $p = .78$, was observed. In order to determine whether children's verbal abilities were related to performance on the matching-to-sample task, a correlational analysis was conducted. Performance across all levels of the matching-to-sample task was not found to relate to children's verbal abilities, $r(31) = .12$, $p = .52$, nor was RT across categorization levels, $r(31) = -.09$, $p = .62$.

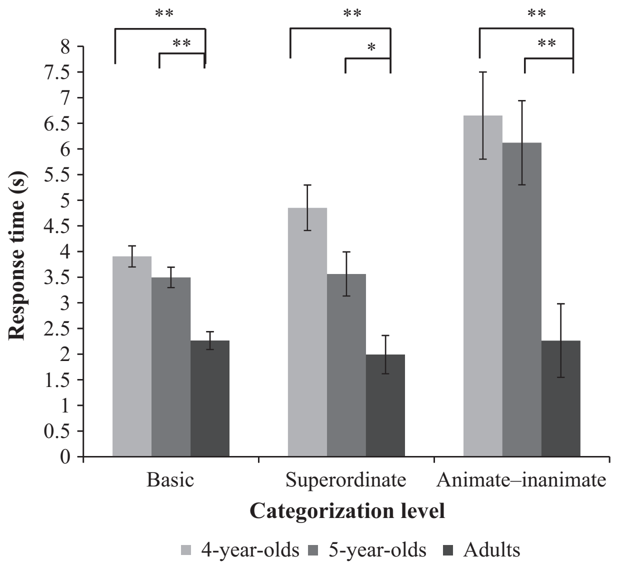

Figure 2. Mean reaction time (in seconds) as a function of taxonomic level for the matching-to-sample task. *Note.* ~ Indicates $p < .10$; $*p < 0.05$; $**p < 0.01$.

Object sorting task

To examine children's taxonomic accuracy on the object sorting task a 2 (Age) × 3 (Level) ANOVA was conducted. A significant main effect for Level $F(2, 86) = 67.68$, $p < .01$, $\eta^2 = .62$, but no significant main effect for Age, $F(1, 41) = 2.05$, $p = .16$, $\eta^2 = .05$, or Age × Level interaction, $F(2, 82) = .29$, $p = .75$, $\eta^2 = .01$, was found. Pairwise comparisons for the effect of Level revealed that children's performance followed the same pattern as the matching-to-sample categorization task, wherein basic (3.67) and superordinate (3.95) level categorization abilities were equal, yet superior to A–I (1.53) level abilities. Pairwise comparisons for categorization performance as a function of level and age are shown in Figure 3.

To examine developmental changes in performance, age was correlated with performance on the A–I categorization only, as performance on the basic and superordinate-level trials was at ceiling. The relation between age and A–I object sorting score was not statistically significant, $r(44) = .23$, $p = .14$. Correlational analyses were conducted to determine whether children's verbal abilities were related to performance on the object sorting task. Performance across all levels of the object sorting task tended to relate to children's verbal abilities, $r(32) = .30$, $p = .09$.

How children reasoned about each category was investigated using the content of children's verbal explanations (e.g., taxonomic, thematic, perceptual) across categorization levels. As children were able to provide more than one verbal response on each trial, the total number of responses for each level was used. The null hypothesis that the total number of verbal responses for each category level would be equally distributed among the different types of explanations was tested using a series of binomial chi-square tests. For each categorization level, chance responding was calculated as 33.3% of responses, as there were three possible response options. As the same pattern of verbal responses was observed in both 4- and 5-year-old children, the reported analyses were

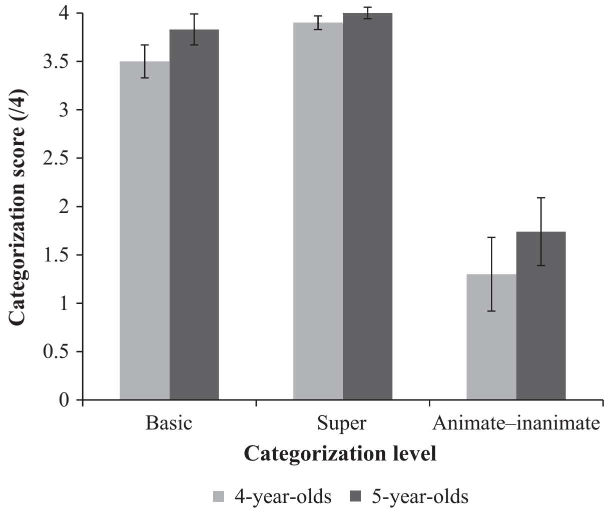

Figure 3. Mean scores as a function of taxonomic level for the object sorting task. *Note*. ~ Indicates $p < .10$; $^*p < 0.05$; $^{**}p < 0.01$.

collapsed across age. Figure 4 shows the percentage of each response type for each category level.

A total of 47 responses were provided at the A–I level. Although it was expected that children would be more likely to provide taxonomic responses as rationale for their categorization choices, children were not more likely to describe the A–I relationship taxonomically (17% of responses), $\chi^2(2, n = 43) = 3.75$, $p > .10$. In fact, 45% of the responses children provided as rationale for their categories were based on thematic associations, while 38% of responses were based on perceptual associations. It is

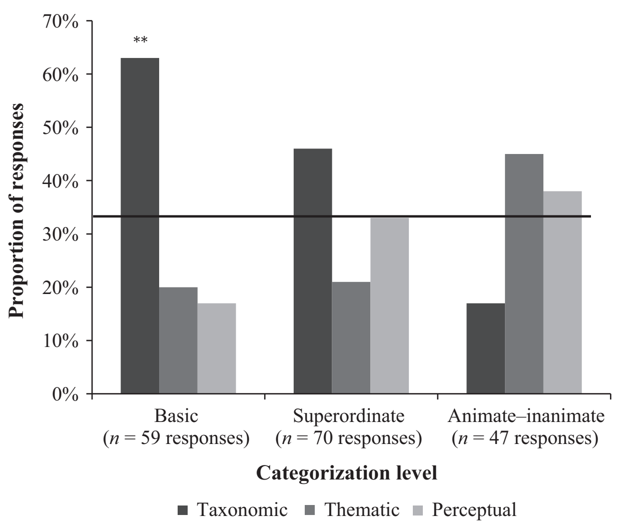

Figure 4. Percentage of verbal explanations at each category level. Solid line denotes chance responding (33%). *Note*. ~ Indicates $p < .10$; $^*p < 0.05$; $^{**}p < 0.01$.

important to consider these results when interpreting children's relatively low A–I taxonomic categorization accuracy scores, as these data suggest that some children were indeed using a thematic categorization strategy when sorting animate and inanimate objects. At the superordinate level, children successfully formed categories of animals, vehicles, and furniture; however, their preference for providing taxonomic explanations (46% of responses) did not reach statistical significance, $\chi^2(2,\ n = 43) = 3.22$, $.10 < p < .20$. At the superordinate level, thematic responses were provided 21% of the time (not significantly different from chance), while perceptual responses occurred the remaining 33% of the time. At the basic level, however, children were significantly more likely to describe the relationship as taxonomic (63% of responses), $\chi^2(2,\ n = 43) = 15.29$, $p < 0.01$. Thematic responses were provided 20% of the time, while perceptual responses were provided the remaining 17% of the time.

Additional analyses were conducted to determine whether children's verbal abilities were related to the number of verbal responses children provided. At the A–I level, verbal abilities were correlated with the number of verbal responses children provided, $r(33) = .41$, $p < .01$; However, at the superordinate, $r(33) = -.06$, $p = .73$, and basic levels, $r(33) = -.05$, $p = .79$, verbal abilities were not related, presumably due to the fact that both 4- and 5-year-old children mastered object sorting at the basic and superordinate levels.

Intertask correlations

Intertask correlations between the matching-to-sample (accuracy and RT) and object sorting (accuracy) tasks were examined for the A–I category level only, as children performed at ceiling on both the basic and superordinate-level trials of the object sorting task. Among 4-year-olds neither accuracy, nor RT on the matching-to-sample task were found to correlate with accuracy on the object sorting task, $r(18) = -.15$, $p = .55$, $r(18) = -.19$, $p = .47$, respectively. Similarly, among 5-year-olds, the relation between A–I categorization accuracy and object sorting performance was not statistically significant, $r(21) = .31$, $p = .16$, nor was the relationship with RT, $r(21) = .17$, $p = .52$. Whether or not a child adopted a taxonomic or thematic object sorting strategy was analysed to determine whether adopting either sorting strategy would generate corresponding differences in performance on the A–I taxonomic categorization trials of the matching-to-sample task. Across 4- and 5-year-old age groups, preference for adopting either a taxonomic ($n = 21$) or thematic ($n = 22$) sorting strategy was not found to relate to performance on A–I trials of the matching-to-sample task, (taxonomic sorting preference $M = 0.63$; thematic sorting preference $M = 0.65$), $t(41) = .28$, $p = .78$. This suggests that children who adopted a thematic sorting strategy on the object sorting task simply preferred thematic associations (as in pretend play), despite possessing the relevant taxonomic knowledge of A–I categories, as demonstrated by their performance on the matching-to-sample task.

Discussion

The primary goal of the current research was to investigate the development of children's taxonomic categorization abilities, particularly at the A–I level. While most previous research investigating the A–I distinction in childhood has employed inductive inference procedures (e.g., whether animates or inanimates possess various biological properties), the current study tested children's ability to make spontaneous categorical judgments about which objects are *the same kind of thing.* That is, unlike the inductive inference procedure, children were not told which properties to attend to when making decisions about category membership. Converging evidence from the matching-to-sample and object sorting categorization tasks revealed a similar sequence of development in category levels, although individual children did not perform similarly on both tasks. The results of this experiment provide support for the hypothesis that children's categories are acquired in a sequence from least to most inclusive (e.g., from basic to superordinate to A–I level).

Consistent with previous research using the matching-to-sample task (Mervis & Crisafi, 1982; Tager-Flusberg, 1985), basic- and superordinate-level categories were found to be mastered by 4 years of age. The present study attempted to replicate and extend this research by testing children's matching-to-sample performance at these levels, as well as at the A–I level (e.g., categorizing people with animals, and furniture with vehicles). At the A–I level, 5-year-olds' performance was above chance, but not as well developed as adults. Our results are consistent with the body of literature, showing that children as young as 5 years of age possess an emerging conceptual understanding of ontological kinds (Erickson, Keil, & Lockhart, 2010; Gottfried & Gelman, 2005; Jipson & Gelman, 2007; Margett & Witherington, 2011; Rhodes & Gelman, 2010).

The results of the object sorting task also suggest that by 4 years of age, children reliably create basic- and superordinate-level taxonomic associations. However, at the A–I level, children demonstrated fewer A–I taxonomic associations in comparison with less inclusive category levels. Verbal explanations for the associations children created among objects in each category were found to vary as a function of category level. Specifically, while taxonomic responses were most frequently provided on basic- (e.g., dogs, airplanes) and superordinate-level (e.g., animals, vehicles) trials, thematic explanations were most frequently provided on A–I level (e.g., people in their cars) trials. That children did not prefer taxonomic explanations for the A–I level is consistent with the results of Massey and Gelman's (1988) study where children's spontaneous verbal explanations for their decisions about which kinds of things could travel up a hill independently were analysed. Although Massey and Gelman (1988) concluded that taxonomic category membership was most frequently described (25%), their enabling parts (15%) and appearance (15%) categories would both be considered perceptual explanations using our coding scheme and therefore would comprise the majority (30%) of responses. Thus, a similar proportion of taxonomic (17% current study) and perceptual (38% current study) explanations were provided across both studies. Interestingly, this same pattern of verbal responses was also found when examining only those children who sorted objects taxonomically. That is, children who correctly sorted A–I objects according to taxonomy still provided thematic (40%) and perceptual (44%) descriptions, rather than taxonomic (16%) descriptions. This suggests that 4- and 5-year-old children who are able to create A–I categories are still developing their ability to verbally reason about these relations.

Results of the current study extend those of Margett and Witherington (2011) who found that 4-year-olds had an emerging, yet incomplete, understanding of living and non-living things, which was based on whether or not an object was able to move. In the present study, all animate and inanimate stimuli were presented as unable to move (e.g., as static images). Notwithstanding, 5-year-olds were still able to categorize at the animate-inanimate level above chance on the matching-to-sample task. This suggest that by 5 years of age, children have developed a more nuanced understanding of the A–I distinction, whereby humans and animals were still considered animate despite being presented as static images, and vehicles were still categorized as inanimate despite previous experiences where these objects were capable of movement. That 5-year-olds in the current study were found to perform above chance, but not as proficiently as adults, is also consistent with the results of Erickson *et al.* (2010) who demonstrated a similar emerging knowledge of biological and psychological causation.

The hypothesis that children's categorization ability may be related to the development of their verbal abilities was investigated using correlational analyses. These analyses showed that verbal ability was not related to performance accuracy or RT on the matching-to-sample task, but tended to correlate with accuracy scores on the object sorting task and was significantly related to the number of verbal responses children provided. Overall, the correlational analyses suggest that verbal abilities were not strongly related to performance on non-verbal aspects of the categorization tasks; however, when verbal explanations were required, children with a larger vocabulary were shown to provide more verbal responses.

Interestingly, children's A–I categorization performance was not correlated among the matching-to-sample and object sorting tasks. These results, however, are not surprising due to the fact that the two tasks differed in a number of important ways. In the matching-to-sample task, object anchors remained present on the screen throughout the trial and thus were more noticeable in children's decision making. In contrast, in the object sorting task, the distinctiveness of category anchors diminished as more objects are added to each bowl. That is, if children made categorization errors early on in the procedure (e.g., after sorting two of six total objects), the cohesiveness of the category decreased, making it more likely that additional errors would be made. The two tasks differed, more importantly, in terms of whether or not children were able to create both taxonomic and thematic object associations. In the matching-to-sample procedure, image triads were selected to prevent children from making thematic associations (e.g., matching a person with furniture or vehicles), therefore, providing a 'cleaner' test of children's A–I understanding. As we were also interested in whether the saliency of thematically relevant associations would influence children's ability to demonstrate taxonomic object associations, children were given the opportunity to sort objects according to thematic associations on the object sorting task.

The comparison of results across categorization tasks is relevant to the broader theoretical debate concerning the flexibility and nature of children's categorization development (Blaye & Bonthoux, 2001; Denney & Ziobrowski, 1972; Waxman & Namy, 1997). Specifically, the matching-to-sample task provided a 'pure' assessment of the development of children's taxonomic categories, while the object sorting task allowed children to flexibly group objects according to either taxonomic or thematic associations. Given the differences in task demands, it is important to consider the question of whether it is children's abilities, or merely their preference, which is being reflected by their performance. Our results indicated that 5-year-olds were able to categorize at the A–I level on the matching-to-sample task, but did not form taxonomic categories as readily on the object sorting task. This suggests that 5-year-olds indeed possess the A–I distinction; however, their taxonomic knowledge could be masked when given the opportunity to form thematic associations. The fact that children who sorted thematically on A–I trials of the object sorting task were also able to categorize taxonomically on the matching-to-sample task suggests that the object sorting task provided a measure of taxonomic versus thematic preference, rather than a 'pure' measure of taxonomic knowledge. Thus, on the object sorting task, the salience of thematic associations interfered with children's ability to demonstrate their knowledge of A–I taxonomy.

A number of explanations can be proposed to explain why the A–I level is the last to emerge in children's conceptual development. First, A–I categories are the broadest and can only be formed by attending to common abstract features among category members. Second, the terms 'animate' and 'inanimate,' or 'living' and 'non-living' are not frequently used as descriptors when teaching children the names of different objects and entities, so unlike basic-level categories, a common label cannot facilitate categorization. Finally, the complete development of the A–I distinction in childhood may take longer due to a qualitative restructuring of the A–I concept (Carey, 1985). Although an implicit form of the A–I distinction has been documented in infants during the second year of life, such categories are largely based on static and dynamic perceptual cues. In childhood, the development of A–I distinction has been shown to be affected by children's tendency to make similarity judgments in comparing other animate exemplars to humans as an 'animate standard', rather than considering other aspects of an exemplars' biological relatedness (Carey, 1985; Inagaki & Hatano, 1987). That is, children seem to find challenging the idea that humans are another type of animal.

The research presented here contributes to a more complete understanding of the development of the animacy concept in childhood. It is one of the few studies to provide a detailed account of the emergence of the A–I distinction using tasks that measure children's ability to form taxonomic categories. The matching-to-sample and object sorting tasks provide unique measures of children's spontaneous categorical decisions. Thus, this research provides a complement to the body of research investigating whether children extend various properties to animates or inanimates (Inagaki & Hatano, 1996; Jipson & Gelman, 2007; Massey & Gelman, 1988). The present research adds to our current understanding of children's conceptual development by presenting additional evidence that A–I level categorization is the last to develop in childhood. These results therefore support the hypothesis that the development of older children's categorization abilities follows a bottom-up developmental trajectory. Taken together, results of the matching-to-sample and object sorting tasks provide further support for the emerging development of the A–I distinction in the early childhood years.

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